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The Nexus between Research and Industry: Key to Innovation and Sustainable Development
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**12TH ZIRS ORGANISING COMMITTEE**

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   RCZ Board Member
4. Prof. H Chimhundu  
   RCZ Board Member
5. Mr D.E.H. Murangari  
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BACKGROUND OF ZIRS

The Research Council of Zimbabwe (RCZ) is a statutory body established in terms of the Research Act [Chapter 10:22]. It is mandated to promote, direct, supervise, and co-ordinate research. RCZ hosts biennial Symposium to give local and International Researchers a forum to present their research findings and share experience with fellow professional and policy makers. RCZ will host the 12th Edition of the Zimbabwe International Research Symposium on 13 - 15 February 2019. The theme for this Symposium is “The Nexus between Research and Industry: Key to Innovation and Sustainable Development”. The theme was motivated by the policy direction of His Excellency, the President and Chancellor of Public Universities enunciated on strengthening linkages between Academia and Industry for economic growth. The pronouncement was made at his meeting with Vice Chancellors on 9 January 2018. RCZ directs its efforts towards demand-driven research for sustainable development. The symposia, therefore, is a strategy to provide platform for creating lasting linkages between and stakeholders within the National Science Technology and Innovation System of Zimbabwe.

RCZ has successfully hosted eleven symposia under the following themes:

- 2017: Research for Unlocking Entrepreneurship: Bridging the Gap
- 2015: Research for Empowerment and Socio-economic Transformation
- 2013: Driving Socio-economic Develop through Research Output
- 2007: Knowledge Based Development for Zimbabwe
- 2004: Impact of Innovative Science and Technology for Wealth Creation
- 1999: A Century of Science and Technology Challenges for the Next Millennium
- 1996: Towards Capacity Building in Science and Technology
- 1994: Advances in Productive and Sustainable Applied Technologies
- 1992: Innovation Self-Reliance and Development
- 1990: No Theme
- 1988: No Theme
OBJECTIVES OF THE 12TH ZIRS

The main objective of the 12th ZIRS is to provide a platform for nurturing relationships between industry and academia for national socio-economic growth. Other objectives of the 12th ZIRS are:

1. To facilitate increased transfer of knowledge from knowledge generators to knowledge users (Industry, entrepreneurs, investors).

2. To popularise commercial outputs that also fund scientific progress

OVERVIEW OF THE 12TH ZIRS

In order to bring the Guest of Honour to speed, the RCZ Executive Director, Mrs. S. Muzite provided an overview of the 12th ZIRS focusing on events and activities that had transpired on the first two days of the 12th ZIRS. The overview brought to the attention of delegates the key issues deliberated on during plenary sessions of the two days. Statistics and areas of focus for the research papers presented at the 12th ZIRS were shared with delegates. The Executive Director also mentioned the participation and role played by young scientists and corporates who exhibited their innovations at the symposium. An introduction of the International Guest Speaker for the 12th ZIRS, Mr. A Butt who is the Chief Executive Officer of Lancor Scientific, capped the presentation by the Executive Director.
PRESENTATION BY THE INTERNATIONAL GUEST SPEAKER

Building from the prior presentation on “The Science of Entrepreneurship” made on the second day of the 12th ZIRS, the International Guest Speaker shared his experiences with delegates on how Lancor Scientific came into being. The presentation was premised on some of the important steps and considerations to be taken into account by entrepreneurs. Emphasis was raised on the journey traversed by the International Guest Speaker, and how he eventually collaborated with academics and business people for the development of a solution on early detection of cancer.
PLENARY SESSIONS PRESENTATIONS

The 12th ZIRS incorporated two (2) plenary sessions. These were facilitated by expert speakers identified in line with the theme. The plenary presentations focussed on research and industrialisation, role of intellectual property in national innovation systems and a special Paper on Research, Innovation and Entrepreneurship Ecosystem in Zimbabwe. The 12th ZIRS headline sponsor, the Zimbabwe Energy Regulatory Authority (ZERA), delivered a presentation on the linkage between research and industrialisation placing emphasis on the importance of research on renewable energy. ZERA reaffirmed its commitment to continue funding Research and Development (R&D) in Renewable Energy under the existing Memorandum of Understanding with RCZ.

Donsa, Nkomo and Mutangi (DNM) Attorneys enlightened delegates on the role of Intellectual Property Rights in National Innovation Systems. Research and Academic Institutions were challenged to develop their Institutional Policies modelled along the National Intellectual Property Policy recently launched by Government.

RCZ took the opportunity to situate the nexus between research and industry by delivering a special Paper on the Research, Innovation and Entrepreneurship Ecosystem. The importance of synergies among players within the National Science Technology and Innovation System with RCZ playing an intermediary role was emphasised. The presentation by the Executive Director bordered on knowledge transfer and acknowledging Government’s gesture for allocating a significant amount of resources towards R&D. An emphasis was made for Zimbabwe to occupy its niche in the global economy by producing and marketing “Go to Zimbabwe for Goods” through research effort.

Lancor Scientific represented by their Chief Executive Officer, who was the 12th ZIRS International Guest Speaker, presented on ideation to commercialisation. The International Guest Speaker took participants through an interactive workshop on the Science of Entrepreneurship. The presentation highlighted that the quest for entrepreneurship was not only local but an international phenomenon with similar opportunities and challenges. Key issues which emanated from the presentation were on how to fund and govern entrepreneurial activities.

From a local perspective, the Postal Regulatory and Telecommunications Authority of Zimbabwe (POTRAZ) gave a presentation on their Innovation Drive which is supporting local Innovators to use Information Communication Technologies (ICT) solutions for sustainable development. The presentation featured testimonials from young innovators who were beneficiaries of the POTRAZ Innovation Drive. The beneficiaries had made some breakthroughs in the areas of agriculture.
PARALLEL SESSION PRESENTATIONS

Eighty-three (83) papers contributed by participants were presented under the four National Research Priority Areas namely Social Sciences and Humanities, Sustainable Environment and Resources Management, Promoting and Maintaining Good Health, and National Security of Zimbabwe. The papers were spread as follows.

<table>
<thead>
<tr>
<th>National Research Priority Area</th>
<th>Papers Presented</th>
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<tbody>
<tr>
<td>Social Sciences and Humanities</td>
<td>19</td>
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<tr>
<td>Sustainable Environment and Resources Management</td>
<td>46</td>
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<tr>
<td>Promoting and Maintaining Good Health</td>
<td>12</td>
</tr>
<tr>
<td>National Security of Zimbabwe</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>83</strong></td>
</tr>
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Social Science and Humanities

Topical issues discussed under the Social Sciences and Humanities theme area included promotion of business incubation programmes, importance of Intellectual Property in the research to product value chain and the utility of ICTs in enhancing agricultural marketing among local farmers. The theme area constituted 23% of the research papers at the 12th ZIRS.

Sustainable Environment and Resource Management

The theme area on Sustainable Environment and Resources Management topped the list by contributing 55% of the papers presented at the 12th ZIRS. Research papers were in the areas which included climate change, environment, mining, renewable energy and agriculture. More than half of the papers under this category were in the field of Agriculture confirming that indeed Zimbabwe was an agro-based economy. The need to create value chains around agriculture to boost the country’s exports and attract Foreign Direct Investment (FDI) was elaborated during the presentations.

Promoting and Maintaining Good Health

Despite the high intensity of research in the medical field, the theme area on Promoting and Maintaining Good Health, contributed 14% of the research papers. This position could be attributed to the fact that research in this sector is mostly funded by donors who place stringent conditions on publicity of research findings. This leaves local researchers with the only one option of presenting findings of such studies at platforms approved by the donors. The few papers presented, however, were insightful as they focussed on the role of the pharmaceutical sector in promoting industry, the relationship between non-communicable diseases and traditional foods, and HIV drug resistance.

National Security of Zimbabwe

The theme area on National Security of Zimbabwe, regardless of its strategic nature, has always received the lowest number of research papers. During the 12th ZIRS only 7% of the research papers were presented in the area of National Security. The papers were in the area of food security, cyber-security and invasive species.
EDITORIAL

The Research Council of Zimbabwe (RCZ) has successfully hosted the Zimbabwe International Research Symposium (ZIRS) since 1988, every two years (biannually). This in itself has been a remarkable fit. This in many ways underlines the great achievement and success which has been achieved by the RCZ in implementing its mandate of coordinating, promoting, and supervising research activities in the country. Well done indeed!

With the ever ballooning technological era spurred by the explosion in advance of the information technologies, the themes of the symposium have become more sophisticated and in tandem with scientific progress. This year’s theme “The Nexus between Research and Industry: Key to Innovation and Sustainable Development” is as appropriate and fitting like a hand in a glove! With the national vision of becoming an upper middle economy by 2030 it is perhaps only natural that we emphasize the importance of research for sustainable socio-economic growth. The basis of economic growth is research which is translatable into the kind of technologies which provide goods and services generated by industry. Research and development and Industry has to be linked to realise sustainable development. This effort was given a critical boost by the President’s pledge to increase funding for research and development up to 1% of Gross Domestic Product.

The science of Entrepreneurship was highlighted by this year’s International guest speaker who pointed out some of the important steps encountered by entrepreneurs. Once more the link, the nexus between research (academics) and industry (business) was emphasized and illustrated with practical examples.

The appropriateness of the current theme is rooted in the objectives of the symposium’s main objectives which were outlined as:

1. To provide a platform for nurturing relationships between industry and academia for national socio-economic growth.
2. To facilitate increased transfer of knowledge from knowledge generators to knowledge users (Industry, entrepreneurs, investors).
3. To popularise commercial outputs that also fund scientific progress.
4. The symposium has continued to infuse widespread interest and has grown bigger with each subsequent event. This year an average of 700 delegates daily over the three days. In all around a hundred papers were received by the RCZ. Of these, 83 were presented at the Parallel sessions under the National Research Priorities of Social Sciences and Humanities, 19, Sustainable Environment and Resource Management, 46, Promoting and Maintaining Good Health, 12, and National Security of Zimbabwe, 6. The four plenary presentations were represented by Research on Renewable Energy, Intellectual Property Rights in Innovation Systems, Science of Entrepreneurship and Research and lastly Research, Innovation and Entrepreneurship Ecosystem.

The Executive Director of the Research Council of Zimbabwe emphasized research transfer and encouraged Zimbabwe to occupy its Global Economic Niche by marketing “Go to Zimbabwe for Goods through Research Effort”

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Professor CFB Nhachi
Chief Editor
Salutations

Ladies and gentlemen, it is a great pleasure for me to be here today. This auditorium is filled with strong vibes from intellectuals mingling with entrepreneurs, industrialists, policy makers and others at this 12th Zimbabwe International Research Symposium. Your presence here, is a true demonstration of the seriousness you give to socio-economic development. The Symposium brings together stakeholders in the policy, research, innovation, entrepreneurship and industry ecosystem of Zimbabwe to work at an area that resonates well with the aspirations of the Second Republic, in an effort to attain a knowledge-based economy that delivers prosperity at all levels down to the person. Through this Symposium, you engage with one another in an open and transparent way on the nexus between research and industry. There is no monopoly to invention. The willing are provided an appropriate platform to identify research results with potential for uptake in order to produce world class goods and services that are competitive in local, regional and global markets.

As I delve more into the details of this symposium, I wish to thank the Research Council of Zimbabwe Board, represented here by Engineer, Dr Mike Tumbare and its secretariat, represented by Mrs Susan Muzite for making this event a success. My administration takes seriously the role and mandate of the Research Council of Zimbabwe, that of promotion, direction, supervision and co-ordination of research with particular reference to the interests of Zimbabwe.
United by our national vision to be a Middle Income Economy with a per capita income of USD3500, increased investment in research will result in innovations and industrialization that create decent jobs and broad-based empowerment, free from corruption by 2030. We therefore, must individually and collectively play our part in advancing the National Research Agenda. This Symposium is an important step in that regard. The inclusivity of the symposia series, of which this is the twelfth, must be embraced by all. For my part, I will support it from the highest level of Government.

The theme of the 12th Zimbabwe International Research Symposium namely **Nexus between Research and Industry: Key to Innovation and Development** was thoughtfully crafted. It has the nation’s vision in mind, and buttresses our mantra *Zimbabwe is Open for Business*. The theme endeavors to connect the dots in Zimbabwe’s research, science, innovation and entrepreneurship ecosystem. The ecosystem emanates from a live Research, National Science, Technology and Innovation system. A myriad of complexities are inherent to the system but we must navigate through them as a nation in order to grow our local industry.

Silos must be broken, synergies and partnerships brokered. As our intellectuals generate scientific knowledge at the frontiers of discovery, we must breakdown silos. National confidence, saying to ourselves “we can do it” is paramount. That, coupled with creativity and determination will land our nation with goods and services that hold their own in the now highly competitive global village. Dynamic and effective interaction among all players will bring about social cohesion. However, in order to have a vibrant and effective research, innovation, entrepreneurship and industry ecosystem, and links to big data, open access and open science platforms are also imperative. I have been briefed that the Research Council of Zimbabwe has created budget lines for facilitating access to big data, open access and open science platforms in its 2019 budget. Specifically, the amounts are to cover access licenses and software costs when required for research programmes. My administration allocated 0.3% of its budget to Research and Development for 2019. Specifically, as a turning point,
for the first time we allocated 8.1 million dollars to the Research Council of Zimbabwe. Indeed it is not an option for Government not to invest in Research and Development.

Ladies and gentlemen, I repeat as I said at my inauguration that, “My Government will, in the next five years accelerate industrialization, modernization and mechanization, with greater emphasis on market driven policies”. This symposium is one strategy in which convergence of minds and sharing ideas, experiences and knowledge happens in order to inform our individual actions to deliver prosperity.

I urge you to remain focused on using scientific knowledge for the creation of internationally competitive goods and services. Before I conclude, let me acknowledge the sponsors, who have expressed their support for this Symposium in a very practical way. Thank you for trail blazing. Particular mention goes to the Zimbabwe Energy Regulatory Authority, the Headline Sponsor and Postal and Telecommunication Regulatory Authority of Zimbabwe, the Gold Sponsor. I also thank the seniors, those above 60, scientists and industrialists who graced this Symposium to mentor the young and upcoming. Further, the presenters on the programme invested time to research. The scientific knowledge they generated and made available present’s limitless opportunities for the inspired to produce bankable proposals leading to production of goods and services. The exhibitors, more than showcasing, they also demonstrated that it is possible to achieve. Special accolades go to the young scientist exhibitors and school children. Keep it up.

On behalf of my Government, the Research Council of Zimbabwe and indeed on my own behalf I thank Mr. Aamir Butt our International Guest Speaker. We are indebted to you Sir, for gracing this occasion. Symposium delegates learned about early cancer detection. You pioneered translational research on cancer early diagnosis and screening. Through Lancor Scientific, the Lancor Blockchain (LBP) was prototyped to detect cancer earlier in order to save lives. Symposium delegates have learned, in a practical way the value chain from research to product using the example of early detection of cancer. In conclusion let me say congratulations, Makorokoto, Amhlope to award winners. I encourage all delegates to this symposium to keep on improving on your work. Next time you will be the winners. With this, I declare this 12th Zimbabwe International Research Symposium officially opened. I thank you.
**PLenary Presentations**

**Introduction**
- Aamir Butt
- 20 years in startups
- 5 Startups, 4 exits
- Chief Marketing, VMware
- CEO
- Salaris, CEO
- NED

**Vision and Mission**

**What is Science?**
- [http://www.oxforddictionaries.com/definition/English/science](http://www.oxforddictionaries.com/definition/English/science)
- The intellectual and practical activity encompassing the systematic study of the structure and behaviour of the physical and natural world through observation and experiment.
- Hypothesis (testable, falsifiable)
  - A prediction statement that includes variables and a measurable or testable scenario.

**Scientific Method**
- Phenomenon
- Hypothesis
- Prediction
- Experiment
- Peer Review
- Publication
- Replication

**The Pain and Opportunity**
- See a need, fill a need
- People buy painkillers, not vitamins
- 73% fail because of need.

**The Perspective**
- Crowd contagion

"The majority of men, especially among the nations, do not possess clear and necessary ideas on any subject whatever outside their own specialty. The leader serves them as guides. It is not possible that he may be replaced, though very efficiently, by the peripheral scientists who manufacture opinions for their masters and pass them with ready-made phrases which impress them with the trouble of reasonings."

**Workshop**
- Co-Founders
- First Employees

**Need for Science**
- Business plans
- Value proposition
- Value chain
- Channels
- Customer relations
- Revenue model
- Partnerships
- Resources

**Being Rigorous**
- Value hypothesis
- Test
- Observe
- Collect data
- Analyze
- Repeat

**Focusing on the Beachhead**

**The Perspective**
- Crowd sentiment

"A group of individuals united by a common idea, belief, or ideology."

"Crowds rather than isolated individuals may be induced to run the risk of death to secure the triumph of a crowd or an idea, that may be fired with enthusiasm for glory and honour... Such heroism is without doubt somewhat unconscious, but it is of such heroism that history is made."

**Why Science?**

Count how many times the players wearing white pass the basketball.
## The ICT Innovation Drive

### Current Status of the Drive
- Currently giving loans in all sectors
- 6 Months grace period
- 3% Interest rate
- Payable over 36 months
- 9 projects have qualified for support to date
- Another 2 projects identified

### Success Story – Shift Organics
- **Current Project being supported**: Shift Organics
- **Background**: The success of Shift Organics in the ICT field highlights the potential of innovative technology in driving economic growth.
- **Objectives of the Drive**: The objectives include fostering innovation, creating new industries, and supporting existing ones.
- **Current status**: The project has received funding and is now in its initial stages of development.

### Challenges
- **The need for capacity building among innovators**
- **Proposed solution**: A series of workshops and training sessions will be conducted to enhance the skills of innovators.

### Lessons Learnt
- **The capacity building framework**
- **Protection of IP**: Ensuring that intellectual property rights are protected is crucial.
- **A loans approach alone may not be the best approach**
- **Need for approaches that benefit more innovators**
- **Organisation Hackathons**: The integration of hackathons into the innovation process.
- **Innovation hubs**: Establishing a network of innovation hubs across the country.

### Long Term Focus
- **Create a digital innovation ecosystem that promotes competition among different approaches**: This includes fostering a culture of innovation, encouraging collaboration between stakeholders, and providing a supportive regulatory environment.
- **Focus on innovation in different sectors**: ICT, education, health, agriculture, and more.

### Thank you!

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### Workshops held in Byo & Hre
- **The need for capacity building among innovators**
- **Proposed solution**: A series of workshops and training sessions will be conducted to enhance the skills of innovators.
- **Objectives**: Improve the quality of innovations, increase the number of applications benefiting from the Drive, and ensure that all innovators have access to the necessary resources.

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### Background
- The Zimbabwe ICT Innovation Drive is an initiative by the Ministry of ICT, Postal and Courier Services in partnership with the telecommunications regulatory authority of Zimbabwe (POWRAZC), through the Universal Services Fund (USF).
- The purpose of the Drive is to identify, support, and capacitate ICT innovators in the country, in order to develop their start-ups into sustainable solutions for Zimbabwe and the global market.
ZERA
Research, Energy and Industrialization
E.T. Masebane – ZERA A/CEO
12 February 2010 – Research Council of Zimbabwe

1) The ZERA Mandate
2) The Energy Environment
3) ZERA and Research
4) Some Research Findings
5) Challenges in R&D
6) Concluding Remarks

ZERA’s Mandate
The Zimbabwe Energy Regulatory Authority (ZERA) is a body corporate established in terms of the Energy Regulatory Authority Act [Chapter 13:23] of 2011.
- Mandated to regulate the entire energy sector in Zimbabwe in a fair, transparent, efficient and cost effective manner for the benefit of the consumers and energy suppliers.

ZERA and Research Promotion
- To ensure security of energy supply;
- To promote energy efficiency throughout the energy delivery chain;
- To promote and encourage use of renewable energy;
- To promote energy industry expansion;
- To encourage advancement of technology relating to the energy industry.

The Research Agenda
- Pure Research – seeks to establish functional relationships between identified and disparate variables
- Pure Research – economic consequences generally long term. Can we afford to wait?
- Applied Research – directed at improving specific processes
- Applied Research – application usually in the short to medium term

1) For Domestic Use Flat Plate Collector
2) Solar Fraction: >90%
3) IRR: 20%, Payback Period: ~6yrs
4) GHG Abatement: 120ton/m2/year
5) Electricity Saved: 20MWh/m2/year

Solar Water Heating: Economics

From His Excellency
“Research must not be an end in itself or remain in archived journals, theses and documentaries in our libraries. It must speak to our problems, be relevant, usable, practical and transform our lives and advance our economic development!”
# THE ROLE OF INTELLECTUAL PROPERTY IN NATIONAL INNOVATION SYSTEMS

**Presentation Title**: Research

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## What is IP
- The term 'IP' refers to unique, value-adding creations of the human intellect that result from human ingenuity, creativity and inventiveness.
- The World Intellectual Property Organization (WIPO) defines IP as the power to exclude others from using inventions, art works, or industrial designs, and inventors and artists have the freedom and authority to decide how their IP is used.

## Intellectual Property Rights
- These are legal rights granted in respect of new knowledge and creative expression of mankind, which make it possible to harness the commercial value of the outputs of human inventiveness and creativity through excluding unauthorised persons from exploiting the protected intellectual property.
- The exclusivity given by IP rights gives value to the intellectual property they protect.

## Importance of IP in Research
- Local Universities and research institutions have identified the need for and have sought to establish research it in a wide range of areas in response to national, regional and global problems.
- The research has generated critical knowledge products, discoveries, technologies and innovations. It is vital to appreciate that the research outputs generated are in fact intellectual property assets which can be protected, commercialized, managed and enforced in ways that can bring economic benefit to the institutions.

## How to leverage IP for economic advantage
- Universities and research institutions must craft and implement intellectual property policies and strategies, align such policies and strategies to the mainstream institutional strategic plans. Since the main output is knowledge, intellectual property must be the centerpiece of the institutional strategies.

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## What is Intellectual Property

![Image: Creations of the mind]

**Introduction**
- Public research institutions (PRIs) play a key role in innovation through their contribution to the production and diffusion of knowledge.
- Patents and licensing inventions based on public research can be used as instruments for accelerating knowledge transfer, fueling greater cross-fertilisation between faculty and industry which leads to entrepreneurship, innovation and growth.
- If PRIs are to play their part in the attainment of Vision 2030, they invariably need to embrace intellectual property as a key strategy.

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## The IP Value Chain
- Creation
- Protection
- Commercialization
- Management
- Enforcement

## IP in the research process

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<th>Value addition</th>
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<td>Research</td>
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<td>Technologies</td>
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<td>Intellectual Property Agreements</td>
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<td>Collaborative Research Agreements</td>
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## IP as an enabler for research and innovation
- It is a requirement for the granting of a patent that the Patentee discloses his invention in such detail that a person skilled in the art can work the patent.
- Researchers can therefore access patent documents and develop their own inventions on the basis of already existing patents.
- There is an exception to the exclusive rights granted to a patentee.
- Patents rights are territorial in nature, so if the patent is not registered in Zimbabwe, there is no bar to adapting the invention to the local environment.

## IP as a catalyst for research
- An effective institutional IP framework attracts collaborative research partners as it assures them of security of their investment.
- A good institutional IP policy provides for incentives and rewards for its researchers and consequently attracts high caliber researchers.
- A healthy IP Portfolio now contributes to the overall ranking of the institution and attracts appropriate partners.

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## Conclusion
- It's now time for every university and research institution to pay attention to its intellectual property assets and put in place policies, strategies, structures and systems which would enable them to optimise the creation, protection, commercialisation, management, and enforcement of their intellectual property rights for economic advantage. IP is a key ingredient for the attainment of Vision 2030!

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RESEARCH, INNOVATION AND ENTREPRENEURSHIP ECOSYSTEM OF ZIMBABWE

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ABSTRACT
Entrepreneurship has gained a position of centrality in socio-economic development. Globally, governments are in agreement that it is an enabler for sustained socio-economic growth. However, success of the entrepreneurial sector depends on the understanding of roles and magnitude of interaction among different actors of the ecosystem. Currently, knowledge generated through research and innovation is available for use by entrepreneurs, but absorption is not always a given. In Zimbabwe, through the National System of Science, Technology and Innovation, (i) an inventory of participants has been provided, (ii) their connections, roles and relationships mapped, and (iii) their potential to interact and transform the economy is acknowledged. The aim of this research paper was to understand the RIE ecosystem of Zimbabwe in order to unlock the opportunities within and outside the ecosystem for the benefit of the ecosystem of Zimbabwe and beyond. An exploratory design, through conducting desk review of government policies, Research Council of Zimbabwe (RCZ) policy briefs, annual reports, workshop resolutions and others was used to collect data. Thematic content analysis (TCA) was used to consolidate data into sub-themes. Findings of this study established that in some cases the connections were not very strong, the magnitude of interaction low and direction of progress not very clear. The situation is exacerbated by new and developing constructs such as big data, open access, and open science which introduce complexities in connecting the dots. Nonetheless, connecting the dots, building strong linkages among the various players in the Research, Innovation and Entrepreneurial (RIE) Ecosystem is imperative. The conclusions are that, the RCZ is in a strategic position to catalyse the desired connections. A quest for effective strategies to bring vibrancy in the Zimbabwean RIE ecosystem is a practical, realistic and required goal. Continuous engagement leading to understanding the importance of strong linkages and then performing within the ecosystem for achieving a sustainable socio-economic transformation is an imperative.

Keywords: Connecting the dots, Ecosystem, Research, Innovation, Entrepreneurs, big data, open data, open science
INTRODUCTION

Research, innovation and entrepreneurship (RIE) play vital roles in driving national socio-economic development in all countries including Zimbabwe. Resonating with the Doctrine for the Modernization and Industrialization of Zimbabwe through Education, Science and Technology Development to achieve Vision 2030, is the development of a knowledge economy (Government of Zimbabwe: GoZ, 2018). Through a vibrant RIE ecosystem, Zimbabwe is assured a prosperous posterity. The philosophy of a heritage-based development gels well with a vibrant RIE ecosystem that deliver relevant goods and services that satisfy the aspirations of industrialization and modernization. A number of policies and measures have been crafted to ensure fruition of the national aspirations. One such measure is the Transitional Stabilization Programme Reforms Agenda: October 2018 – December 2020, whose theme is “Towards a Prosperous & Empowered Upper Middle-Income Society by 2030”.

In Zimbabwe RIE, occur within the National Science, Technology and Innovation (NSTI) system, creating the Research, Innovation and Entrepreneurship Ecosystem. The two systems are intricate and complex yet indispensable. A healthy operation of one system directly impacts the other. The NSTI system uses the RIE ecosystem to advance the delivery of goods and services. In order for the ecosystem to thrive, complex constructs namely big data, open science and open access need to be understood. These complex concepts and systems, their relationships, connections and relevance are discussed in this paper. The starting point in connecting the dots in the ecosystem, is “knowing what our people (industry, commerce & society) want” (Mapfumo, 2019). This is so, because the ecosystem is there to solve society’s problems.

The RIE ecosystem analogy is borrowed from Ecology. Ecology looks at the relationships in the natural world. An ecosystem is a community of living and non-living things working together (University of Michigan, 2018). The ecosystem concept emerged as a response to and means of explaining the complexities involved in the interaction among different actors and conditions. In the RIE context, the ecosystem refers to interactions among various players in research, RIE, big data, open science and open access for socio-economic development. It encompasses the interactive processes involving key actors in Government, knowledge generators, and users of new knowledge including industry and entrepreneurs to produce, diffuse and use knowledge for societal and economic gain (Isenberg, 2011; World Economic Forum, 2014). The Ministry of Higher and Tertiary Education, Science and Technology Development (MHTESTD) Strategic Plan, 2019-2023 gives a 5.0 NSTI System.

The ecosystem system is informed by teaching, research, community services, innovation and industrialization as pillars for modernization, and socio-economic emancipation of Zimbabweans (GoZ, 2019). The 5.0 point plan intends to provide solutions to multi-faceted challenges that confront society. Within the 5.0 plan is the RIE ecosystem. The RIE ecosystem thrives through a mutual relationship with its natural endowments which forms the basis of Zimbabwe’s heritage. This resounds well with Government’s Innovation culture which should be heritage based (flora, fauna, water, minerals and human resources) for prosperity (Murwira, 2019).

Despite the realization of the roles played by RIE in driving national socio-economic development, little empirical knowledge is available on how to foster entrepreneurial activity in some regions, particularly the developing world. Promoting RIE has potential to create new economic opportunities, which create jobs and wealth in an environmentally sound manner and inclusive society (Economic and Social Commission for Asia and the Pacific: ESCAP, 2016). To realize the ability of RIE to meet both the Zimbabwe National Vision and global ambitions of the 2030 Agenda, it will be essential for players in the RIE ecosystem of Zimbabwe to understand the value chain of innovative entrepreneurship. Lack of understanding of the value chains is the knowledge gap.
Lack of information on the vitality of RIE together with understanding its value chains is exacerbated by limited appreciation and lack of knowledge on the role of big data, open science and open access in the fast changing Information and Communication Technology (ICT) or digital age. In order to connect the dots in the RIE ecosystem of Zimbabwe, being part of the big data, open science and open access platforms is imperative. Indeed, there is no monopoly over research, science and knowledge. Whilst the RIE playing field is seemingly not level, what is required is the “we can do it” attitude within the RIE ecosystem of Zimbabwe.

STATEMENT OF THE PROBLEM

Zimbabwe has a well-established ecosystem for research, innovation and entrepreneurship, as evidenced by availability of policy frameworks. The National Science, Technology and Innovation System has an inventory of participants or dots whose connections, roles and relationships have been mapped, and whose potential to transform the economy is acknowledged. However, there is lack of scientific evidence on connections and linkages within Zimbabwe’s RIE ecosystem. More-so, scholarly research and understanding of RIE value chains within the context of big data, open access and open science remains a research gap militating against Zimbabwe’s full realization of socio-economic transformation. Building synergies, bringing vibrancy within the ecosystem and promoting continuous engagements to understand the importance of connecting the dots, is vital to bring long term impact and unlimited opportunities into the whole ecosystem. Innovative strategies by RCZ on strengthening interactions with big data, open access, open science and stakeholders for sustained socio-economic growth and improved wellbeing for all Zimbabweans are imperative.

OBJECTIVES OF THE STUDY

The aim of the study is to understand the RIE ecosystem of Zimbabwe in order to unlock the opportunities within and outside the ecosystem for the benefit of not only the ecosystem but Zimbabwe at large. The specific objectives of the research paper are:

a) To assess the level and magnitude of interaction of actors in the Zimbabwe RIE ecosystem;
b) To generate an understanding of the Zimbabwe RIE value chains within the context of big data, open access and open science; and
c) To develop strategies to bring vibrancy to the Zimbabwe RIE ecosystem.

DEFINING THE KEY CONCEPTS

The paper is underpinned by the following key concepts: - research, innovation, entrepreneurship, STIs, ecosystem big data, open science and open access.

Research: Broadly refers to creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of humans, culture and society, and the use of this stock of knowledge to devise new applications (OECD, 2012). Research is a rigorous process of asking question(s), gathering data, analyzing, interpreting, and proposing response(s) (Kinash, 2019). It is finding out, in a more or less systematic way, things you did not know, or advancing the frontiers of knowledge (Walliman, 2011). This paper adopts the Research Act [Chapter 10:22] definition, that research is any systematic, critical or scientific study of, or inquiry into, any subject or matter for the extension of knowledge;

Innovation: Innovation is the development of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization (OECD/Eurostat, 2005). Innovation processes can differ according to sectors and technological areas. They can also differ in terms of development, rate of technological change, linkages and access to
knowledge, as well as in terms of organizational structures and institutional factors. Šakalytė and Bartuševičienė (2013) see innovation as the introduction of new process(es) or idea(s) that can solve a problem, the purpose being to reorganize, reduce costs, improve the organization's networks, develop new systems as well as generating, accepting and implementing the new ideas, processes, products or services. In this paper, in addition to these definitions, we adopt Popa et al (2013) who view innovation as the ability to continuously make knowledge, ideas, and the ability to continuously transform them into new products, processes and systems, to the benefit of organizations, other stakeholders and the society at large.

Entrepreneurship: Entrepreneurship is exploiting market opportunities through technical and/or organizational innovation (Schumpeter, 1965). Hisrich (1990) defined entrepreneurship as demonstrating an initiative and creatively thinking, to organize social and economic mechanisms to turn resources and situations to practical account, and accepting risk and failure. Bolton and Thompson (2000) view entrepreneurship as habitually creating and innovating to build something of recognized value around perceived opportunities. Entrepreneurship is a process of creating opportunities for new goods and services to be explored, evaluated and exploited (Shane and Venkatamaran, 2000). Onuoha (2007) sees entrepreneurship as the practice of establishing new organizations or revitalizing them, in response to identified opportunities. In this case entrepreneurship starts from researching through venturing into big data and using open science for existing opportunities within the environment, makes strategic decisions on starting or revitalising business through use of knowledge and innovative ideas.

Science Technology and Innovation (STI): Science, technology and innovation (STI) are key drivers of economic and social development (innovation@unctad.org). Science is the systematic study of the physical or material world (natural science) and of society (social science) that generates, or creates, knowledge from which data and information is drawn. Technology is the application of scientific knowledge to develop techniques to produce a product and/or deliver a service or as the application of scientific knowledge for practical ends. Innovation is deriving the benefits from a new or significantly improved product (good or service); or process such, as a new marketing method or a new organizational method, such as in business practices, workplace organization or external relations (Economic and Social Commission for Asia and the Pacific: ESCAP, 2016:5).

Ecosystem: It is a complex multi-level construct. It includes stakeholders, such as political decision makers, government departments and agencies, universities and industry associations (Isenberg, 2011; Schwab, 2014). The term originally was coined by James Moore in the 1990s (Mason and Brown, 2014). Moore postulated that businesses don’t evolve in a ‘vacuum’ but are relationally embedded in nature of how firms interact with suppliers, customers and financiers (Eroğlu, 2011). Firms created within dynamic ecosystems have better opportunities to grow, and create employment, compared with those created outside (Mason and Brown, 2011).

At enterprise level, the activities of new start-up and existing small or larger firms represent the engine to spur innovation-based socio-economic development. The relevant activities are often spread across organizational boundaries as knowledge and resources are shared. An ecosystem is the enabling environment, which reflects a set of interrelated conditions and interactions of political, legal, social and cultural relationships that govern the generation of new knowledge, flow of that knowledge and use in the production of goods and services. It encompasses the knowledge systems of big data, open science and open access. Ecosystem is a myriad of these doted interactions.

Big data: Big data is a broad concept. Big data often refers to the use of predictive analytics or other certain advanced methods to extract value from data, of a particular size (Zennaro, 2016). Big data has three characteristics namely volume (size of data in terms of storage and access), velocity (the speed of incoming data and the time it takes to process it) and variety (type of files and format of data as well as source - being
structured or unstructured). Big data is a combination of data management technologies and market, which enable organizations to store, manage, and manipulate vast amounts of data at the right speed and at the right time to gain the right insights (Hurwitz et al., 2013). Big data can feed into innovation and entrepreneurship for business and socio-economic transformation. Big data has become one of the most important technology trends with potential to drastically change the way organizations utilize information to enhance the customer experience. Understanding the big data value chain is the biggest challenge among most LDCs and developing countries. Zennaro (2016) itemises the value chain as: collection - of data from multiple sources and formats; ingestion - loading vast amounts of data onto a single data store; discovery and cleansing data - understanding format and content, clean up and formatting; integration - linking, entity extraction, entity resolution, indexing and data fusion; analysis - intelligence, statistics, predictive and text analytics, machine learning and; delivery - querying, visualization, real time delivery on enterprise-class availability. Big data is important in that, researchers, innovators and entrepreneurs can take data from any source, analyse it and get answers at a reduced price. Reduced cost of knowledge results in improved and affordable products and services. Furthermore, consumers of knowledge, get it in minimal time frames, make quick decisions and develop new products. Big data enables organizations to store, manage, and manipulate vast amounts of data at the right speed and at the right time to gain the right insights for use in innovation and strategic business decisions (Hurwitz et al., 2013).

Open Science: Open Science is a scientific process based on cooperative work and new ways of diffusing knowledge by using digital technologies and new collaborative tools. The idea captures a systemic shift in science and research, that is from the standard and traditional practices of publishing research results in scientific publications towards sharing and using all available knowledge at an earlier stage in the research process (EU, 2012). It can also be viewed as a means for accelerating research, enhancing transparency, collaboration, and fostering innovation (OECD, 2015). Open Science refers to efforts by researchers, governments, research funding agencies or the scientific community itself to make the primary outputs of publicly funded research results i.e. publications and the research data publicly accessible in digital format with no or minimal restriction as a means for accelerating research; with the primary interest of enhancing transparency and collaboration, and fostering innovation. It includes post-publication peer review, open research notebooks, and open access to research materials, open source software, and citizen science OECD 2015). Open access is sometimes referred to as open scholarship in English. Although there is use of the word science, all academic disciplines fall within its purview. This is so because it refers to a culture change in the way various stakeholders in the research, education and knowledge exchange communities, create, store, share and deliver the outputs of their activity. Open science is concerned about greater efficiency, productivity, more transparency and a better response to interdisciplinary research needs (League of European Research Universities: LERU, 2018). Open Science opens up new ways in which research/ education/innovation are undertaken, archived and curated, and disseminated across the globe (LERU, 2018). Open science, open access and big data improve efficiency in accessing scientific inputs and outputs. They do this by reducing duplication and the costs of creating, transferring and reusing data. Further, they allow more research from the same data, multiply opportunities for participation within and outside the RIE ecosystem (OECD, 2015).

Open access: Open access is restricted online access to scientific articles. Access can occur via a number of channels, such as institutional repositories, journal publishers’ websites, researchers’ webpages, and many others (LERU, 2018). Open access makes copyrightable works available without all of the access barriers associated with the “all rights reserved” model (Rubow, et al., 2015). It comes in two forms. Gratis open access, is making work available online free of charge (Rubow et al., 2015). They are scientific publications that are free of charge with technical restrictions and legal restrictions (OECD, 2015). Libre open access or full open access refers to making a work available online free of charge and with some additional reuse rights, typically granted through a Creative Commons license (Rubow et al., 2015).
The concept open access is an effort to uphold the United Nations Universal Declaration on Human Rights of 2015, which calls for non-discrimination against persons, groups or fields of study. Open access platforms hold tremendous potential for solving some complex societal development issues (Foley, 2016). Currently, the Global Research Council is in the process of coming up with a statement of principles and actions to make open access a reality. ICSU (2015) stresses the need for openness and transparency within the knowledge industry. However, inaccessibility to big data is one cause for the deep and persistent development inequalities (UNESCO, 2016). Bottlenecks still exist in the form of license requirements, which may be out of reach for some.

1. METHODOLOGY
The study adopted an exploratory critical analysis design, through desk review of relevant literature. An exploratory design was employed in reviewing related literature on research, innovation and entrepreneurship policies and strategies in Zimbabwe. The exploratory design was conducted on the research problem because few or no earlier studies have been conducted to predict outcomes (Cuthill, 2002; Taylor et al., 2002). The design was adopted to gain insights and familiarity to the subject under review. Thematic content analysis of Creswell (2009) was applied to consolidate the results of this qualitative data into sub-themes. A theme is an important idea related to the data in the research question or level of patterned response within a data set. Braun and Clarke define thematic data analysis as a method for identifying, analysing and reporting patterns within data. Thematic content analysis was chosen because of its flexibility. Analysis of relevant literature was done through the extensive reading of government policies, Research Council of Zimbabwe policy briefs, annual reports, resolutions from workshops and other literature on the subject. In the process mind-maps were done, and themes were reviewed. Finally interpretations were made and conclusions reached.

2. FINDINGS
In his foreword in the Second National Science, Technology and Innovation (NSTI) Policy of Zimbabwe (2012), the then President of Zimbabwe HE R.G. Mugabe is quoted saying: 
For a nation to be able to develop sustainable solutions to pressing developmental challenges and to grow in a competitive global marketplace there is need to be innovative and make use of the dynamic new technologies that create the ability to generate its own solutions while it adapts outside technical knowledge to suit the local environment.

The study findings revealed that Zimbabwe has a RIE ecosystem enshrined in the National Science Technology and Innovation System (NSTIS). The ecosystem has many players interacting in complex directions and magnitudes. Bottlenecks to smooth interaction were identified which include fragmented approaches resulting in dotted activities. Fragmented approaches impede smooth connection and linkages among the dots, resulting in low investment in Research and Development by both Government and private players. Uptake and use of big data, open access and open science remain the biggest bottleneck to unlock the RIE potential in Zimbabwe. Therefore identification of critical development challenges and problems of national significance is imperative to unlock the potential (Mapfumo, 2019).

3.1 The National Science Technology and Innovation System of Zimbabwe
Muzite (2013) posits that the NSTI system can be seen as a web of interconnected institutions involved in the organisation and steering of the production of scientific knowledge, generation and uptake of innovations. At the core of the NSTI system in Zimbabwe, is generation, diffusion and promotion of scientific knowledge for facilitating socioeconomic growth and development (Muzite 2013). The NSTIS in Zimbabwe is a three tier
hierarchical pyramid (NSTIS Policy Brief 2014). Figure 1 explains the hierarchy in diagrammatical form. At
the apex is the Government (ministries, government departments and parliament). The primary function of the
apex is creation and management of an enabling environment. The middle level is an interface between the
apex and the lower level. The interface functions are translating government values to those of the research
system and vice-versa, to ensure uptake of outputs of the research system by entrepreneurs. In Zimbabwe, the
RCZ is the conduit and catalyst for this interface. At the bottom are the institutions responsible for knowledge
generation and entrepreneurs for knowledge absorption. Knowledge generators include the universities,
colleges, polytechnics, research institute, laboratories and research stations. Another important component of
the system is funding sources. These include banks, regional and international development partners as well as
companies (both national and multinational). The RCZ plays a central role within the NSTIS.

3.1.1 The Research Council of Zimbabwe
The Research Council of Zimbabwe (RCZ) is a statutory body established in terms of the Research Act
[Chapter 10:22]. Its mandate is to promote, direct, supervise, co-ordinate research and provide policy advice
to Government. The RCZ was established to be the central public catalytic agent for research, which is financial
and infrastructural support for collaborative research among research institutes and councils, facilitating
generation and absorption of scientific knowledge in Zimbabwe. RCZ does this through providing exceptional
forums for interaction and discussion for mutual benefit of Government, academia and industries (Muzite
(2013). From the core of the NSTIS system of Zimbabwe, the RCZ works closely with 15 other Science
Granting Councils in Africa. RCZ also has links with the Global Research Council, the International Science
Council (ISC) and the Group on Earth Observation (GEO). The ISC has a global membership of more than 40
international scientific Unions and Associations, over 140 national and regional scientific organizations
including Academies and Research Councils. As a member of these renowned knowledge gatekeepers, RCZ
is well positioned to ensure a thriving RIE ecosystem of Zimbabwe. The second STI policy of 2012 is currently
the main document giving direction to STI activities in the country. Findings of the ecosystem of Zimbabwe
are detailed below.

3.1.2 Knowledge Generators
Knowledge generators as alluded to above, include research councils, statistical agencies, standards and
measurement bodies, public and private laboratories, research centres, universities, colleges and polytechnics.
Their responsibility is to research, discover, create and develop scientific knowledge. Delivery on mandates is
enhanced through participation in big data, open science and open access platforms. The platforms are the right
track for knowledge generators (ICSU, 2018). Knowledge generators are tasked with development of the requisite
absorptive capacity by knowledge users to ensure that the knowledge generated is effectively and
efficiently converted into products and services for the benefit of society. Indigenous knowledge systems are
also a valuable component of the knowledge that flows within the national STI system. The knowledge
generating institutions need to learn and utilise knowledge generated from other countries through technology
transfer (Muzite, 2009).

However, the majority of academic institutions in Zimbabwe felt that their role ended at generating new
knowledge. They felt that the issue commercialisation of knowledge was a prerogative of entrepreneurs (Mbizi
et al., 2013). Besides emphasis on generating new knowledge, Zimbabwe lacks sufficient Full Time Equivalent
(FTE) researchers. Zimbabwe has ninety researchers per million people, compared to other countries in the
region. South Africa has 385/million people and Botswana 165/million people (Africa Capacity Building
Foundation: ACBF, 2016). China has around 1000-1200 researchers per million people. FTE researchers are
required for reducing bottlenecks within the big data, open access and open science realms.

3.1.3 Knowledge Users
It was noted that the bulk of the new scientific knowledge produced by the public R&D institutions was not
readily transformed into useful products and services. Muzite (2013) notes that knowledge generated within
the STI system was not disseminated widely for use due to challenges such as the IP regulations in the country.
Furthermore, institutions within RIE ecosystem of Zimbabwe had seemed to have weak entrepreneurial culture and capacity to work closely with the entrepreneurs and private sector. Secondly, the majority of players in the ecosystem were ignorant about the big data, open access and open science platforms. Consequently, local entrepreneurs were unaware of the value of investing in RIE to improve productivity and competitiveness. Improving synergies between public and private sector, and encouraging partnerships between government, industry and academia in developmental RIE, both locally and internationally has the potential for unlocking transformative innovation value chain.

3.1.4 Industry and Entrepreneurs

Industry is a key player in the RIE ecosystem of Zimbabwe. In addition to being the main end user of new knowledge, industries acquire new knowledge from other countries. Industry also provides employment to members of society. Currently, Zimbabwe’s industry is largely constituted by SMEs and entrepreneurs. Study results revealed that knowledge seeking behaviour among entrepreneurs was generally low. Most of their work was born out of innovation occurring in the absence of research. Further Muzite (2013) notes a general disjointedness in the NSTI system with its related systems, e.g. the RIE ecosystem. This led to lack of cooperation among players and reluctance to absorb locally generated knowledge. Global inequalities in access to big data, open access and open science also contributed. Resultantly, Muzite (2013) argues that the country is failing to generate knowledge to deal with some dire challenges such as climate change, food and nutrition insecurity which are constantly derailing Zimbabwe’s development gains since independence in 1980. ICSU (2017) affirms that an inequality in access to new knowledge remains significant.

3.1.5 The Society

Society is the primary recipient of the STI interventions. In this paper STI and RIE are treated as having the same intended outcome and impact namely goods and services that benefit society. Reviewed literature revealed comprehension of the impact STI interventions in solving societal challenges, and improving the quality of life. Knowledge is viewed as a public good and fundamental basis for human judgement, innovation and the wellbeing of society (ICSU, 2017). As such, research and development outcomes should find their way into society. Planning of STI/RIE activities should therefore be sensitive and responsive to the demands of society at any given time. The demand for RIE by society is significantly high (GoZ, 2012). Social and economic challenges in Zimbabwe, including poor infrastructure and need to beneficiate the country’s natural resources require the intervention of research and development, technology, innovation and interaction with industry. Public awareness of STI/RIE issues needs to be increased. ICSU (2017) posits that availing knowledge, increases accountability and responsiveness by government to citizens’ needs.

3.2 Level of Interactions within the RIE Ecosystem System of Zimbabwe

The interaction among players in the RIE ecosystem was depicted in the NSTIS with the pictorial presentation in Figure 1. Mapping of players in the ecosystem was done. The Figure uses arrows to shows the interactions that occur and the relationships that exist among different institutions, although their level and magnitude of interaction is complex. Public-private linkages remain weak. The long-standing tobacco industry and agricultural sector, have traditionally been characterised by limited collaboration with academia in Zimbabwe. Technology transfer to the business sector, development of industry and research are low. This is regardless of the fact that commercialization of research outputs is one major goal of the Second STI Policy. Stakeholders and players in the ecosystem argued that the silos attitude riled the potential of RIE to transform the economy of Zimbabwe from its current state to a multi-billion economy. In simple terms, the right hand does not know what the left hand is holding, implying that various initiatives dotted within the RIE ecosystem are not effectively connected. Stakeholders are largely unaware of the need to ensure that national STI/RIE programmes, projects and policies are internally and externally consistent. This led to lack of coherence, complementarity and effective coordination and linkages among actors (Jowi and Obamba, 2013).
Unwillingness of knowledge generators to share their research results was found to be common especially in universities and research institutions citing lack of a sound Intellectual Property Policy and respect for proprietary rights. In a related study, Muzite (2013) affirms this reality. Lack of clear intellectual property regulations and the glass ceiling within the big data, open access and open science platforms indeed exacerbate low absorption of new RIE products and services.

**FIGURE 1: THE SCIENCE TECHNOLOGY AND INNOVATION SYSTEM OF ZIMBABWE – A SCHEMATIC VIEW: ADAPTED FROM MUZITE, S (2009).**
3.3 RESEARCH AND DEVELOPMENT FUNDING

Government is the main contributor of gross domestic product (GDP) expenditure on public domain R&D, with the private sector being a small player. The Government of Zimbabwe through the Second STI Policy (2012) is committed to fund R&D to at least 1% of the country’s GDP. Fulfilment of the commitment is being hampered by challenges, resulting in some resources coming from foreign funder. Objectives of foreign sources may not be in tandem with national priorities. Low investment in R&D has resulted in limited generation of new knowledge, sustainable innovation and ultimately entrepreneurship. President Mnangagwa in His Official Opening Speech of the 12th ZIRS said that the Government will continue prioritising research and innovation through allocation of one percent GDP towards research. The President argued that the current 0.3 percent in the 2019 budget was a first step which will improve incrementally in future (RCZ, 2019).

3.4 STRATEGIES EMPLOYED FOR ENGAGING STAKEHOLDERS

The relationship among players within the STI and RIE systems should be characterised by co-existence and close cooperation (Muzite 2013). Functional connectedness and linkages, is key to socioeconomic development of Zimbabwe. The Research Council of Zimbabwe as a catalyst in the ecosystem has embarked on a number of initiatives to connect and link the dotted efforts of various players in the ecosystem of Zimbabwe. One engagement of stakeholders was the presentation of the Zimbabwe STI study findings at the invitation of the then Minister of Science and Technology, in plenary at the Research and Intellectual Outputs Science, Engineering and Technology Expo (RIOSET) in 2014. Delegates recommended submission of the same to Government as a Policy Brief. The Policy Brief received commendation from Government and approval for implementation.

3.4.1 CONNECTING THE DOTS

Based on research by Muzite (2013), we noted that the dots within RIE ecosystem of Zimbabwe are loose. RCZ as a catalyst for research and development identified critical players to pilot connecting and linking the dots. The Scientific and Industrial Research and Development Centre (SIRDC), an R&D Centre in Zimbabwe was approached. The Industrial Development Corporation (IDC) whose mandate is to incubate new industries in Zimbabwe was also identified. The two were linked up as a step towards unlocking value from local innovation efforts and building local capacity. Build up meetings were held. This was a strong initiative. Non-disclosure agreements were signed between the two organisations. More such, endeavours will be initiated with key stakeholders such as the Ministry of Higher and Tertiary Education, Science and Technology Development, Confederation for Zimbabwe Industries, representatives of SMEs and the Private sector. These processes will connect the whole ecosystem of Zimbabwe to ensure its viability and contribution towards socio-economic transformation.
3.4.2 ADOPTION OF RAPID RESULTS FRAMEWORK

The Rapid Results Approach (RRA) is a method used to improve performance within large organisations. The RRA enables public sector leaders to address real-life complexities (Matta et al., 2005). RRA is a set of management tools, processes, and skills that help leaders in organizations use a series of short-term projects to translate long term goals into concrete actions, results and impact (Matta et al., 2005). The Government of Zimbabwe through the Office of the President and Cabinet (OPC) adopted RRA in 2014. RRA is aimed at accelerating implementation of policies, programmes and projects by the government and other agencies. RCZ intends to use the RRA framework to clarify roles of respective players in the NSTIS. This will result in a paradigm shift in R&D funding, creation of smart partnerships among researchers, entrepreneurs, industry, private sector and other users of research results. Ultimately this brings life to the NSTIS to ensure transformation of the citizens’ livelihoods through improved incomes and employment.

An example of adoption of RRA is the Zimbabwe National Geospatial Space Agency Programme (ZINGSA) which is being administered by RCZ. The programme has seven Projects. The deadlines are strict considering results are expected within 100/200 days. Understandably, reporting on a monthly basis, with a bi-weekly tracker is done. Updates on a project milestones system is done, in order to turn project plans into actions and concrete results. The project objectives aim at solving Zimbabwe’s complex issues of a security and civic nature, hence use of big data, open access and open science platforms is being adopted.

3.4.3 SYMPOSIA

RCZ organises biennial symposia to provide platform for showcasing research outputs, dissemination, documentation and popularising research. The symposia enable the ecosystem of Zimbabwe to receive new scientific knowledge. Knowledge is used to inform decision making, and development of goods and services. RCZ previously held the 11th Zimbabwe International Research Symposium (ZIRS) under the theme Research for Unlocking Entrepreneurship: Bridging the Gap, in February 2017. The colloquium bridged the research-entrepreneur gap. As key players in the economy, entrepreneurs increasingly need to acquire new knowledge for innovation. Symposia enable players in the ecosystem to keep abreast with new developments in RIE. For example the vitality of big data, open access and open science in relationship with their current endeavours. In the process, entrepreneurs can find niches. RCZ promotes uptake of research findings as well as transformative innovations by the whole ecosystem. The 12th ZIRS, theme “The Nexus between Research, Industry and Development: Key to Innovation and Sustainable Development”, is a step towards achieving innovative entrepreneurial transformation in the RIE ecosystem of Zimbabwe.

3. DISCUSSION

The RIE Ecosystem of Zimbabwe is mirrored through the NSTI system. The NSTI system has mapped the players involved and their connections established (GoZ, 2012). The Doctrine to Guide the Translation of the Vision 2030 and the Transitional Stabilisation Programme in Higher and Tertiary Education, Science and Technology Development 5.0 reiterates the RIE ecosystem of Zimbabwe as enshrined in the Zimbabwe NSTIS. However, that alone has not guaranteed harmonious interaction of the stakeholders in the RIE ecosystem. The findings showed that there
are complex relationships among players, and knowledge flow is not well defined. Coherence in the system is still to be achieved. This does not resonate well with the national Vision 2030 of modernising and industrialising Zimbabwe (GoZ, 2018) due to interaction complexities in the RIE ecosystem. United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP, 2016) posits that at national level, there are complex STI systems of knowledge links among the private sector, public research organisations, government regulatory agencies, financial institutions and academia working toward innovation and technological change. Capacity and performance of the country, however, heavily depends on the strength of the NSTI and RIE systems. Dynamic and effective interaction among various STI has far reaching benefits for innovative and entrepreneurial societies like Zimbabwe.

Knowledge generators were found to have a weak connection with the industry, especially entrepreneurs. Public leaders do not fully appreciate the benefits or spill-overs derived from RIE. Isenberg (2011) notes that public support for entrepreneurship is generally low due to lack of full understanding. Research and Development institutions are expected to view themselves as knowledge and service providers in the context of proffering solutions to address developmental needs. Efforts should be made towards harnessing resources to strengthen the linkages. Elements of mistrust within the RIE ecosystem were noted. The reason is not yet clear, but could be attributed to the current national IP Policies and proprietary rights of the outputs, technologies, and commercialisation, which are not well defined. IP and proprietary rights are clear internationally. The Berne Convention contains a rule known as the ‘lex loci protectionis’. Within this rule, protection can be claimed (Publishing Research Consortium: PRC, 2015). Copyrights are human rights, as articulated in section 27(2) of the Universal Declaration of Human Rights. Copyrights, like the law of patents and trade secrets, copyright protects intangible assets and creations of the human mind. They protect the moral and material interests from originators of knowledge’s scientific, literary or artistic production. Without IP protection, mistrust is inevitable.

Trust is a social capital which has to be invested in, for socio-economic development. Trust refers to mutual faithfulness (Lewis & Weigert, 1985). The term faithfulness was borrowed from Simmel’s (1964) sociological work. It is a multi-layered concept. It encompasses attributes such as dependability, credibility, faithfulness, information sharing, and the expectation of cooperation between partners (Lamothe & Lamothe, 2011). Trust is the cornerstone of all socio-economic relationships. From a sociological perspective, trust is a precondition for a functional society. The alternative for trust is chaos and paralysing fear (Luhmann, 1979).

Effective knowledge flow in the RIE ecosystem was also affected by low investment in R&D. There is improved political commitment as enshrined in the STI Policy for supporting R&D to at least 1% of the GDP. For some time this had remained a commitment without the real allocation of funding in the budgets, but the 2019 Zimbabwe National Budget has been a turning point. Watkins and Mandell (2010) posit that, STI systems of most African countries find themselves in a vicious cycle, with low funding to support high quality socio-economic supportive R&D programmes as well as institutions. The link between knowledge generators and entrepreneurship is enhanced if the former is well funded. Heavy reliance on restricted funding from development partners has a negative implication. Isolation of STI efforts from the national economic agendas result in little mass impact (ACR, 2017). Funding research should be viewed as investment.
RCZ is strategically positioned to facilitate Zimbabwe achieve a knowledge-based economy by breaking down silos and putting up research infrastructures, supportive technical and professional competencies, connected to entrepreneurship and a conducive policy environment for STI. RCZ in its budget lines has proactively placed access to big data, open access and open science platforms as a strategic investment to achieve a knowledge-based economy. The status quo performance within the global RIE ecosystem is not generating sufficient economic growth, or an improvement in human development indicators (Hassall, 2018).

RCZ has come up with strategies to strengthen the linkages of the STI ecosystem in Zimbabwe and connecting the dots. Linking SIRDC and IDCZ was an important step in unlocking value from local innovation efforts and building local capacity (Muzite et al., 2017). Adopting the Rapid Results Approach (RRA) in the STI programs implementation is a result oriented development with tried and tested monitoring and evaluation for outcomes. RCZ dedicated the whole symposium (12th ZIRS) on strengthening the nexus between research, innovation and entrepreneurship as a strategy. Further, RCZ is crafting strategies to be the host for the national open science hub within the region. This will be cutting-edge for transformative innovations to become a reality, nationally initially and then regionally.

The relationship between economic growth models, technological change, and RIE is close (Sener and Sarıdoğan, 2011). Research breeds innovation. Innovations improve entrepreneurship which conversely turns around the economy, by way of low production costs, and improved products and services. Vibrant entrepreneurship creates employment and improves the citizens’ incomes and livelihoods. By definition, research is any systematic, critical or scientific study of, or inquiry into, any subject or matter for the extension of knowledge (Research Act Chapter 10:22). Innovation is implementation of a new or significantly improved product (good or service) or a process, a new marketing and an organisational method in business practices (OECD and European Union Statistical Office: Eurostat, 2005). There are complex relationships among research, innovation and entrepreneurship. The relationship requires a multi-disciplinary approach in attempts to realise the potential in RIE. Understanding the complex relationships in the RIE ecosystem of Zimbabwe promotes transformative innovation for improved entrepreneurship. RIE ecosystem is indeed a response to the ineffectiveness of existing approaches to stimulate high growth enterprises (Mason and Brown, 2014). The idea of high growth enterprises focuses on more holistic activities such as development networks, priorities alignment, building new institutional capacities and fostering synergies among stakeholders (Rodriguez-Pose, 2013; Warwick, 2013). These activities promote transformative innovations.

Transformative innovations have great potential to accelerate resource efficiency, increase resilient economies, and achieve Sustainable Development Goals (Attri, 2016). Transformative innovations have some spill-over effects in the form of creation of new jobs, new technologies and improved incomes to the citizens. Transformative RIE ecosystem is only possible in the presence of a strong STI system. The two systems have a symbiotic relationship. They operate within and through each other. This is where some of the complexities lie. Promoting a RIE ecosystem is incomplete without full consideration of the STI system. Countries with low STI capabilities have tremendous constraints in mobilising financial resources (UN, 2015). STI capabilities can be improved through investing in worldwide digital connectivity for accessing big and open data. The worldwide digital connectivity system uses the World-Wide Web platformDigital information networks are parts of the dots in the RIE ecosystem, which require
unlocking and connecting. ICSU (2015) posits that, “the great promise of big data remains remote for many less affluent countries and especially for the least developed countries”. This is one of the bottlenecks that need to be attended to. RCZ in its wisdom has made some budgetary commitments to break this seemingly glass ceiling.

In order to connect the dots in the RIE ecosystem, there is need for strategies to access and utilise big data as well participate in open science platforms. Open science raises awareness to and for demanding access to big data in which scientific discovery and transformative innovations are hidden. Bottlenecks exist in the form of legal barriers such as copyright licenses. Nevertheless, open science platforms are an opportunity to influence impact on a large scale. The platforms make data accessible in an affordable manner by availing costly infrastructure openly for shared use by scientists. RCZ as one of the Science Granting Research Councils in Africa endeavours to play a critical role in networking, knowledge generators to advance open science in Zimbabwe.

Dealing with the data platforms enables designing and funding science within multi-disciplinary, interdisciplinary and trans-disciplinary models become a reality. Choi and Pak (2006) define multi-disciplinarity as drawing on knowledge from different disciplines but stays within their boundaries, whilst inter-disciplinarity analyzes, synthesizes and harmonizes links between disciplines into a coordinated and coherent whole. On the other hand, trans-disciplinarity integrates natural, social and health sciences in a humanities context, and transcends their traditional boundaries. The RIE ecosystem of Zimbabwe needs the three models oriented researches for use, now and into the unforeseeable future. ICSU (2018) is putting measures in place to become the international community’s leader in breaking research disciplinary boundaries. As part of the Scientific Granting Councils Initiative (SGCI), RCZ is also participating in generation and application of the three models oriented knowledge, through apportionment of research funds, to fulfill the current social contract between science and society. Nationally, Zimbabwe has developed several dotted initiatives to nurture the nexus between research, innovation and entrepreneurship. The different models will be used as appropriate.

The work by other players is also relevant. The then Ministry of Science and Technology produced the Second Science, Technology and Innovation Policy in 2012. The Ministry of Industry and Commerce through the Industrial Development Policy (2010-2016) envisages transforming Zimbabwe from a producer of primary goods, into a producer of processed value-added goods for both the domestic and export market. Promotion of viable industrial and commercial sectors is the success ingredient. Technology Transfer and R&D are fundamental strategies recognised by the policy, as having potential for supporting socio-economic growth and development. The Ministry of Small to Medium Enterprises and Cooperative Development (MSMECD) was created in 2002 to promote the development of the entrepreneurship sector. RCZ is well placed to coordinate RIE as a means to connect and link the various Government departments and Ministries that are part of the ecosystem. SMEs are an important sector in the Zimbabwean economy due to their provision of employment and contribution to the GDP (Chidamoyo and Dumba, 2012). They contribute in alleviation of poverty GoZ (2012). SMEs also provide opportunity for women and youth to participate in the mainstream economy. Government has initiated the formalisation process of the SMEs sector which was largely informal with the view of harnessing their potential in the mainstream economy. Isenberg (2010)
gives a case of Rwanda’s business revolution, whose popularity has turned from a genocide nation of the 1990s to one of the fastest growing economies in recent years.

Despite the well-crafted policy and legal environment to support RIE, there are still significant bottlenecks. ICSU (2017) affirms this by noting that the emerging trends in data sharing and publication, open access to, and reuse of data are yielding positive signs of an evolving research environment but, cultural and technological difficulties prevent the research community from realising full benefits. Limited funding and resources for R&D, critical technical skills and weak linkages of players in the ecosystem are hindrances as well (Africa Capacity Building Foundation: ACBF, 2017). In its Africa Capacity Report 2017, ACBF established that underdevelopment in Africa is closely linked to limited capacity to deploy STI for inclusive sustainable development and transformation.

Although RIE are increasingly acknowledged as key forces for transformation, the linkages are too complex to understand and warrant bold leadership to break the seemingly silos rocking the players in the ecosystem in Zimbabwe. RCZ is strategically positioned to facilitate interaction and connections of different players in the Zimbabwe RIE ecosystem. This paper seeks to explore and share the efforts which have been initiated by RCZ to ensure a vibrant RIE ecosystem of Zimbabwe.

4. CONCLUSIONS
Connecting the dots and building strong linkages among players in the Research, Innovation and Entrepreneurial (RIE) Ecosystem is imperative. Research and innovation are stimuli for entrepreneurial growth. Connecting the dots in the RIE ecosystem of Zimbabwe and implementing informed innovation value chains has long term benefits, in the form of employment creation, attracting investors and sustainable livelihoods of communities. RIE is the principal factor for Zimbabwe’s survival in today’s fast changing and highly competitive Information and Communications Technology (ICT) driven global business world. Understanding innovation value chains through use of big data, open access and open science is required. RCZ is mandated to coordinate knowledge systems. Big data and open science are part of the knowledge systems. RCZ has already played its part in the promotion of ICT, biotechnology, nanotechnology and space science. In order to reap full benefit, access to big data and participation of researchers, innovators and entrepreneurs in the knowledge world is important. Further, comprehending innovation concepts and value chains enables multiple connections throughout the entire RIE ecosystems. RCZ is well positioned to connect the dots in the Zimbabwean RIE ecosystem by virtue of its mandate, as well as its networks with the external environment. RCZ is ready to promote, assist and encourage research results uptake by small and emerging entrepreneurs for creation of new goods and services. Investing in the RIE ecosystems reduces costs, re-organises and improves the ecosystem's networks, develops new systems, generates acceptance and implementation of new ideas, processes, products or services for Zimbabwe’s prosperity. The aim is to make most use of talent among the citizens, meet the changing needs of society and keep abreast with the competitive regional and global market trends. RCZ is already connected to regional, international and global networks. Synergies are required as they afford opportunity for small and emerging entrepreneurs to penetrate the traditional markets reserved for big players or bring about entry into new ones. Growth in this frame will deliver the socio-economic transformation sought. Also, synergies
intensify visibility of talent, business potential and investment opportunities in and outside the
Zimbabwean RIE ecosystem. Using its networks and knowledge of big data, open access and
open science platforms RCZ coordinates articulation of research needs identified within the dots
of the Zimbabwean ecosystem and foster investment in addressing those needs. The dots in the
form of researchers, innovators, entrepreneurs, regulators, investors and community members
must be proactive in the utilisation of big data, open access and open science. Quest for effective
strategies to bring vibrancy in the Zimbabwean RIE ecosystem is a realistic and required goal.
Vibrancy can be achieved by facilitating public lecture series, harnessing and utilization of open
science and big data programmes. RCZ is aware that opportunities exist in big data, open access
and open science platforms. Researchers, innovators and entrepreneurs, by participating in
knowledge platforms, will discover niches for themselves. New businesses, services, inventions
and fields can be discovered, pursued and absorbed. RIE aims to radically change products using
inventions or applying advantages of technology that may not have been previously used in
production. The national mantra “Zimbabwe is Open for Business” must come alive.

RCZ promotes smart partnerships in the RIE ecosystems through administration of grants,
linking emerging and seasoned entrepreneurs. RCZ also invites investors and renowned
entrepreneurs biennially, to participate and showcase innovative entrepreneurship programmes
through the Zimbabwe International Research Symposiums (ZIRS). RCZ has capacity to
coordinate and source funding for more platforms of a related nature. In these platforms
academics, researchers, industrialists, entrepreneurs, regulators and others exchange ideas and
fill in research and development gaps. Inventions, prototypes and innovations being done by
small industries, in areas such as Magaba in Mbare, Harare can, benefit immensely from
mainstream science and technology.

Continuous engagement leading to understanding the importance of strong linkages and then
performing within the ecosystem for achieving a sustainable socio-economic transformation is
an imperative. RCZ’s role is to facilitate removing silos within the RIE ecosystems of Zimbabwe.
RCZ cooperates with various stakeholders and coordinates public awareness programmes on the
importance of strong linkages within the ecosystem for sustainable development. RCZ has the
broader watching briefs into the big data world, open access and open science development to
connect the whole RIE ecosystem of Zimbabwe. The long term impact is unlimited opportunities
viz existing natural, technological, material and human resources. Strong linkages make every
member of the ecosystem a stakeholder, rather than mere customers or consumers of new
products, services and knowledge.

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PRESENTED PAPERS

1. SOCIAL SCIENCES AND HUMANITIES

DETERMINANTS OF INTENSITY CONSUMPTION OF SELECTED
INDIGENOUS VEGETABLES IN ZIMBABWE

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ABSTRACT

Indigenous vegetables has been of high significance in rural diets, however the determinants and consumption patterns has been historically overlooked. This study, based in Wedza district, Mashonaland East Zimbabwe seeks to examine the socio-economic factors that influence intensity consumption of indigenous vegetables during and after the growing season. Data were collected from 54 households using the questionnaire as the main tool. Triangulation was done using focus group discussions and observations. The logit regression model was used to analyse the data. Results revealed that gender and income had a significant (p<0.05) influence on intensity of consumption during the growing season only. Age, education level and market options had a significant (p<0.05) influence during and after growing seasons. Hence, socio-economic factors influence intensity consumption of indigenous vegetables during and after the growing season. It is recommended that households integrate modern food technologies and indigenous knowledge to improve consumption of indigenous vegetables.

Key words: indigenous vegetables, consumption intensity, socio-economic
1. INTRODUCTION

Indigenous vegetables have an important role in food and nutritional security of households. They offer a potential to diversify food sources among both rural and urban families, resulting in health families (12,36). These qualities make them a potentially affordable source of food, and essential nutrients for most of the population in both rural and urban areas (12,44).

Therefore they provide critical support to food shortages, insurance against drought and crop failure. (38) Highlighted that rural and urban households utilize indigenous vegetables, at least for its use and own food production. They provide nutritional elements such as proteins, Vitamin A, C and iron which are essential for human growth and development, (43,1,26,13,23).

Naturally Zimbabwe has been endowed with a variety of indigenous vegetables that can proliferate diversity to rural households food and nutritional sources (34). Throughout history, these vegetables have been playing a significant role in risk management strategies for rural households. They grow under various conditions such as road side, disturbed agricultural lands, and backyards with minimum to no management. Their food availability potential varies with region, socio economic factors and seasons. (36) Observed that many African households have been mainly growing indigenous vegetables in the rural set up chiefly for feeding the family.

Presently, Zimbabwean women are involved in gathering of these vegetables from the wild or in the fields. Notably, this has contributed to nutritional and food availability for urban and rural population. There is a growing awareness and increasing emphasis on the need to unlock the potential of indigenous vegetables to food and nutritional security (29,39). Despite this, little information is known on specific consumption patterns and factors that influence the patterns. This study aims to fill this gap by evaluating the determinants that influence intensity consumption of indigenous vegetables to households in Wedza rural community. Specific attention is made to three selected indigenous vegetables namely pumpkin leaves, cowpea leaves and spider flower.

1.1 OBJECTIVES
To evaluate social and economic factors that influence the intensity consumption of spider flower, pumpkin leaves and cowpea leaves.

2. METHODOLOGY

The study was conducted in Wedza district. It is one of the nine districts in Mashonaland East Province. The area lies in region 2b of the agro ecological zones of Zimbabwe and lies about 50 km south of Marondera town and 127 km south of Harare. Rainfall pattern in this district is diverse and it ranges from less than an annual average of 600mm to 800mm. The district has 15 wards. Ward 3, 5, 6 were selected for the purpose of study. The three wards were opted because they are well known of intensive cropping activities. These wards have an average population of 1451 households with an average of 38 households per village.

2.1 Research design and sampling technique

The study employed the survey research design because it is regarded as the best method to collect original data for the aim of describing a situation which is too large to observe (10). The survey research was therefore the best since it entails gathering of raw information from a representative sample of a communal household in Wedza.

Probability and non-probability methods were used to delineate the sample. (14) Define probability sampling as a method in which all members of the population have an equal chance of being chosen. Multi stage sampling, purposive and random sampling were employed.
2.2 DATA COLLECTION AND ANALYSIS

A structured questionnaire and Focus Group Discussion (FDG) guide were used to collect data through face to face interactions. A questionnaire is a document consisting of items to solicit information from a participant that is suitable for research analysis (10). After completing data collection on socio-economic factor, FDGs composed of six members were conducted to validate some data collected from farmers.

FDGs also aided in obtaining insights into target audience perceptions, needs, available knowledge, problems, beliefs and reasons for certain practices. The collected data was used to validate the research questions and objectives. Data were manipulated using SPSS 22 and STATA 13 logit based analyses.

2.3 LOGIT REGRESSION MODELING

In the context of this study intensity of consumption was defined as the frequency of consuming any of the three selected indigenous vegetables in a week. A censoring point of 50% was established with households consuming the vegetables for times below the threshold being defined as non-intensive consumers. This definition created a binary dependent variable since any household would either be an intensive or non-intensive consumer. The specification of the logit model (derived from the logistic regression function) allowed for the determination of the determinants of the intensity of consumption decision (37). The likelihood of observing the dependent variable \( P_i \) was tested as a function of variables which include age, education and gender of household head. Therefore:

\[
P_i = \Pr(Y_i = 1) = \frac{\exp(Z)}{1+\exp(Z)} \quad \text{..................................................} (1)
\]
The natural log transformation of (1) results in (2):

$$\ln \left( \frac{P_i}{1-P_i} \right) = \beta_0 + \sum_{i} \beta_i X_i + \mu_i \quad \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots 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\cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdOTS
3. RESULTS AND DISCUSSION

Determinants of intensive consumption of indigenous vegetables

Table 1 shows results for intensity of consumption of indigenous vegetables during growing season of indigenous vegetables (November to March) and after growing season (April to October).

TABLE 1: LOGIT REGRESSION MODEL RESULTS

<table>
<thead>
<tr>
<th>Variables</th>
<th>Regression Coefficient</th>
<th>During growing season</th>
<th>After growing season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age of household head</td>
<td>0.024** (0.034)</td>
<td>0.011** (0.057)</td>
<td></td>
</tr>
<tr>
<td>Upbringing</td>
<td>-0.266 (0.752)</td>
<td>-0.345 (0.168)</td>
<td></td>
</tr>
<tr>
<td>Household education</td>
<td>0.255** (0.365)</td>
<td>0.197*** (0.477)</td>
<td></td>
</tr>
<tr>
<td>Gender of household</td>
<td>1.446** (0.811)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household size</td>
<td>0.177 (0.183)</td>
<td>0.217 (0.263)</td>
<td></td>
</tr>
<tr>
<td>Livelihood source</td>
<td>-0.207 (0.793)</td>
<td>0.561 (1.321)</td>
<td></td>
</tr>
<tr>
<td>Monthly income</td>
<td>-0.006** (0.004)</td>
<td>-0.005 (0.007)</td>
<td></td>
</tr>
<tr>
<td>Landholding size</td>
<td>-0.024 (0.278)</td>
<td>-0.306* (0.465)</td>
<td></td>
</tr>
<tr>
<td>Market options</td>
<td>0.894** (0.698)</td>
<td>1.606 (1.240)</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-3.823 (3.430)</td>
<td>-4.248 (4.905)</td>
<td></td>
</tr>
</tbody>
</table>

Source: Generated by authors from 2017 survey data using STATA.
Notes: *; ** and *** indicate p-values significant at 1 %, 5 % and 10 % levels respectively.
-Standard error for each estimate is placed in parenthesis.
The operational models for intensity of consumption are:

**During growing season**

\[-3.823 + 0.024 \text{ age} - 0.027 \text{ upbringing} + 0.255 \text{ education} + 1.446 \text{ gender} + 0.177 \text{ household size} - 0.207 \text{ livelihood} - 0.006 \text{ income} - 0.024 \text{ landsize} + 0.894 \text{ market}\]

**After growing season**

\[-4.248 + 0.011 \text{ age} - 0.345 \text{ upbringing} + 0.197 \text{ education} + 0.217 \text{ household size} + 0.561 \text{ livelihood} - 0.005 \text{ income} - 0.306 \text{ landsize} + 0.606 \text{ market}\]

Out of nine factors that were hypothesized to have an influence on intensity consumption of indigenous vegetables during the growing season, five were found to be significant (p<0.05). Results in Table 1 indicate that out of nine factors hypothesized to have an influence on intensity of consumption after growing season three were found to be significant.

Age is one of the factors which were found to have a positive and significant influence on intensity of consumption both during and after growing season. This is explained by the fact that, age affects efficiency of carrying out farm activities and is also associated with experiences in farming practices over time.

According to (35), the age variable is critical for enhancing agricultural production. Although experience comes with years of practice is important, young decision makers can also make more informed decisions since they are more networked. More food and nutritional security oriented production activities could be engaged by the younger respondents’ hence higher productivity.

However, in some studies carried out in South Africa (15,42) the younger age was said to be influenced by modernization and globalization. There is likelihood that they would therefore shun indigenous vegetables and prefer exotic vegetables. (41) Also argued that age has an impact on food choices and preferences as guided by taste perceptions. Therefore in light of
this; we observe that older people tend to consume more of indigenous vegetables than the younger counterparts.

Education level of the farmer was also significant hence, was seen to contribute to the decision to consume indigenous vegetables both during the growing and after the growing season. This was similar to a study that was conducted in Nigeria (35) which revealed that those who attained higher education status tend to consume and produce more indigenous vegetables. This, they attributed to their human capital status hence the ability to acquire and process knowledge on several aspects of indigenous vegetables such as agronomy, nutritive value, marketing strategies before embarking on production.

Gender of household head was positive and significant, which is strong relationship during the growing season of indigenous vegetables but was insignificant after the growing season of indigenous vegetables. During the growing season of indigenous vegetables, it is explained by the fact that, due to the patriarchal nature of the culture, gender of household head is very important in deciding types of crops to be grown and dishes consumed by a household. Studies revealed that in African society’s males are dominant in decisions regarding agricultural activities as compared to female. The latter sex are not entirely left out and they serve as helping hands in harvesting and processing of produce (29). However, after the growing season gender was found to be insignificant and this is explained by the fact that during this period food options are limited. Therefore, most households will be consuming previously dried vegetables since they will be out of season hence the decision to cook is normally made by women.

Household monthly income was another economic factor that was negative and significant during the growing season of indigenous vegetables but insignificant after growing season. The variable can determine decisions including dishes that household frequently consume (20). According to,(7,33) low income households and household who work as farm workers consume indigenous vegetables due to limited food options. This observation contradicts with
who revealed that high income status people were seen to be potential buyers and consumers of indigenous vegetables in Kenya.

This is explained by the fact that although higher income earners are associated with diversifying their diets, they are not much aware about indigenous knowledge on healthy diets hence they consume less of indigenous vegetables. Therefore, low income earners have been seen consuming more indigenous vegetables in this study. However, after the growing season the household income was both negative and insignificant. This was explained by the fact that since the households do post-harvest technology of drying indigenous vegetables during the growing season and very limited families grew indigenous vegetables after growing. This reflects shortages of indigenous vegetables after the main growing season. As such, monthly income of a household became irrelevant in decisions of a household to consume indigenous vegetables.

The estimated coefficient for household land holding size was negative and insignificant during the growing season of indigenous vegetables and negative but significant after the growing season. This is explained by the fact that in this study land was not an important factor during the growing season of indigenous vegetables since indigenous vegetables were cropped in mixed cropping or intercropping. After the growing season, what is observed to be explained by the fact that after growing season, production of indigenous vegetables is carried out in protected areas which are near water sources for irrigation hence land was significant after growing season of indigenous vegetables.

In this regard, as also reported by (28) who noted that landholding size influences intensity consumption of indigenous vegetables. This is similar to (9) who revealed that household land holding size is critical to agricultural production. In their study conducted in Nigeria, they reported that households with access to land may be able to augment income from a number of small scale farming activities with income from alternative sources. Similarly, (5) revealed that households with larger pieces of land can produce indigenous vegetables both for consumption and for sale.
Market options are highly significant during growing season of indigenous vegetables. This is explained by the fact that market options such as roadside, local growth point/shops and neighbours are convenient to the consumer hence intensity of consumption is high. Distance and other transaction costs associated with accessing the vegetables will be also reduced thereby incentivizing intensive consumption. This is similar to study carried out by (27) in Limpopo province which indicated that sell of indigenous vegetables was highly among roadside, local shops/growth points and neighbours.

![CONSUMPTION PATTERNS](image)

**Figure 1: Consumption of indigenous vegetables during and after growing season**
3.1 CONSUMPTION OF INDIGENOUS VEGETABLES DURING AND AFTER GROWING SEASON

Figure 1 above shows the percentage consumption of indigenous vegetables during and after growing season in the study area. All the sampled households indicated the availability of indigenous vegetables during the growing season hence high consumption and food secure. The variation in intensity consumption and availability was due to differences in the type they prefer. This implies that they are different species of indigenous vegetables which household prefer most and expected to make them food secure. This findings confirms with (29) that availability and consumption of indigenous vegetables offer great promise for household producers in the informal economy.

(14) Reported that native African vegetables are not well researched and documented. The three isolated in this study proved to have potential food and economic benefits. In Kenya and Nigeria there is promotion of local cultivation, conservation of many indigenous vegetable species, especially those facing genetic erosion. Borrowing from successful experiences in other parts of Africa, the levels of consumption in Wedza can be increased if indigenous vegetables are commercialized to enhance consumption, household food availability during and after the growing seasons.

4. CONCLUSIONS

From the study, a conclusion that several socio-economic factors influence intensity of consumption during and after the growing season can be made. During and after the growing season, these are age and education level during the growing season and after the growing season. Gender and income and market options had an influence during the season only. The apriori hypothesis made was therefore not rejected in this case. Although food availability varies among region, it is one of the three pillars of food
security. This context indicated that there was availability of indigenous vegetables both during and after growing season but more abundant during growing season. Therefore, high consumption rate in summer resulting in households being food, nutrition and food secure.

5. RECOMMENDATIONS
Based on the study findings, the research output recommends the following:

- Integration of modern food technologies and indigenous knowledge to improve production and consumption of indigenous vegetables. The integration of modern technologies and indigenous knowledge will allow improvement of consumption of indigenous vegetables hence will enhance market and participation by young people in the mainstream.

- Awareness campaigns on the benefits and business potential of indigenous vegetables to both rural and urban households is essential. The main focus of campaign should incorporate recruitment of youth to agriculture and further incorporate indigenous vegetables in the agriculture school curricula. This will facilitate a change to negative perception of young people towards indigenous vegetables hence they can frequently consume indigenous vegetables. In addition, this will initiate indigenous vegetables to enter into the food systems.

- There is need to encourage the formation of a well local oriented formal institutions that will also discuss issues associated with indigenous vegetables. This will organise households into groups and treat their farming of indigenous vegetables as a guarantee for food and nutritional security.

- A number of stakeholders such as the health sector need to be involved in the development stage of awareness of these vegetables. Food industry should also be involved so that they will come up with different recipes of preparing indigenous vegetables and this will assist to introduce an appealing product into the market, the product that will be highly demanded rather than be forcing a product into customers. Further research should be done on other alternative uses.

These efforts should facilitate high intensity consumption of indigenous vegetables since the study shows that they have contributed significantly to food and nutritional security.
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RELEVANT SCIENCE EDUCATION AS A KEY FACTOR TO FIGHT YOUTH UNEMPLOYMENT: A CASE OF BULAWAYO METROPOLITAN PROVINCE.

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Abstract
Just like most developing countries, Zimbabwe is faced with a daunting challenge of dealing with the scourge of youth unemployment. This challenge is exacerbated by the shutting down of companies and relocation of industries. This study sought to explore relevant science education as a key factor to fight youth unemployment. The study employed a mixed-method research approach and data were collected through questionnaires and generated through interviews and focussed group discussions. A purposive sample of 100 unemployed science graduates and 20 science educators participated in this study. The qualitative data from open-ended questions in questionnaires, interviews and focus group discussions were analysed thematically. Research findings revealed that the outgoing Ordinary Level science syllabi did not lay a firm science foundation which gives birth to graduates who are employment generators. The study also revealed that equipping learners with relevant science skills enables the graduates to be employment generators. The researchers recommended that the school science curriculum should be practical-oriented so as to make the graduates more relevant to the needs of the society and industry. The researchers further recommend that the government of Zimbabwe should ensure that the updated science curriculum should be fully implemented so as to produce science graduates will desirable skills for the industry.

Keywords: unemployment, relevant science education, science graduates; youth, updated science curriculum
1.1. INTRODUCTION

Youth unemployment is a global challenge especially to developing countries like Zimbabwe. The collapse of the economy in 2008 further aggravated the youth job crisis in Zimbabwe as well as in Bulawayo. (13) states that Zimbabwe has the highest unemployment rate in the world, with unemployment rate of over 90%. According to (4), 190 million people were unemployed in the world. The causes of unemployment in Zimbabwe are manifold including the incompatibility of secondary school science education with needs of the society and industry. In the same vein, (6) pointed out that curriculum mismatch has been singled out as a key driver of youth unemployment. The outgoing science curriculum for secondary schools was too theoretical and did not prepare the learners for after school life upon the completion of their education. The outgoing secondary school science syllabi assessed practical skills mainly through an alternative to practical component. It has been criticised for producing half baked science graduates who could not wire a three pin plug for example (4). Most of the unemployed youths are recipients of science education system which inadequately met the needs of society and industry (1). As noted by (3), one of the causes of unemployment in Zimbabwe is the incompatibility between the science curriculum and the needs of the industry. Previously science learning was centred on imparting theoretical knowledge. The coming of technology revolution led to the realisation that there is an urgent need to focus on hands-on skills if our graduates are to survive competitively in the global village. The school science graduates, who are products of outgoing science curriculum, have no necessary skills that are in line with the everyday needs of the society. However the updated science curriculum seeks to address this problem. Thus, for Zimbabwe to succeed in its drive to fight youth unemployment, relevant science education needs to be taken at the centre stage. Relevant science education entails science that will equip the learners with 21st century skills such as problem solving, creativity and innovation. Science should be taught and assessed correctly for them to be successful innovators in a 21st century workforce. The methods of science instruction should be practical-oriented and contextualised to meet the needs of the learner.

Bulawayo Metropolitan Province as one of the ten provinces has not been spared from the job crisis affecting young people. The youths constitute 60 percent of the total population of Bulawayo and has the highest unemployment rate (8). As a result of the unemployment rate many youths in Bulawayo have resorted to migrate to neighbouring countries like South Africa and Botswana (10). The closing down and relocating of industries has also exacerbated the problem of unemployment in Bulawayo (10). Furthermore Bulawayo being found in ecological region five where there is little rainfall and little agricultural activities, making formal employment the only source of livelihood (10).
Zimbabwean government has made numerous efforts to improve the livelihoods of youth. One of the efforts done was to create the Ministry of Youth, Indigenization and Economic Empowerment with the mandate of empowering youth economically, socially and politically (9). It sought to empower and improve the livelihoods of people through employment creation and poverty alleviation. As a nation, Zimbabwe has been working tirelessly since the collapse of the economy in 2008 to achieve youth independence and improved economic status through several reforms and programme initiatives such as Indigenization and Economic Empowerment, Kurera/Ukondla youth fund, provision of youth empowerment fund and others.

Despite these policies and programmes, youth unemployment remains a major challenge to the developmental process of the Zimbabwean economy. Youth unemployment appears to be sky-rocketing as many Zimbabwean youths lack appropriate skills that empower them after graduating from secondary school and tertiary institutions. Most youths graduate from school without the needed skills or competencies that would enable them to function effectively in today’s emerging society. Thus, it is apparent that the role of relevant science education in the creation of employment among the youths may not be overemphasized. Science education is very important to the development of any nation in the world. For example, a graduate of science education can be self employed as opined by (11). Many of the physics graduates have some knowledge of electronics that is enough for them to be able to have a little period of training as apprentices and then stand alone as electronic technician. With relevant science education many science graduates can start home industries such as making detergents, dyes, soap, and others. The importance of relevant science education cannot be over-emphasized since appropriate skills acquisition through science education could help to make science graduates to be self-reliant and improve their economic status. The study, therefore, sought to investigate the extent to which relevant science education might fight youth unemployment in Bulawayo Metropolitan province in particular and Zimbabwe at large.

1.2 PURPOSE OF THE STUDY

The purpose of this study is twofold. First, it seeks to examine the role of relevant science education in unemployment reduction and employment creation in Bulawayo Metropolitan Province. Secondly, it sought to get the science educators’ input on what could be included in the science curriculum to make it more relevant to needs of society and industry.
1.3 OBJECTIVES OF THE STUDY

The objectives of the study were to:

- examine the role of relevant science education in unemployment reduction and employment creation in Bulawayo Metro Province,
- identify the science educator’s input on what should be included in the science curriculum to make it relevant to needs of industry and society.

1.4. METHODOLOGY

The study adopted mixed-method research approach. The mixed-method approach was chosen for its ability to offset the weaknesses of both qualitative and quantitative methodologies. The mixed-method research approach provided researchers with a more complete and comprehensive understanding of the research problem than either using quantitative or qualitative approach alone. This enhanced the validity and reliability of the research. The study was based on descriptive research design. This research design was deemed appropriate as it involved the collection of extensive and cross-sectional data for the purpose of describing and interpreting an existing situation under study. The use of descriptive research design enabled the researchers to gather data about the relevant science education as key factor to fight youth unemployment.

The sample comprised 100 science graduates and 20 science educators from Reigate district in Bulawayo Metropolitan Province. The researchers employed purposive sampling technique to select the participants. This sampling technique enabled the researcher to identify certain respondents as being potentially able to provide significant data in the study. The researchers employed a combination of both primary and secondary data. Primary data were collected through questionnaires, focus group discussions and face-to-face interviews. The secondary data were generated from reports on youth unemployment rates and statistics of science graduates. The questionnaire was chosen because of its ability to reach many participants who live at widely dispersed geographical area and preserves anonymity which encourages greater honesty. The questionnaire for unemployed science graduates had both open-ended and close ended questions. (4) states that close-ended questions enabled the researchers to collect pre-determined participants’ opinion regarding the studied phenomena. The open-ended questions afforded the respondents with opportunity to express their views about how science education can reduce youth unemployment rate. The researchers also used the focus group discussions to extract qualitative data from the respondents. The focus group
discussions were a follow up of the questionnaire. This was done in order to check consistency of participant’s responses and for clarification of some responses from the questionnaires.

The questionnaire’s reliability was tested using the Cronbach’s alpha coefficient. The degree of internal consistency of a questionnaire gave a Cronbach’s Alpha coefficient of 0.76. Hence the questionnaire was deemed reliable for this study. To ensure validity of the research tools used in the study, two expects from the department of research at the college assessed the face validity of the instruments and the corrections were made accordingly before the instruments were finally used in the study. The questionnaire was pilot tested using five science graduates who were not part of sample for the study. This allowed the researchers to redesign some questions that brought ambiguity before the actual study. Assurance of anonymity and confidentiality was given to the participants before administering the questionnaire, conducting interviews and focus group discussions. Four focus group discussions were done each with 8-10 participants. The use of multiple data collection instruments allowed cross method triangulation. Quantitative data from close-ended questions in the questionnaires were analyzed through descriptive statistics using frequencies and percentages. Responses from focus group discussions were analyzed through constant content analysis culminating into emerging themes.

1.5. FINDINGS AND DISCUSSIONS

This section will discuss the results obtained from collected and generated data so as to shed light on the relevant science education as key factor to fight youth unemployment.

Table 1. Highest qualification obtained by unemployed Science graduates

<table>
<thead>
<tr>
<th>Highest qualification</th>
<th>Frequency</th>
<th>Percentage(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>“O” Level</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>“A” Level</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Diploma</td>
<td>46</td>
<td>46</td>
</tr>
<tr>
<td>Bachelor’s degree</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Table 1 above indicates that most unemployed youths had a diploma qualification (46%) followed by those with “A” Level (26%). This means that if the government of Zimbabwe is to address the high unemployment among youths, the country has to align the secondary school science curriculum with
the needs of the society and industry. The curriculum should provide hands-on and relevant learning experiences for learners. According(14), science education should not be solely the ingestion of information, but the development of skills so that students can adapt to an ever-changing world. This entails that if the graduate is not formally employed, s/he can self-employ himself or herself.

### TABLE 2. REASONS FOR BEING UNEMPLOYED

<table>
<thead>
<tr>
<th>Reasons for unemployment</th>
<th>Frequency</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Closing of Industries and Companies</td>
<td>26</td>
<td>2</td>
</tr>
<tr>
<td>2. Relocation of Industries to other towns.</td>
<td>16</td>
<td>3</td>
</tr>
<tr>
<td>3. I do not have relevant qualifications and skills required by the employer.</td>
<td>34</td>
<td>1</td>
</tr>
<tr>
<td>4. The shrinking economy</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>5. Lack of capital to start up my own business.</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>6. Family commitments</td>
<td>4</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 2 above shows the reasons given by the unemployed graduates for being the causes of their unemployment and these were mainly irrelevant science curriculum, shrinking economy, shutting down and relocation of industries. The findings show that most participants in this study blamed their unemployment on the school science curriculum they gone through in their secondary education system. They strongly agreed that science curriculum they gone through, did not prepare them fully for life after school. One of the participants said the curriculum was too theoretical and did not equip them with skills in line with the needs of the industry. The lack of appropriate qualifications and skills which suit the few jobs advertised was rated first. The third most frequently cited cause of youth unemployment was closure of companies and industries which led to retrenchment of workers. The participants also blamed their situation on the relocation of companies which has seen the few which are still open operating at low capacity.
### TABLE 3. PARTICIPANTS WHO ARE WILLING TO START THEIR OWN HOME INDUSTRIES GIVEN THE CAPITAL.

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percentage(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>YES</td>
<td>65</td>
<td>65</td>
</tr>
<tr>
<td>NO</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 3 shows that most participants were willing to start their own home industries if given the capital and empowered with relevant science skills such as detergent making, dye making, and others. This was a positive mindset since a school or college graduates should not only expect to be an employee but also to be self-employed. Science graduates who indicated that they were not willing to start their own home industries said the school science curriculum they did, did not adequately prepare them for such incidences. This is in agreement to what (14) observed, when they indicated that the Zimbabwe currently relies on developed countries such as China, Japan, Korea and Malaysia on technology despite the fact that majority of learners have done science at O-Level. The graduates could not wire a three pin plug for example. The country is importing toothpicks from China as if there are no trees in Zimbabwe. This clearly shows the inadequacy of the outgoing science syllabi in preparing the learners for the world of work. The participants further lamented that home industries had no job security since most informal employment activities were illegal in Zimbabwe. Thus they were not interested in being informally employed.

The findings from focus group discussions with science educators, revealed that most of these science graduates were not able to employ themselves because they did not have necessary skills to venture into science related informal industries. There was a skill gap and needed the science curriculum in schools and tertiary institutions to be revamped so as to be relevant to the current economic situation. The science educators participants reiterated that there is need to restructure the current school and tertiary institutions science curriculum to be practically oriented. The researchers believe that the updated science curriculum, which is incoming if implemented with practical exams, tasks and projects will produce science graduates who meet the needs of the society and industry.
1.6 CONCLUSIONS

The study investigated the role of relevant science education in fighting youth unemployment in Bulawayo Metropolitan Province. It began with the recognition that unemployment was on the rise in Bulawayo with an average of 15% in the ten years. It was noted that the secondary school outgoing science curriculum, did not promote graduates that are employment creators and who can start up home industries. The science curriculum in secondary schools and tertiary institutions promoted the graduates to be employment seekers and this posed youth unemployment problem in this period when the country’s economy is shrinking. The only way to fight the youth unemployment problem was through providing learners in schools and tertiary institutions with relevant science education. The science curriculum that equips graduates with knowledge skills and values that guarantees increased opportunities for employment creation. The updated science curriculum which is incoming if implemented as prescribed will go a long way in alleviating the unemployment problem that has threatened country’s peace and instability. The new science syllabi assesses practical skills in examinations. Relevant science education should give learners real-life skills and enhance transition from school to the world of work for many who do not proceed with further education.

1.7. RECOMMENDATIONS

Based on the study’s findings, the researchers put forth the following recommendations:

➢ The curriculum of science education should help learners develop their talents, interests and skills which would help them secure employment in various sectors of the economy and to be employment creators as well. The scope of science curriculum should not be only limited to preparing learners for employment but equip them with the relevant skills that would make them self-reliant,
➢ Science instruction should focus on teaching relevant, in demand skills that will prepare science graduates to become innovators in an ever evolving world,
➢ Science teaching should be practically-oriented as espoused by the new science syllabi for the updated curriculum and contextualized,
➢ Policymakers and science curriculum developers should ensure that instruction in science education is delivered through use of Information and Communication Technology (ICT) as it is expected in the 21st Century teaching and learning,
➢ There is urgent need to establish a healthy link between the academia and industry to ensure that graduates acquire the desirable skills needed in the labour market. Solution to Zimbabwe’s
problem of unemployment lies in making graduates acquire skills that will prepare them to be employers,

➢ The current revised/updated curriculum need to be fully embraced not to leave others things like tasks and projects. This will result in producing science graduates with practical, technical and investigative skills relevant for solving real life problems.

➢ Carrying out a science skills needs analysis audit so that science education and training respond to the needs of industry,

➢ Government to put a loan and a grant scheme in place so as to assist needy students who want to pursue science related careers.
1.8. REFERENCES.


FACTORS INFLUENCING THE ADOPTION OF INTERNET BANKING BY STUDENTS IN HIGHER EDUCATION INSTITUTIONS IN SOUTH AFRICA

ABSTRACT

The purpose of this study was to investigate factors that influence adoption of internet banking by students at a higher education institution in South Africa. The study followed a quantitative research approach using a survey method. Data was collected using self-completion questionnaires which were distributed to 373 students at the University of Fort Hare. The factors investigated included awareness, perceived usefulness, internet access, perceived risk, trust, perceived complexity and willingness to accept change. Chi-square tests were run to investigate the association between variables. The findings from this study revealed that there is no relationship between these identified factors and the adoption of internet banking by students at this higher education institution. The study concludes that there are factors other than awareness, namely perceived usefulness, internet access, perceived risk, trust, perceived complexity and willingness to accept change, that influence internet banking adoption by students. It is recommended that researchers investigate the significance of these factors in comparative studies between universities.

Key words: internet adoption, students, university, awareness, perceived usefulness, internet access, perceived risk, trust
INTRODUCTION

The evolution of computers in the 1950s brought forth an unending evolution in the world of technology. It also led to a pronounced increase in the use and importance of computers in the daily lives of individuals. Almost three-quarters of a person's daily activities presently involve the use of computers (Akhter, 2015). The internet has modified the life of humans ominously and has dominated many fields including e-commerce, e-health, to name but a few (Thiyagarajan, Aghila & Venkatesan, 2012). Organisations and individuals in different industries have gradually embraced the use of computers as a means of making their operations increasingly efficient and effective.

Banking is and always has been a highly information-intensive activity that relies heavily on information technology (IT) to acquire, process and deliver information to relevant users (Tan & Teo, 2000). From the time when the internet was introduced in 1969, its usefulness has expanded, presenting a new host of opportunities as well as threats to businesses (Tan & Teo, 2000). The expansion of internet usage has resulted in a revolution in the banking sector, that is, the introduction of internet banking services (IBS). The increase in internet use resulted in a rapid increase in online financial transactions such as money transfers, payments and credit card transactions, with studies reflecting a correlation between the frequency of financial transactions and the time spent online (Liang & Pei-Ching, 2014). Internet banking can be defined as a system that allows users to carry out banking transactions through the use of the internet. It is an integrated system that can provide customers with flexible, convenient and inexpensive platforms with integrated services of online personal banking products including online checking, savings accounts, money market accounts and so on (Chen, Hsiao & Hwang, 2012).

In as much as internet banking has a number of benefits including that it is fast, convenient, allows twenty-four hour (24hr) and worldwide access, offers a range of activities and does not require any special software, its introduction in South Africa has brought forth a range of varied reactions. As a result, its acceptance amongst the younger generation, specifically students in higher education institutions, has been somewhat affected. Awareness, perceived risk, perceived usefulness, perceived complexity, trust and customer experiences are some of the factors assumed to have contributed to the low adoption of internet banking by students in higher education institutions.

The Eastern Cape Province has been identified as one of the poorest provinces in the Republic of South Africa (Aspire, 2014). This situation, therefore, worsens the adoption of internet banking amongst students in this province. It adds two more factors to the factors affecting adoption of internet banking amongst students in higher education institutions, which are students' willingness to accept change and internet access by students.
This study, therefore, sought to investigate factors that influence or determine the adoption of internet banking amongst the students in higher education institutions in the Eastern Cape Province, with specific focus on students studying at different levels of education at the University of Fort Hare. The study focused on analysing the factors such as awareness, perceived risk, willingness to accept change, perceived usefulness, internet access by students, perceived complexity, trust and computer literacy, in order to make inferences and draw conclusions on what determines the adoption of internet banking amongst students.

2 PURPOSE AND OBJECTIVES OF THE STUDY

While aiming to stay ahead in terms of operations and service delivery, commercial banks throughout the country have focused on improving their internet-based banking system operations and ensuring that they maintain customer satisfaction from their service delivery at its peak. Regardless of banks' efforts to better their internet banking services, this system has remained ignored and underused by certain customers. Akhter (2015) explained that many consumers have remained sceptical about conducting online financial transactions. The reason for this scepticism remains unknown. There is need to understand the main determinants of adoption of internet banking services (IBS) by students in higher education institutions (HEIs). HEIs are comprised of a diverse mix of students who have varying needs, opinions and perceptions. A vast number of factors exist that can influence their ability and possible willingness to accept and adopt innovative changes. Literature is available on studies which investigated some factors affecting internet banking adoption in South Africa; however, literature focusing on internet adoption by students residing and/or pursuing their studies in a rural setting is not available. This study, therefore, sought to fill this gap by focusing on students studying at the University of Fort Hare’s rural campus.

The main objective of this study was to investigate factors that influence the adoption of internet banking amongst students in HEIs in South Africa. The factors investigated in this study included awareness, perceived risk, and willingness to accept change, perceived usefulness, internet access, perceived complexity, and trust. This study is purposed with providing clarity on human behaviour, perceptions, and interpretations of technological innovations which are aimed at improving human activities by uncovering various influencers of human decisions towards these technologies.

Secondary objectives for this study were to:

- ascertain the relationship between awareness and the adoption of internet banking amongst students in higher education institutions;
- evaluate the extent to which perceived risk influences internet banking adoption amongst students in higher education institutions;
• determine the level to which individuals’ willingness to accept change impacts adoption of internet banking by students in higher education institutions;

• determine how perceived usefulness of internet banking influences its adoption by students in higher education institutions;

• determine the extent to which internet access influences internet banking adoption by students in higher education institutes;

• evaluate the relationship between perceived complexity of internet banking and its adoption by students in higher education institutions;

• determine the extent to which trust influences adoption of internet banking by students in higher education institutions.

2.1 Research hypotheses

The following were the research hypotheses of this study:

H_{01}: There is no relationship between awareness of internet banking and the adoption thereof by students in higher education institutions in South Africa.

H_{02}: There is no relationship between perceived risk of internet banking and the adoption thereof by students in higher education institutions in South Africa.

H_{03}: There is no relationship between willingness to accept change and the adoption of internet banking by students in higher education institutions in South Africa.

H_{04}: There is no relationship between perceived usefulness of internet banking and the adoption thereof by students in higher education institutions in South Africa.

H_{05}: There is no relationship between internet access and the adoption of internet banking by students in higher education institutions in South Africa.

H_{06}: There is no relationship between perceived complexity of internet banking and the adoption thereof by students in higher education institutions in South Africa.

H_{07}: There is no relationship between trust and the adoption of internet banking by students in higher education institutions in South Africa.
3 METHODOLOGY

The research study followed a quantitative research method so as to allow for attaining statistical evidence regarding the significance of each factor that was being investigated. The target population comprised all students studying at the University of Fort Hare.

A probability sampling method was used and the probability sampling procedure utilised was the simple random sampling technique. Simple random sampling is a process through which subjects in the population are randomly chosen using a random number generator or a random number table so that each person remaining in the population has the same probability of being selected for the sample (Frerichs, 2008). A sample size of 373 was selected from a population of 12000, with this figure being derived using the Raosoft sample size calculator. The sample indicator drew this sample with a 95% confidence level of accuracy predicted.

Both primary and secondary data was used, that is, data observed or collected firsthand through the direct efforts of the researcher for the purpose of aiding in the research process at hand and also data collected by other researchers for past studies similar to the study being conducted. In this study, self-administered questionnaires were designed and completed by respondents. The questionnaires were mainly composed of closed-ended questions. The Statistical Package for Social Sciences (SPSS) was used in the analysis of the data. Chi-squares tests were used to measure the association between variables.

Ethical considerations were firmly observed in this study. The ethical considerations undertaken included keeping the identities of participants completely anonymous, ensuring informed consent to participate in the study and allowing for voluntary participation in the study. Permission to conduct this research was sought from and granted by the University of Fort Hare’s Research Ethics Committee.

4 RESULTS/FINDINGS

Of the 373 questionnaires issued, a 100% response rate was obtained. Of the respondents who participated, 52% were female and 48% were male, indicating that an almost equal gender distribution was achieved. The results indicated that the majority of the respondents accessed their bank accounts and used the internet frequently. However, only 61% of the respondents revealed that they were users of internet banking. This is relevant for the study because it suggests that the decision to adopt internet banking is not necessarily influenced by students' ability to access the internet or the frequency with which they access their bank accounts.

For each hypothesis tested, the null hypothesis was not rejected. Thus, the primary null hypothesis which stated that there is no relationship between the identified factors (awareness, trust, willingness to accept change, internet access, perceived risk, perceived usefulness, and perceived complexity) and the adoption
of internet banking by students in higher education institutions in South Africa was not rejected. The relationship between the identified factors (awareness, trust, willingness to accept change, internet access, perceived risk, perceived usefulness, and perceived complexity) and internet banking adoption by students at a higher education institution in South Africa can thus be said to be statistically insignificant. The results presented below are a reflection of the tests conducted which led to the failure to reject the null hypotheses set in this study.

The chi-square test is used to test the level of association between two variables while the p-value shows the probability of observing a sample statistic as extreme as the test statistic, which in this case is the chi-square. The significance level can be viewed as a measure of expected accuracy of the results. If the p-value is less than the set significance level, the null hypothesis will be rejected, meaning whatever way the null hypothesis reads, it is viewed as being inaccurate or insignificant and therefore will be rejected. In layman terms, a low p-value suggests that the chances of finding a discrepancy between the observed and expected distribution that is at least this extreme is low as well. In this study, a 5% significance level (0.05) was used. A p-value that is less than 0.05 will result in the null hypothesis being rejected.

Hypothesis 1

H₀: There is no relationship between awareness of internet banking and the adoption thereof by students in higher education institutions in South Africa.

H₁: There is a relationship between awareness of internet banking and the adoption thereof by students in higher education institutions in South Africa.

<table>
<thead>
<tr>
<th>Table 1: Chi-square tests for hypothesis 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
</tr>
<tr>
<td>------------------------------------------</td>
</tr>
<tr>
<td>Pearson chi-square</td>
</tr>
<tr>
<td>Likelihood ratio</td>
</tr>
<tr>
<td>Linear-by-linear association</td>
</tr>
<tr>
<td>No. of valid cases</td>
</tr>
</tbody>
</table>

<sup>a</sup> 5 cells (31.3%) have an expected count of less than 5. The minimum expected count is .77.

<table>
<thead>
<tr>
<th>Table 2: Symmetric measures for hypothesis 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
</tr>
<tr>
<td>Nominal by Phi</td>
</tr>
<tr>
<td>Nominal by Cramer's V</td>
</tr>
<tr>
<td>No. of valid cases</td>
</tr>
</tbody>
</table>

The chi-square (9) = 15.914.
A p-value of 0.069 was achieved from the tests conducted. With this value being higher than the level of significance set, the null hypothesis, which states that no relationship exists between awareness and adoption of IB by students in HEIs in South Africa, could not be rejected. This reveals that the relationship between awareness and internet adoption is statistically insignificant. This contradicts findings of Satye (1999) and Nasri (2011) who stated that awareness is one of the main factors influencing adoption of any technologies, specifying that awareness is a major factor in adoption. With awareness possibly aiding in the decision to adopt IBS, this study found that adoption is not the main influence in the process of adoption.

Hypothesis 2

H₀: There is no relationship between perceived risk of internet banking and the adoption thereof by students in higher education institutions in South Africa.

H₁: There is a relationship between perceived risk of internet banking and the adoption thereof by students in higher education institutions in South Africa.

<table>
<thead>
<tr>
<th>Table 3: Chi-square tests for hypothesis 2</th>
<th>Value</th>
<th>df</th>
<th>Asymptotic significance (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson chi-square</td>
<td>.620</td>
<td>1</td>
<td>.431</td>
</tr>
<tr>
<td>Continuity correction</td>
<td>.000</td>
<td>1</td>
<td>1.000</td>
</tr>
<tr>
<td>Likelihood ratio</td>
<td>.963</td>
<td>1</td>
<td>.326</td>
</tr>
<tr>
<td>Fisher's exact test</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linear-by-linear association</td>
<td>.615</td>
<td>1</td>
<td>.433</td>
</tr>
<tr>
<td>No. of valid cases</td>
<td>147</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 4: Symmetric measures for hypothesis 2</th>
<th>Value</th>
<th>Approximate significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal by nominal phi</td>
<td>-.065</td>
<td>.431</td>
</tr>
<tr>
<td>Cramer's v</td>
<td>.065</td>
<td>.431</td>
</tr>
<tr>
<td>No. of valid cases</td>
<td>147</td>
<td></td>
</tr>
</tbody>
</table>

Upon testing the second hypothesis, a chi-square of 0.62 was achieved together with a p-value of 0.431. With the p-value being higher than the significance level set for this study, the null hypothesis in this test was not rejected. The test revealed that the relationship between perceived risk and internet banking adoption is statistically insignificant. The result from this test contradicts Chung and Paynter
(2002) who stated that consumer perceptions or fears about risk are a concern to consumers, making them a likely influence on the decision to adopt.

Hypothesis 3

H₀: There is no relationship between willingness to accept change and the adoption of internet banking by students in higher education institutions in South Africa

H₃: There is a relationship between willingness to accept change and the adoption of internet banking by students in higher education institutions in South Africa

The variable ‘willingness to accept change’ was measured using the scales ‘accessing bank accounts’ and ‘internet usage’. The reason for this decision to assess the impact that willingness to accept change has on the adoption of internet banking by students in higher education institutions in South Africa using these two scales is, individuals’ use of the internet indicates an acceptance to one form of change and hence measuring the influence of individuals’ adoption of internet banking is related to willingness to accept change. For the scale ‘accessing bank accounts’, the chi-square (3) = 1.613. P (0.656) is higher than 0.05, which is the set level of significance. This indicates that the relationship between the variables ‘internet usage’, ‘accessing bank accounts’ and internet banking adoption is statistically insignificant. This therefore means that the null hypothesis, which states that individuals’ willingness to accept change has no relationship with the adoption of internet banking by students in higher education institutions in South Africa, could not be rejected. This contradicts the results from Shacklett (2011) who established that where adoption is concerned, there is a link between internet banking adoption and willingness to accept change.

Hypothesis 4

H₀: There is no relationship between perceived usefulness of internet banking and the adoption thereof by students in higher education institutions in South Africa

H₄: There is a relationship between perceived usefulness of internet banking and the adoption thereof by students in higher education institutions in South Africa
Table 5: Chi-square tests for hypothesis 4

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>Df</th>
<th>Asymptotic significance (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson chi-square</td>
<td>1.786a</td>
<td>2</td>
<td>.409</td>
</tr>
<tr>
<td>Likelihood ratio</td>
<td>2.052</td>
<td>2</td>
<td>.358</td>
</tr>
<tr>
<td>Linear-by-linear association</td>
<td>.967</td>
<td>1</td>
<td>.326</td>
</tr>
<tr>
<td>No. of valid cases</td>
<td>147</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. 3 cells (50.0%) have an expected count of less than 5. The minimum expected count is .10.

Table 6: Symmetric measures for hypothesis 4

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>Approximate significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal by phi nominal</td>
<td>.110</td>
<td>.409</td>
</tr>
<tr>
<td>Cramer's V</td>
<td>.110</td>
<td>.409</td>
</tr>
<tr>
<td>No. of valid cases</td>
<td>147</td>
<td></td>
</tr>
</tbody>
</table>

The chi-square (2) in this test is 1.786 whilst the p-value is 0.409. As this is higher than the level of significance, the null hypothesis could not be rejected. Chung and Paynter (2002) stated that consumers who did not use the internet banking service did not feel a need to do so due to their perceptions of its usefulness – which suggested that perceived usefulness had an influence on internet banking adoption. This study therefore contradicts this notion through establishing that the relationship between perceived usefulness of internet banking and its adoption by students in higher education institutions in South Africa is statistically insignificant.

Hypothesis 5

H0: There is no relationship between internet access and the adoption of internet banking by students in higher education institutions in South Africa.

H1: There is a relationship between internet access and the adoption of internet banking by students in higher education institutions in South Africa.
Table 7: Chi-square tests for hypothesis 5

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>df</th>
<th>Asymptotic significance (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson chi-square</td>
<td>.941</td>
<td>2</td>
<td>.625</td>
</tr>
<tr>
<td>Likelihood ratio</td>
<td>1.326</td>
<td>2</td>
<td>.515</td>
</tr>
<tr>
<td>Linear-by-linear assoc.</td>
<td>.227</td>
<td>1</td>
<td>.634</td>
</tr>
<tr>
<td>No. of valid cases</td>
<td>147</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3 cells (50.0%) have an expected count of less than 5. The minimum expected count is .05.

Table 8: Symmetric measures for hypothesis 5

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>Approximate significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal by nominal phi</td>
<td>.080</td>
<td>.625</td>
</tr>
<tr>
<td>Cramer’s V</td>
<td>.080</td>
<td>.625</td>
</tr>
<tr>
<td>No. of valid cases</td>
<td>147</td>
<td></td>
</tr>
</tbody>
</table>

The chi-square (2) = 0.941. The results indicate a p-value of 0.625. As 0.625 is higher than 0.05 it means that the relationship between internet access by students in higher education institutions in South Africa and internet banking adoption is statistically insignificant. As a result, the null hypothesis, which states that there is no relationship between internet access and the adoption of internet banking by students in higher education institutions in South Africa, was not rejected.

Hypothesis 6

H₀: There is no relationship between perceived complexity of internet banking and the adoption thereof by students in higher education institutions in South Africa.

H₁: There is a relationship between perceived complexity of internet banking and the adoption thereof by students in higher education institutions in South Africa.

Perceived complexity was measured against internet banking using the scales ‘easy navigation’ and ‘ease of use’. The reason for this is that ‘easy navigation’ was used on non-users of internet banking to explain whether they would use internet banking if internet banking had easy navigation. On the other hand, ‘ease of use’ was used on users of internet banking to whether internet banking’s ease of use was one of the factors that motivated them to use it. For ‘easy navigation’, the chi-square (3) = 6.041 whilst the p-value = 0.110. With ‘ease of use’ the chi-square (3) = 2.163 whilst p-value = 0.539. This shows that the relationship between either ‘easy navigation’ or ‘ease of use’ and internet banking adoption by students in higher education...
institutions in South Africa is statistically insignificant. As a result, the null hypothesis, which states that no relationship exists between perceived complexity of internet banking and its adoption by students in higher education institutions in South Africa, was not rejected. This contradicts the work of Ndubishi and Sinti (2006) who stated that the complexity factor plays a major role in the adoption of internet banking.

Hypothesis 7

H₀: There is no relationship between trust and the adoption of internet banking by students in higher education institutions in South Africa

H₁: There is a relationship between trust and the adoption of internet banking by students in higher education institutions in South Africa

Table 9: Chi-square tests for hypothesis 7

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>df</th>
<th>Asymptotic significance (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson chi-square</td>
<td>1.794a</td>
<td>3</td>
<td>.616</td>
</tr>
<tr>
<td>Likelihood ratio</td>
<td>1.905</td>
<td>3</td>
<td>.592</td>
</tr>
<tr>
<td>Linear-by-linear association</td>
<td>.727</td>
<td>1</td>
<td>.394</td>
</tr>
<tr>
<td>No. of valid cases</td>
<td>226</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2 cells (25.0%) have an expected count of less than 5. The minimum expected count is 2.26.

Table 10: Symmetric Measures for hypothesis 7

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>Approximate significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal by nominal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>phi</td>
<td>.089</td>
<td>.616</td>
</tr>
<tr>
<td>Cramer's V</td>
<td>.089</td>
<td>.616</td>
</tr>
<tr>
<td>No. of valid cases</td>
<td>226</td>
<td></td>
</tr>
</tbody>
</table>

The chi-square (3) = 1.794. This test produced a p-value of 0.616. Since 0.616 > 0.05, which means that the relationship between trust and the adoption of internet banking by students in higher education institutions in South Africa is not statistically significant. As a result, the null hypothesis, which states that there is no relationship between trust and the adoption of internet banking by students in higher education institutions in South Africa, is not rejected. This contradicts the results provided by Suh and Han (2009) who found that trust is a factor influencing consumer banking adoption.
5 DISCUSSION

This study investigated the factors influencing adoption of IBS by students at a higher education institution in South Africa. Seven factors, namely awareness, perceived risk, willingness to accept change, perceived usefulness, internet access, perceived complexity and trust were tested against IBS adoption by HEI students. The results revealed that the relationship between the dependent variables and independent variables is statistically insignificant.

The results of this study provide a unique perspective in literature as they significantly differ from results attained in past studies that investigated IBS adoption. In a study carried out by Raza and Hanif (2013) which investigated IBS adoption in Pakistan, perceived usefulness and information of internet banking (awareness), perceived risk and security or privacy (risk) showed a more significant impact in increasing the intention of external customers rather than internal customers. This difference may be attributed to differences in geographical locations of the target population of each study.

In the South African context, Ramavhona and Mokwena (2016) conducted a study investigating factors influencing internet banking (IB) adoption in South African rural areas, where they found perceived compatibility and external variables such as awareness and security to have a significant influence on the adoption of IB in South African rural areas. Evidently, this study is similar in nature to the study conducted by Ramavhona and Mokwena (2016). This then poses questions on why the findings between these two studies are different. The target population for these studies were different. This study focused on students studying at an HEI situated in rural areas whilst the study by Ramavhona and Mokwena (2016) targeted people who live in rural areas.

Past investigations like those of Satye (1999) and Nasri (2011) established awareness as one of the main factors influencing adoption of technologies. Chung and Paynter (2002) presented the notion that perceived usefulness has an influence on IB adoption as their studies found that customers who did not use IBS did not feel a need to do so due to their perception of its usefulness. Suh and Han (2009) identified trust as a factor influencing IB adoption. The findings from the studies conducted by these researchers and this study are notably different. In this study, awareness, perceived usefulness and trust were found to have a statistically insignificant relationship with IBS adoption. The differences between the findings of these authors and those from this study are mainly due to the differences in the nature of the target population.

With this study focusing on students, the target population can be viewed as mainly consisting of youth, that is individuals aged between 18-40 years. This is often known as the ‘informed generation’. Individuals in this category or group tend to be highly informed about technologies, making awareness a less likely factor to influence their adoption of IBS, as evidenced by the results of this study. Trust and perceived
usefulness are, to a certain extent, influenced by awareness. Once these individuals are aware of the existence of a service, they often go on to gather information about the usefulness of the service and upon gaining a proper understanding of these services, are then able to decide whether or not to trust the service. In summary, the nature of the target population for this study influenced the differences between findings from this study and those of past studies.

Chung and Paynter (2002) found that consumer perceptions or fears about risk are a concern to consumers, making them a likely influence on the decision to adopt. In essence, these researchers found perceived risk to be a factor influencing adoption. Organisations offering internet-based technologies have gone the extra mile to ensure safety. Information on the measures undertaken to ensure safety of technologies is made available to all consumers. As a result, perceived risk is significantly depleted, leading to the results established in this study which revealed that the relationship between perceived risk and IB adoption is statistically insignificant.

In this study, the variable ‘willingness to accept change’ was measured using the scales ‘accessing bank accounts’ and ‘internet usage’. With perceived complexity, the scales ‘easy navigation’ and ‘ease of use’ were used. The results of the tests conducted on these variables led to a failure to reject the null hypothesis for each of these variables, indicating that no relationship exists between the variables and the adoption of IBS by HEI students. Shacklett (2011) stated that where adoption is concerned, there is a link between IB adoption and willingness to accept change, while Ndubisi and Sinti (2006) indicated that the complexity factor plays a major role in the adoption of IB. The results of this study differ from the results of these authors, likely due to the differences in scales used to measure each variable.

6 RECOMMENDATIONS AND CONCLUSIONS
The results of this study differed significantly from results of past studies on the topic of IBS adoption. The main cause of these differences was noted to be the nature of the target population for this study and the place where this study was conducted. For future researchers therefore, this study recommends conducting studies that hold constant one element that made results from this study unique and changing the other. An example of how to do this is to conduct a similar study which has students in HEIs as the target population while being conducted at different HEIs. This could provide results that could determine whether geographic location of respondents plays a part in influencing the adoption decision of IBS.

This study encountered a problem of limited variation between users and non-users of IBS. It was noted that some of the factors that motivated users to adopt were the same factors non-users indicated as being potential motivators towards the decision to adopt. For managers and marketing personnel, this study suggests ensuring uniformity in product marketing to ensure that all customers and potential customers
are made aware of the bank’s product offerings. Users of IBS indicated that awareness, for example, motivated them to adopt IBS while non-users identified awareness as a potential factor that could usher them towards the adoption decision. It is likely therefore that banks are not providing services in a uniform way or exerting marketing efforts broadly enough to cater for all clients. This result shows that banks have a tendency to keep their current customers fully informed of all new technologies they offer, whereas potential clients are exempted from this privilege. For banks seeking to increase adoption of IBS, there is thus the need to change marketing efforts to include increasing exposure of new technologies to the potential clients.

To conclude, the study investigated factors that influence the adoption of internet banking amongst students in HEIs in South Africa and has provided significant findings. This study will go a long way in influencing future studies on IBS adoption and aiding banks in modifying their marketing strategies so as to abate the adoption problem they encounter.

7 REFERENCES


Wu J. (2005). *Factors Influencing the Adoption of Internet Banking by South Africans in Ethekweni Metropolitan Region*. Durban: Masters Dissertation: Durban Institute of Technology
THE INFLUENCE OF HUMAN RESOURCES MANAGEMENT PRACTICES (HRMPS) ON SMALL MEDIUM ENTERPRISES (SMES) PERFORMANCE IN ZIMBABWE.

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ABSTRACT

The main purpose of the study was to evaluate the influence of human resources management practices (HRMPs) on Small Medium Enterprises (SMEs) performance in Zimbabwe. Many SMEs encounter serious human resource management problems. It is important to examine whether existing HRMPs are relevant to SMEs in emerging economies and decide how they are supported and challenged. In this study five hundred (500) respondents in Mashonaland West Province were used as research subjects. The study adopted a mixed method approach rooted in the pragmatist paradigm. A cross sectional survey research design was used and the sample was randomly selected from the population. Interviews and questionnaires were data collection instruments used in this study. Data was analysed using non parametric Chi-square test of independence through SPSS. Findings from this study suggested that there is evidence to suggest an association between HRMPs and SMEs performance. There was significant correlation between HRMPs and job position in the firm, the study also found a close connection between HRMPs and business strategy, where an integration and alignment between the two gave rise to a further increase in performance, in this study HRMPs of recruitment and selection is correlated to level of education of employees in SMEs leading to performance. Similar results are shown that HRMPs increases decision making and innovation which correlate with type of firm leading to performance. Findings from the study further show that there is correlation between training and development which increases performance. The study also tested the relationship between compensation management and decision making and innovation of employees in SMEs which was found to be significant. The Ministry of SMEs and Cooperative Development should organise a number of workshops and training of the owners and managers in the implementation of HRMPs. Further, the study recommends that managing and maintenance of HRMPs should be mandatory in the running of SMEs in order to improve management practices.

Key words: Human resources management practices, Small and Medium Enterprises, performance.
1 INTRODUCTION

Human resources are perceived as the most important asset of an organisation and being the base of achieving competitive advantage the influence of human resources management practices (HRMPs) is considered extremely challenging for effective organisational performance (1). (2) asserted that the increasing interest in HRMPs is due to the assumption that employees and the way they are managed are critical to the success of the firms. There is limited information on the influence of HRMPs on Small and Medium Enterprises (SMEs) performance. (3) The SMEs Act Chapter 24:12 in Zimbabwe defines SMEs as a business entity whether corporate or unincorporated, which together with any of its branches or subsidiaries is managed by one, two or more persons and carries on business predominantly in a sector or subsector of the economy. SMEs sector has grown to become a veritable engine of economic growth globally resulting in employment creation, expansion of domestic and international market as well as widening of tax base among others (4). (4) avers that SMEs provide more than 50% of productive employment in developed countries whereas in developing nations over 95% people are dependent on SMEs for employment. (5) highlighted that in Zimbabwe, there are 2, 8 million SME owners employing 2, 9 million people contributing more than 60% to GDP). HRMPs are increasingly being recognised in SMEs sector as a management system globally (6). However, it has been noted in other studies that SMEs lack performance standards, do not attract appropriately trained personnel, have poor training and compensation systems and lack employee involvement in decision making (7). (8) explored HRMPs in SMEs in Kenya and argued that microenterprises are almost an ignored area when it comes to their management. (9) exploring a similar issue of HRMPs in Malaysia SMEs noted that there existed a feasible interrelationship between HRMPs and enterprise performance within Iranian enterprises. However, (10) avers that SMEs may face the need to adopt and formalise HRMPs not because of government regulations but also from the need to stay competitive, attract and keep good employees. Furthermore, (11) asserted that the founding owner’s personality, management style and knowledge may also predetermine HRMPs and outcomes. Stenholm, (12) argue that in the case of family ownership, lack of separation between family and ownership issues may result in ambiguity of HRM systems. (12) suggested that employee ownership may require a greater emphasis on commitment and collaboration where SME infrastructure, size structure effects, growth stage, culture and management is expected to influence HRMPs. (2) alluded that the relevance of family business reflects differences in goals, attitudes and abilities of the management of the enterprise. Thus, it is assumed firm size is positively related to the adoption of HRMPs by SMEs. According to (13) employment ownership, collective labour agreement, unionization or quality standards in SMEs may be associated with the adoption of more formal HRMPs and policies, while ownership by a larger company may lead to transfer of human resources management (HRM) approaches to SMEs. The relationship between HRMPs and SMEs performance involves a complex interaction between bundles of HRM activities and outcomes (10). (14) opined that there is a link between performance and HRMPs and found a tendency for performance enhancing HRMPs to occur together, thereby creating high performance work systems. (14) argue that, because of potential complementarities between related practices, HRMPs are most conducive to performance when adopted, not in isolation, but as a system of mutually reinforcing practices. (15) found that HRMPs focused on enhancing employee commitment such as decentralised decision making, comprehensive training, salaried compensation and employee participation were related to higher performance measured by higher productivity. Increased productivity derived from human capital investments depends on the contribution of employees to a firm. Thus, the higher the potential for employee contribution in a firm the more likely the firm will invest in human capital through adopting HRMPs (8). Conversely HRMPs that focused on control, efficiency and the reduction of employee skills and discretion are associated with increased turnover (16). (8) opined that HRMPs impact positively on organisational performance when aligned with organisation’s business strategy leading to employee commitment which results in high productivity. (17) also supports the notion that business which manage
employees with more progressive HRMPs can expect to see higher operational performance as a result. Thus, it is assumed that when employees are managed with progressive HRMPs, they become more committed to their organisation. Despite the important role of HRMPs for achieving sustained competitive advantage SMEs are constrained by a number of factors in the adoption of HRMPs [18]. (19) opined that SMEs encounter problems of liabilities of newness in incorporating HRMPs in their entities and these external liabilities of newness include lack of experience, which make mobilisation and acquisition of resources difficult. (20) alluded that SMEs with scarce resources usually do not adopt formal HRMPs. While larger organisations typically have personnel or human resources management (HRM) department, SMEs require that owners and managers combine HRM function with other duties. (21) noted that family beliefs play a very important role as a hindrance in the adoption of HRMPs by SMEs. In some cases, family principles shape one’s personality and leadership qualities to a large extent. Thus it is assumed that the family can have both positive and negative influence on the way entrepreneurs run their businesses. In spite of the growing importance of the SME sector in Zimbabwe, there is a lack of understanding concerning HRMPs and SMEs performance and hence this study aims in enriching the existing body of knowledge. This recognition has influenced this study to explore the influence of HRMPs and SMEs performance in Zimbabwe.

2 Objectives

2.1.1 To analyse factors contributing to the adoption of human resources management by SMEs.

2.1.2 To evaluate the influence of human resources management practices and SMEs performance.

2.1.3 To evaluate hindrances in the adoption of human resources management practices by SMEs.

3 Method

This study adopted the cross sectional survey research design as it attempted to seek the relationship between HRMPs and SMEs performance in the context of Zimbabwe in Hurungwe District. (22) posit that surveys are specific type of field study that involves the collection of data from a sample of elements drawn from a well-defined population. In this study, respondents were selected from owners or managers of 500 SMEs located in Hurungwe District in the following sectors; whole selling, transport and service provision. This location was chosen as it consists of urban and suburban to ensure all SMEs were located in different places. For the purpose of this study, stratified random sampling method was employed to provide context for generalizing data. The type of survey used in this study was self-administered questionnaire in order to provide comfort to the respondents’ in answering the questions without the existence of an interviewer. Besides that, through this method, it reduces interview bias and interview costs.
## 4 Findings

### 4.1.1 HRMPs Adoption Frequencies

**TABLE 1 HRMPS ADOPTION FREQUENCIES**

<table>
<thead>
<tr>
<th>HRMPs Adoption Influences</th>
<th>Number</th>
<th>Percent</th>
<th>Percent of cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>173</td>
<td>18.4%</td>
<td>34.7%</td>
</tr>
<tr>
<td>Skilled personnel</td>
<td>241</td>
<td>25.6%</td>
<td>48.3%</td>
</tr>
<tr>
<td>awareness of current HRM trends</td>
<td>328</td>
<td>34.9%</td>
<td>65.7%</td>
</tr>
<tr>
<td>Company Structure</td>
<td>137</td>
<td>14.6%</td>
<td>27.5%</td>
</tr>
<tr>
<td>Regulations</td>
<td>62</td>
<td>6.6%</td>
<td>12.4%</td>
</tr>
<tr>
<td>Total</td>
<td>941</td>
<td>100.0%</td>
<td>188.6%</td>
</tr>
</tbody>
</table>

*Dichotomy group tabulated at value 1.*

*Source: SPSS Output Field Survey, 2018*

Percent of cases indicate multiple responses from respond
In this study (34.7%) respondents pointed out that HRMPs adoption was necessitated with cost to their organisation, (48.3%) pointed the availability of skilled personnel while (65.7%) noted the awareness of current HRM trends, (27.5%) were not in position to implement HRMPs due to company structure and (12.4%) indicated regulations as catalyst to adoption of HRMPs (Refer to Table 1).

4.1.1 THE INFLUENCE OF HUMAN RESOURCES MANAGEMENT PRACTICES ON SMES PERFORMANCE

Table 2 Influence of HRMPs frequencies

<table>
<thead>
<tr>
<th>HRMPs Influences</th>
<th>Number</th>
<th>Percent</th>
<th>Percent of cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>need to create value of firm</td>
<td>392</td>
<td>56.2%</td>
<td>78.6%</td>
</tr>
<tr>
<td>to be in position to manage size of firm</td>
<td>266</td>
<td>38.2%</td>
<td>53.3%</td>
</tr>
<tr>
<td>to fit into type of service rendered or market structure</td>
<td>33</td>
<td>4.7%</td>
<td>6.6%</td>
</tr>
<tr>
<td>None</td>
<td>6</td>
<td>.9%</td>
<td>1.2%</td>
</tr>
<tr>
<td>Total</td>
<td>697</td>
<td>100.0%</td>
<td>139.7%</td>
</tr>
</tbody>
</table>

Dichotomy group tabulated at value 1.

Source: SPSS Output Field Survey, 2018

Percent of cases indicate multiple responses from respondents.
The study indicated that (78%) respondents pointed the need to create value of their firm as the adoption influence of HRMPs, (53.3% respondents indicated the need to manage size of the firm, (6.6 %) pointed to fit into type of service rendered or market structure while (1.2%) respondents were neutral. (11) noted that engaging employees in recognition schemes may influence the working climate within the organisation leading to employee commitment and job satisfaction since employees will be aligning themselves with organisational culture. The administration involved for HRM can benefit SMEs by being in tune with expected professional code of conduct and adhering to set legal framework guiding employment (12).

4.1.3 HINDRANCES IN THE ADOPTION OF HUMAN RESOURCES MANAGEMENT PRACTICES BY SMES.

Table 3 Hindrances Of Hrmps Frequencies

<table>
<thead>
<tr>
<th>Hindrances frequencies</th>
<th>Number</th>
<th>Percent</th>
<th>Percent of cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>inadequate resources</td>
<td>290</td>
<td>40.4%</td>
<td>58.0%</td>
</tr>
<tr>
<td>law and regulations of employment</td>
<td>200</td>
<td>27.9%</td>
<td>40.0%</td>
</tr>
<tr>
<td>Size of Firm</td>
<td>223</td>
<td>31.1%</td>
<td>44.6%</td>
</tr>
<tr>
<td>Neutral</td>
<td>4</td>
<td>.6%</td>
<td>.8%</td>
</tr>
<tr>
<td>Total</td>
<td>717</td>
<td>100.0%</td>
<td>143.4%</td>
</tr>
</tbody>
</table>

Dichotomy group tabulated at value 1.

Source: SPSS Output Field Survey, 2018

Percent of cases indicate multiple responses from respondents.

The study indicated that 58% respondents had inadequate resources to adopt HRMPs, 40% respondents indicated that laws and regulations hindered them to adopt HRMPs, 46.6% were inhibited to adopt HRMPs by the size of their firms while 0.8% respondents were neutral (Refer to Table 3). This confirms the study by (2) who argued that SMEs lack significantly in adopting and implementing HRMPs since there is no perfect exchange of knowledge with other bigger firms in areas of operational management. (19) opined that SMEs encounter problems of liabilities of newness in incorporating HRMPs in their entities and these external liabilities of newness include lack of experience, which make mobilisation and acquisition of resources difficult. (14) noted that HRMPs
require considerable costs and due to the tight supply of resources SMEs often fear that this is a cost disadvantage for smaller organisations lack the resources they need to develop and implement their strategy. (28) concurred with (14) that financial hindrances are integrally entwined with regulatory and administrative barriers.

Table showing Correlations of HRMPs on SMEs Performance

Table 4: Correlations of HRMPs on SMEs Performance

<table>
<thead>
<tr>
<th>VARIABLE 1</th>
<th>VARIABLE 2</th>
<th>CORRELATION (r)</th>
<th>P-VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>HRMPs increases performance</td>
<td>HRMPs increased productivity and service delivery</td>
<td>0.702**(2)**</td>
<td>0.000</td>
</tr>
<tr>
<td>HRMPs reduces absenteeism and increase motivation</td>
<td>HRMPs increases performance</td>
<td>0.679**(2)**</td>
<td>0.000</td>
</tr>
<tr>
<td>HRMPs increases job security of employees</td>
<td>HRMPs reduces absenteeism and increase motivation</td>
<td>0.656**(2)**</td>
<td>0.000</td>
</tr>
<tr>
<td>HRMPs increases decision making and innovation</td>
<td>HRMPs increases performance</td>
<td>0.259**(2)**</td>
<td>0.000</td>
</tr>
<tr>
<td>HRMPs increases job security of employees</td>
<td>HRMPs increased productivity and service delivery</td>
<td>0.656**(2)**</td>
<td>0.000</td>
</tr>
<tr>
<td>Recruitment and selection</td>
<td>HRMPs reduces absenteeism and increase motivation</td>
<td>0.183**(2)**</td>
<td>0.000</td>
</tr>
<tr>
<td>Performance management</td>
<td>HRMPs increases performance</td>
<td>0.103**(2)**</td>
<td>0.022</td>
</tr>
<tr>
<td>Performance management</td>
<td>HRMPs increased productivity and service delivery</td>
<td>0.015**(2)**</td>
<td>0.011</td>
</tr>
<tr>
<td>Training and development</td>
<td>HRMPs increases performance</td>
<td>0.099**(2)**</td>
<td>0.028</td>
</tr>
<tr>
<td>HRM implementation practices</td>
<td>Compensation management</td>
<td>0.118**(2)**</td>
<td>0.009</td>
</tr>
<tr>
<td>Compensation management</td>
<td>Performance management</td>
<td>0.557**(2)**</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------</td>
<td>--------------------------------</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Performance management</td>
<td>Cost</td>
<td>0.118**(**</td>
<td>0.021</td>
</tr>
<tr>
<td>Number of HRM personnel</td>
<td>Awareness of current HRM trends</td>
<td>0.132**(**</td>
<td>0.003</td>
</tr>
<tr>
<td>Compensation management</td>
<td>Awareness of current HRM trends</td>
<td>0.261**(**</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Compensation management</td>
<td>Company structure</td>
<td>0.015**(**</td>
<td>0.010</td>
</tr>
<tr>
<td>Training and development</td>
<td>Company structure</td>
<td>0.180**(**</td>
<td>0.000</td>
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<td>Training and development</td>
<td>Awareness of current HRM trends</td>
<td>0.151**(**</td>
<td>0.001</td>
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<td>Training and development</td>
<td>HRMPs increased productivity and reduce cost</td>
<td>0.151**(**</td>
<td>0.010</td>
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<td>Recruitment and selection</td>
<td>Size of firm</td>
<td>0.096**(**</td>
<td>0.033</td>
</tr>
<tr>
<td>Training and development</td>
<td>Reduces absenteeism and labour turnover</td>
<td>0.102**(**</td>
<td>0.023</td>
</tr>
<tr>
<td>Training and development</td>
<td>Justify use of resources</td>
<td>0.095**(**</td>
<td>0.034</td>
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<td>Compensation management</td>
<td>Gross profit</td>
<td>0.173**(**</td>
<td>0.000</td>
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<td>Compensation management</td>
<td>Net profit</td>
<td>0.268</td>
<td>0.000</td>
</tr>
<tr>
<td>Financial performance measurement</td>
<td>Type of firm</td>
<td>0.136**(**</td>
<td>0.002</td>
</tr>
<tr>
<td>Regulations</td>
<td>Type of firm</td>
<td>0.172**(**</td>
<td>0.000</td>
</tr>
<tr>
<td>Performance management</td>
<td>Sustainability measurement</td>
<td>0.101**(**</td>
<td>0.025</td>
</tr>
</tbody>
</table>

**Correlation is significant at 0.01 level (2-tailed)**

*Correlation is significant at the 0.05 level (2-tailed)

Source: Field Survey 2018
There was also consensus among respondents who agreed that HRMPs increases SMEs performance which correspond with compensation management in SMEs (r=0.118, p=0.009) (refer to Table 4). This confirms arguments by (23) that HRM-systems; synergy is established providing an edge over other organisations as HRM systems are difficult to imitate which can only be done when an organisation is aware of current HR trends based on experience in operation. (8) asserted that formal adoption of HRMPs showed marginally significant relationship with financial performance of the organization. (24) argue that product quality can be improved by following specific HRMPs. (25) confirms that SMEs treat HRMPs as a strategy to encourage team responsibilities, enhance organisational culture and build up customer relationships through participation and empowerment leading to organisational performance.

The study results in Table 4 show that there was significant correlation between HRMPs and productivity and service delivery (r=0.072, p=0.00). This is in line with (24) who observed that HRMPs significantly contribute to organisational results in that the HR practices affects the employees in a positive matter by increasing job satisfaction and motivation, which in turn affects the operational results positively through increasing quantity and quality of the products and services and improve finance and market performance. Interestingly (25) investigated the Taiwanese steel industry, and found a significant and positive correlation between HRMPs and job satisfaction. HR practices, such as training and development, teamwork, incentive systems, performance appraisals, and job security, were positively connected to the companies’ financial results. (25) also found a close connection between HRMPs and business strategy, where an integration and alignment between the two gave rise to a further increase in performance. It is reasonable to assume that if HRM has an effect on organisational performance, the HRMPs will first have an effect on employee attitude and behaviour or at least on operational results before one can see effects on the financial performance.

Similar results are shown that HRMPs increases decision making and innovation which correlate with performance (r=0.259, p=0.000) (refer to table 1). (26) asserted that effectively to manage human resources decision making and innovation can be essentially understood as an ongoing process of interpretation and sense making and thus a cognitive process.

In addition, the results in Table 4 showed correlation of HRMPs reduces absenteeism and type of firm (r=0.119, p=0.008). This confirms the assertion of (15) that SMEs treat HRMPs as a strategy to encourage team responsibilities, enhance organisational culture and build up customer relationships through participation and empowerment leading to organisational performance and reduction of absenteeism. From Table 4, it shows that there is a positive correlation between HRMPs of performance management, productivity and service delivery (r=0.015, p=0.011). This confirms the study by (27) assessed HRMPs and firm’s performance in Pakistan. Furthermore, it is assumed that the HRMPs can indirectly influence productivity by reducing the fluctuation of employees. This suggests that HRMPs can increase the ability of small companies to select, develop and motivate a labour force capable to produce superior results.

Findings from the study further show that compensation management is correlated to awareness of human resources current trends (r=0.261, p=0.00) (see Table 4). In support of the above, [28] pointed
out that properly established HRMPs of compensation and performance appraisal systems can influence entrepreneurial activities in a positive way if it corresponds well with skills and education attained by employees in an organisation. (29) suggest that adequate compensation potentially attracts a quality workforce, maintains the satisfaction of existing employees, keeps quality employees from leaving and motivates them for higher productivity. The philosophy of compensation management also recognises that it must be strategic in the sense that it addresses longer-term issues relating to how employees should be valued for what they do and what they achieve (30). Therefore it is assumed that HRMPs of compensation management will be affected by the business and the human resource strategies of the organisation, the significance attached to reward matters by top management, and the internal and external environment of the organisation.

Study results as shown in Table 4 pointed out that recruitment and selection is correlated to reduction in absenteeism and increase motivation in SMEs ($r=0.183$, $p=0.00$). In SMEs the recruitment process can be strategic if the stated recruitment objectives, strategy, activities and applicant factors are considered carefully (2). (31) asserted that the recruitment and selection process involves selecting an applicant whom the recruiter predicts will contribute the maximum to the organisation by having right qualifications to suit the type of job being offered and to be in position to execute desired objectives.

In small organisations the process may be managed by the owner who determines the relevant factors and requirements for the job. If the recruitment process is not done procedurally (29) argue that this may lead to several hiring blunders such as not following proper selection process, scarce information of candidates, disregarding information, falling for candidates, overpromises and trusting completely the hiring staff’s assessment which however may affect performance. In the same line the study results as indicated in Table 4 show that there is correlation between recruitment and selection and absenteeism and increase motivation of employees ($r=0.679$, $p=0.000$). Employee attendance at work, productivity and organisational commitment has become critical components of human resource performance (10). Additionally, it is further argued by (2) that well-functioning HRMPs should increase performance as long as the system consists of policies and practices that work well together.

Findings from the study further show that there is correlation between training and development and increase of performance ($r=0.099$, $p=0.028$) (see table 4). (27) explains training to be the nerve that bares the necessity for the eloquent and impeccable functioning of work, which assists in boosting the excellence of work, the lives of employees as well as organisational development. (32) further state that organisations that empower employees through training and development are prone to have less employee turnover, greater productivity and greater financial performance. In other words, training refers to a planned effort by an organisation to enable employees to acquire certain job-related competencies, such as knowledge, skills or behaviours that are essential for positive job performance (2). It is assumed that if training is implemented by SMEs, performance will be realised.
<table>
<thead>
<tr>
<th>Variable 1</th>
<th>Variable 2</th>
<th>Chi-square ((x^2)) Value</th>
<th>DF</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recruitment selection</td>
<td>SMEs performance</td>
<td>39.685</td>
<td>3</td>
<td>0.000**</td>
</tr>
<tr>
<td>Training development</td>
<td>SMEs performance</td>
<td>5.559</td>
<td>3</td>
<td>0.119**</td>
</tr>
<tr>
<td>Performance management</td>
<td>Productivity and service delivery of SMEs</td>
<td>10.642</td>
<td>3</td>
<td>0.014**</td>
</tr>
<tr>
<td>Training development</td>
<td>Productivity and service delivery of SMEs</td>
<td>9.569</td>
<td>3</td>
<td>0.023**</td>
</tr>
<tr>
<td>Recruitment selection</td>
<td>Absenteeism and motivation</td>
<td>24.401</td>
<td>3</td>
<td>0.000**</td>
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<td>Absenteeism and motivation</td>
<td>2.574</td>
<td>3</td>
<td>0.033**</td>
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<tr>
<td>Recruitment selection</td>
<td>Job security of employees</td>
<td>10.503</td>
<td>4</td>
<td>0.033**</td>
</tr>
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<td>Compensation management</td>
<td>Job security of employees</td>
<td>9.462</td>
<td>3</td>
<td>0.021*</td>
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<td>Recruitment selection</td>
<td>Decision making and innovation</td>
<td>5.553</td>
<td>3</td>
<td>0.023**</td>
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<td>Decision making and innovation</td>
<td>12.625</td>
<td>4</td>
<td>0.013**</td>
</tr>
<tr>
<td>Performance management</td>
<td>Decision making and innovation</td>
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<td>4</td>
<td>0.007**</td>
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<tr>
<td>Training development</td>
<td>Decision making and innovation</td>
<td>3.874</td>
<td>4</td>
<td>0.032**</td>
</tr>
</tbody>
</table>

*Significant at 0.05 level

**Highly significant at 0.01 level

DF=Degrees of Freedom

SOURCE: FIELD SURVEY, 2018
Chi-square tests revealed that there is a relationship between recruitment and selection and SMEs performance ($X^2=39.685$, DF=3, $p=0.000$) at 95% confidence level as shown in Table 5. It may be argued that if SMEs adopt HRMPs performance will be realised. The ability of SMEs owners to implement HRMPs towards their objectives is an important factor that promotes successful management. The results indicate that there is evidence to suggest that performance management is related to productivity and service delivery of SMEs ($X^2=10.642$, DF=3, $p=0.014$) at 95% confidence level as shown in Table 5. This confirms the study by (6) who asserted that productivity and service delivery is important transmission belt between the HRM intensity and the financial performances in smaller firms. The study also examined to see if there is evidence to suggest on whether HRMPs of recruitment and selection is related to absenteeism and increase of motivation of employees in SMEs. Using Chi-Square statistic the relationship between the two variables was found significant ($X^2 = 24.401$, DF=3; $p=0.000$) at 95% confidence level see Table 5. The results indicate that there is evidence to suggest an association between recruitment and section and absenteeism and motivation of employees and SMEs performance. The study tested the relationship between recruitment and selection and job security of employees in SMEs. Using Chi-Square statistic the relationship between the two variables was found significant ($X^2 = 10.503$; DF=4; $p=0.033$) at 95% confidence level see Table 5. The results indicate that there is evidence to suggest that recruitment and selection is related to increased job security of employees in SMEs. The study also tested the relationship between compensation management and decision making and innovation of employees in SMEs. Using Chi-Square statistic the relationship between the two variables was found significant ($X^2 = 12.625$; DF=4; $p=0.013$) at 95% confidence level. The results indicate that there is evidence to suggest that compensation management is related to decision making and innovation of employees in SMEs as indicated in Table 5.

5 Conclusions

With the aforementioned evidence from the chi-square tests, there is evidence of the relationship between human resources management practices and SMEs performance. As a result it can be argued that human resources management practices provide an alternative towards the achievement of SMEs to achieve desired performance. In this regard evidence is there that certain HRMPs are correlated to performance if they are implemented not in isolation but as a complement to support each other.

6 Recommendations

Contemporary business management has developed to the extent that owners and managers of SMEs must grapple with management issues in the unstable business environment. The Ministry of SMEs and Cooperative Development should organise a number of workshops and training of the owners and managers in the implementation of HRMPs. Further, the study recommends that managing and maintenance of HRMPs should be mandatory in the running of SMEs in order to improve management practices. The implementation of HRMPs by SMEs should be monitored by the officials from Ministry of SMEs and Cooperative Development at District, Provincial and National level from time to time. In line with the findings of this study, further research can be carried out in areas of incorporating entrepreneurship and management education in the SMEs sector of the country so that everyone receives some education and training in relation to business management so that when they
start their own businesses, it becomes easier for them to manage. This situation merits a study of this magnitude in order to understand HRMPs and SMEs performance. There is dearth of study that empirically investigated factors that influence HRMPs and SMEs performance.

7 References


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THE MEGA TRENDING FORCES DRIVING DIGITAL DISRUPTION: DIGITAL VORTEX EVOLUTION.

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ABSTRACT

The purpose of this paper is to give a viewpoint on the main drivers behind digital disruption that have taken the whole globe by storm. The main logic being to alert and advise the leaders of Zimbabwean corporates on the trending matters on how to respond to the forces in a bid to survival the unpredictable competition fostered by this digital disruption. The primary forces driving digital disruption include; technology dynamics, globalisation and demographics. But they evolve in successive waves, and it is these new waves that generate new megatrends. The implications to Zimbabwean corporate management and leadership include: Business leaders are obliged to bring the latest technology trends, insights and kick start joint business and technology innovation agenda; establish the business and technology innovation appetite, secure seed funding and establish a technology innovation service; trial on innovative initiatives, technologies, services and working practices that can begin to address technology complexity. They are to address processes and prepare to operate as a multi-speed business etc.

Key words: Digital Economy, Artificial Intelligence, Digital Technologies, Innovation Wave

Paper Type: Practitioner Viewpoint
1 INTRODUCTION

New digital technologies are driving massive transformation in the global economy, and the convergence of these technologies is enabling innovative business models which are disrupting the status quo for many organizations (Kelly and Schaufenbuel, 2016). Digital disruption is forcing many companies and even entire industries, especially, the developing ones like Zimbabwe to rethink their business models. Digital disruption is the principle reason why just over half of the companies on the Fortune 500 list have disappeared since 2000 (Nanterme, 2016; Kelly and Schaufenbuel, 2016). According to the Global Center for Digital Business Transformation, digital disruption has the power to reshape markets faster than any other force in history. A survey conducted by the Center found that many industries lack the ability to adapt and this means that four out of 10 existing businesses across industries will be displaced within the next five years (Bradley et al, 2015; Kelly and Schaufenbuel, 2016). This paper gives a viewpoint on the forces driving digital disruption meant to alert companies in Zimbabwe, as they thrive for excellence in this digital 4G era.

In a recent study by Price-water-house-Coopers, 77 percent of business leaders responding to a survey agreed that technology will transform stakeholder expectations in the next five years. In a related study by Deloitte, only 14 percent of leaders said their companies were ready to redesign their organizations in response to digital disruption (PwC staff, 2016; Hurd, 2016; Kelly and Schaufenbuel, 2016). Business leaders of today require grand strategies to win in a digitized market especially faced with high volatility, uncertainty, complexity and ambiguity (VUCA) of business operations. A leader with an ability to see beyond the status quo can survive the deep competition by understanding and positioning themselves in the same wave length to the trends taking place in the markets. However, it takes more cognisance to what are the major trends leading to digital disruption so as to craft survival strategies. Digital disruption forces or pushes organisation to rethink and re-strategize its operations so as to fit the needs and demands of the market. A very good example in Zimbabwe, of a company that has managed to cope with the digital disruption is Econet Holdings. It has introduced a lot of innovative moves within its multiple subsidiaries so as to expand its tentacles and survive the tough competition in the oligopolistic telecommunications industry. However, while digital disruption is a threat, it is also an opportunity. It is through digital disruption that the sector will emerge. It will drive change management and the necessity to increase speed to market (Nielsen, 2015).

1.1 DEFINITIONS AND MEANINGS

1.1.1 Digital Disruption

Digital disruption can be viewed as the rapid, transformational changes made possible by digital technologies and the impact they have on existing business practices, challenging and, in some cases threatening, the established ways of doing business (Kelly and Schaufenbuel, 2016). Some might argue that this is nothing new; new technologies have always emerged to replace old technologies. The difference between traditional competition and digital disruption, according to the Global Center for Digital Business
Transformation (2015), comes down to two factors: the velocity of change and the high stakes involved. Technological change is exponential, and the rate of change is always accelerating (Ibid).

1.1.2 DIGITAL VORTEX
The impact of digital disruption can best be understood through the construct of a vortex. Digital Vortex according to the Global Center for Digital Business Transformation (2015), is the inevitable movement of industries toward a digital centre in which business models, offerings, and value chains are digitized to the maximum extent. Possible. A vortex exerts a rotational force that draws everything that surrounds it into its centre. Given the chaos and complexity of digital disruption, it can be difficult to discern patterns or “laws of nature” in this rapidly evolving competitive landscape or a prescription for what to do. Yet, a fundamental understanding of how digital disruption works is vital if companies are to devise effective strategies to exploit it (or counter it) (Ibid).

1.2 RESULTS/FINDINGS
1.2.1 FORCES DRIVING DIGITAL DISRUPTION
The primary forces driving digital disruption include; technology dynamics, globalisation and demographics. But they evolve in successive waves, and it is these new waves that generate new megatrends (Ernest and Young Report, 2016). Understanding the next waves of disruption and the interactions between them gives this root cause first approach more predictive power. Explanation below is the account on primary forces driving digital disruption:

1.2.2 TECHNOLOGY DYNAMICS
While some usually think of disruption in the relatively recent context of IT, advances in technology have been disrupting business models for centuries. The Industrial Revolution, for instance, eliminated guilds and created massive labour displacement. In our lifetime, successive waves of the IT revolution (PC, online, mobile, social) have democratized data, empowered consumers and spawned scores of new industries (Ernest and Young Report, 2016). The next waves the Internet of Things (IoT), virtual reality, AI, robotics promise to be even more revolutionary. There are a variety of technologies driving digital disruption. These include big data and advanced analytics technology that extracts value from very large volumes data. Smartphones, social media, cloud computing, sensors, virtual reality, and cognitive computing (simulating human thought processes into a computer model) are all examples of digital technologies that are disrupting business models (Deloitte staff, 2016; Kelly and Schaufenbuel, 2016). Many of these digital technologies have converged, like social, mobile, and cloud (SoMoClo) to enable new collaborative communication technologies with which consumers can connect and access data anytime and anywhere. These Stechnologies have already become common in our personal lives, and many companies are working to harness the potential of these technologies to enable greater flexibility, innovation, collaboration, and productivity. Digital disruption includes the multitude of applications that are disrupting traditional industries. Airbnb, for example, a service that allows people to list and book housing for short-term rentals all over the world, owns no real estate, yet has rocked the hotel industry; hotel revenues are declining in Airbnb locations (Hurd, 2016). And Uber, the app that helps people find rides in nearly 500 locations across the globe, has disrupted the taxi industry. These digital native companies are using technology to redefine the customer experience, and many established companies have found it difficult.
New companies like Airbnb and Uber have captured market share and headlines, but much of the innovation and disruption is happening behind the scenes within companies trying to anticipate and seize the next opportunity. As Rob Preston of Oracle wrote in an article for Forbes, “FedEx is in a digital arms race with UPS; Toyota with Ford; Goldman Sachs with Bank of America; P&G with Unilever; ExxonMobil with Royal Dutch Shell (Kelly and Schaufenbuel, 2016). Those companies and their myriad other competitors are hiring or acquiring the requisite application development, user experience, software architecture, data analytics, system integration, business analysis, and project management expertise.” These companies must become more nimble to compete with new and existing competition. Digital disruption has rapidly reduced speed-to-market, making agility a key organizational competency. Agility, however, is not something larger, more traditional companies are very good at, making it difficult to capitalize on disruptive innovations. Clayton Christensen of Harvard Business School notes that the business process and models that make large companies good at their existing business makes them bad at competing within disruption (Bradley et al, 2015; Kelly and Schaufenbuel, 2016). However, Facebook is not only looking to disrupt the telecommunications industry. Having introduced person-to-person (P2P) payments via Facebook Messenger, the company is now poised to extend this service to WhatsApp’s 800 million users (Global Center for Digital Business Transformation, 2015). WhatsApp is also testing a business model that would help Facebook challenge Google’s domination of the mobile advertising market by charging businesses for the right to contact its users directly. All this disruption comes from one innovative platform that has the seemingly simple function of allowing consumers to send messages to each other via smartphones for “free.”

Despite the threat of digital disruption, CEOs remain optimistic and perceive digital technology positively. A recent PricewaterhouseCoopers survey found that 68 percent of CEOs believed big data and analytics a key component of digital disruption would help them better understand their customers’ needs and would help them more effectively engage customers (PwC staff, 2016). There’s a recognition that digital technology will help organizations enter new sectors by collaborating with peers and competitors. And it will also lead to the creation of new jobs (Nanterme, 2016; Kelly and Schaufenbuel, 2016). However, while they are starting to recognize the potential impact of digital disruption, they are not ready for the road ahead. According to Cisco’s GCDBT report (2015), business leaders are not prepared to make the necessary changes to adapt their organizations to digital disruption. Their study found that only 45 percent of business leaders thought that digital disruption was worthy of board-level attention, and that 43 percent of business leaders had not even acknowledged the risk digital disruption poses for their organizations or have not addressed it sufficiently (Bradley et al, 2015). Accenture found that only 38 percent of business leaders said they were ready to change HR and talent practices and only 37 percent said they had new work practices and processes in place that were driven by digital technologies. Business leaders also said that leadership and vision were the main challenges to becoming digital (Brecher et al, 2016; Kelly and Schaufenbuel, 2016).

1.2.4 GLOBALISATION IMPACT
Like technology, globalization has been upending the status quo for centuries, going at least as far back as the 15th century launch of the Age of Discovery and colonialism. Globalization has accelerated in recent decades, thanks to trade liberalization and emerging market growth. These trends disrupt existing business models by creating new competitors, reordering supply chains and lowering price points (Ernest and
Young Report, 2016). The next waves including the emergence of Africa and a more multipolar world will increase complexity and require flexible business models to respond to global shifts. Meanwhile, sectors themselves are being redefined, as information technology lowers entry barriers and challenges driven by demographic change and globalization, such as climate change and chronic disease, attract companies from far-flung sectors to develop innovative solutions. This blurring of boundaries is also being driven by the rise of the empowered customer, a product of digital disruption and the changing expectations of the millennial generation (Ibid).

1.2.3 DEMOGRAPHIC CHANGES
Throughout human history, demographics have determined destiny. In the decades ahead, relatively high birth rates will make Africa and India engines of economic opportunity. Aging populations will transform everything from health care to real estate. Millennial-dominated workforces will reinvent the workplace. Urbanization will increase cities’ economic and public policy clout, even as it strains their ability to grow in sustainable ways (Ernest and Young Report, 2016). Migration and immigration will have profound impacts on workforces and economic development. All these demographic shifts will require new strategies and business models. For instance, just as global demographic shifts (population growth and an increasingly urban world), are straining resources and fuelling an urgent need for sustainable solutions, the rise of technologies is providing an answer something explored in the future of smart (Ernest and Young Report, 2016). The same basic interaction between demographic-driven resource constraints and technology-empowered sustainable solutions is at the heart of two other megatrends Health reimagined, and Resourceful planet, page which examine industry specific implications (Ibid).

1.2.5 DIGITAL VORTEX DEVELOPMENT
The construct of a vortex helps to conceptualize the way digital disruption impacts firms and industries. A vortex exerts a rotational force that draws everything that surrounds it into its centre. There are many examples of vortices in nature, such as when fluids or gases are stirred (Global Center for Digital Business Transformation, 2015). These include whirlpools, the wake of an aircraft, and so forth. While vortices are very complex, they have three main features that are relevant to digital disruption: (1). A vortex pulls objects relentlessly toward its centre. As objects approach the centre of the vortex, their velocity increases exponentially. (2). within the basic rule of movement toward the centre, vortices are highly chaotic. An object can be on the periphery of a vortex one moment, and then drawn directly into the centre the next. Objects do not travel a uniform or predictable path from the outside to the centre. (3). Objects within a vortex may break apart and recombine as they collide with one another and converge toward the centre.

The Digital Vortex is the inevitable movement of industries toward a “digital centre” in which business models, offerings, and value chains are digitized to the maximum extent possible. Physical and digital sources are separated by the force of the vortex, creating “components” that can be readily combined to create new disruptions, and blurring the lines between industries (Global Center for Digital Business Transformation, 2015). An industry’s ranking (and its position in the Digital Vortex) represents the extent of potential competitive disruption within five years as a result of digital technologies and business models. Industries poised for greatest disruption are those in which the most digitization is taking place; those on the periphery of the Digital Vortex are less vulnerable to disruption and may enjoy greater relative insularity. However, all industries including those that have been more stable in recent years will see competitive upheavals as innovations become increasingly exponential (Ibid).
1.3 MANAGEMENT AND LEADERSHIP IMPLICATIONS
In a recent poll of Fortune 500 CEOs, the rapid pace of technological change was identified as the single biggest challenge facing companies, and nearly all of the CEOs surveyed (97%) said their companies will change more in the next five years than in the past five years. Technology has always been a transformative force for business, and the pace of technological change is accelerating (Global Center for Digital Business Transformation, 2015). This presents a significant challenge for companies trying to remain competitive, and an even bigger challenge for HR professionals tasked with attracting, developing, and retaining the talent that every company needs to compete. Successful companies must develop the right leadership capabilities, workforce skills, and corporate cultures to support digital transformation (Kelly and Schaufenbuel, 2016). Many organizations in Zimbabwe lack foresight and fail to recognize disruptive threats until it’s too late. Those that do sense an impending threat often fail to act quickly or boldly enough. If organizations are going to survive digital disruption, they are going to have to re-evaluate their current organizational structures, products, services, and talent and evolve. Business leaders in Zimbabwe and beyond borders are obliged to bring the latest technology trends, insights and implications and kick start a joint business and technology innovation agenda; establish the business and technology innovation appetite, secure seed funding and establish a technology innovation service; trial on innovative initiatives, technologies, services and working practices that can begin to address technology complexity. Address processes and prepare to operate as a multi-speed business. The process will expose weaknesses in the strategy and open up the next round of business and technology collaboration opportunities (Accenture strategy, 2015).

1.4 RECOMMENDATIONS
Digital business transformation is a journey to adopt and deploy digital technologies and business models to improve performance quantifiably (Global Center for Digital Business Transformation, 2015). The first step of this journey is to grasp the need for change an imperative driven by the inevitability of digital disruption. Digital disruption now has the potential to overturn incumbents and reshape markets faster than perhaps any force in history. Simply put, digital disruption is the effect of digital technologies and business models on a company’s current value proposition, and its resulting market position. In Zimbabwe, companies need to embrace the knowledge unleashed in this paper, with positivity as this adds much value to their day to day strategic operational efficiency. The reason for this is due to the fact that Zimbabwean digital economy is growing steadfastly as a result of the push by the government to introduce an e-governance schemes. Many parastatals such as the ZIMRA, ZINARA have fully adopted the digital stance in reviving their operation, by adopting for good example the ASCYUDA system at the border posts and major Export Processing Zones (EPZs). Understanding digital disruption allows local Zimbabwean companies to understand the global strategies which are locally relevant (usually termed Glocalisation). This paper acts as an eye opener to the practically relevant issues relation to the general implications of digital disruption in the strategic management of organisation. The effects of the development of the digital vortex can be overwhelming if corporates are not well abreast with currently prevailing issues related to disruption. Zimbabwean and mostly African companies need to stay poised in the look-out for any shock caused by the digital disruption. It is a cause for concern for any manager or leader to understand the major forces leading to digital disruption and therefore establishing related measures to control the effects. Technology dynamics, Globalisation impact and Demographic changes are major driving forces corporate leaders need to be aware of in developing strategies to curb disruption.
REFERENCES


VENTURE CAPITAL FINANCE AS AN ANTIDOTE TO DIMUNITING SMEs

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ABSTRACT
In this study three policy makers, five venture capitalists and fourteen SMEs that have used venture capital finance were used as research subjects. This study sought to establish the capacity of venture capital finance in promoting the growth of Small to Medium Enterprises (SMEs) in Zimbabwe. Questionnaires and interviews were used as research instruments. The study adopted quantitative and descriptive data analysis methodology in order to investigate the subjects. Findings of the study revealed that venture capital has the potential to promote the growth of SMEs in Zimbabwe. Sales, profits, net assets and the number of employees were found to be on the increase after using venture capital by SMEs. In a bid to enhance the use of venture capital in Zimbabwe, the study recommended that the government enacts venture capital investment friendly laws and policies, offers incentives for venture capital investors and come up with regulations that encourage pension and insurance funds to invest in start-up businesses and SMEs.

Key Words: Business Incubation, Capital Accumulation, Sustainable Development Finance
1.1 INTRODUCTION
This study focused on the capacity of Venture Capital (VC) financing as an alternative source of capital for Small to Medium Enterprises (SMEs) to promote the growth of this sector in Zimbabwe. Wright (2005) pronounced venture capital as a medium term equity investment or direct equity that has a clear exit strategy, in young privately held companies. Venture capital falls within the private equity scope. Venture capital investors focus on investing in the development of start-up companies having the intention to exit once the company has grown, thereby realising substantial financial gains in the process (Bender & Ward, 2009). Metrick & Yasuda (2010) assert that there are five features of venture capital finance namely: playing the financial intermediary role; being actively involved in monitoring and assisting a company in its portfolio; seeking return maximisation through exiting in trade sales or initial public offerings; investing only in private companies; as well as investing to promote the internal growth of companies. According to a 2012 Finscope survey in Zimbabwe, Small to Medium Enterprises used to contribute over 60% to Gross Domestic Product (GDP) of the national economy.

1.1.1 BACKGROUND AND PROBLEM STATEMENT
The Zimbabwe Independent dated 18 November (2015) reported that SMEs in Zimbabwe had an estimated turnover of $7.4 billion circulating within the sector with 2.8 million Micro, Small to Medium Enterprises (MSME) owners, owning 3.5 million MSMEs and employing 2.9 million people. Small and medium enterprises have been one of the solutions to Zimbabwe’s economic problems given the appropriate financial support. The Zimbabwe Association of Microfinance Institutions (ZAMFI) Published on 17 February 2015, noted that, SMEs require strategic guidance and financial suppor to be able to play a bigger and effective role in driving the economy. Business financing has remained one of the key managerial problem decisions that keep confronting SMEs in Zimbabwe today. SMEs in Zimbabwe have difficulties in accessing business financing that they hardly grow beyond start-up stage. Some SMEs go out of business at a very early stage. It is in view of the challenge faced by SMEs in accessing finance due to a number of reasons that venture capital financing has become a major source of finance in the developed world economies. Thus, proper shaping of venture capital financing is essential for the development of SMEs. In Zimbabwe the venture capital market appears to be biased towards large corporates and paying little attention to SMEs. Can venture capital financing be the answer to financing and growth challenges of SMEs in Zimbabwe? Do the SMEs have what it takes to attract venture capital finance? Thus, this study seeks to explore the capacity of venture capital financing as a financing option, to promote the growth of small to medium enterprises in Zimbabwe. The venture capital financing usage in SMEs is an important area to study in order to help SMEs regain their competitive strength in a tough fight against domestic and foreign competitors. As such, SMEs do not only provide employment and income opportunities to a large number of people, but also are at the forefront of technological innovations and export diversification given appropriate financial options to expand these businesses. As a matter of fact, this study seeks to examine the capacity of venture capital as a financing option to promote the declining growth of SMEs in Zimbabwe.

1.1.2 LITERATURE REVIEW
Mishkin et al, (2013) described venture capital as the equity used to finance start-up businesses or providing seed capital as in some cases. Jääskeläinen, (2012) and Metrick & Yasuda (2010) do agree that after investing venture capitalists will be actively involved in managing their investments by way of getting board representation as well as being actively involved in the day-to-day management of the businesses.
This description concurs with assertions of Bender and Ward (2009) and Metrick and Yasuda (2010) who argued that venture capitalists specialize in investing in new, untested, high-risk but high-potential start-up businesses by acquiring a controlling stake in the businesses they invest in and exit after they have realized significant returns, and in most cases they exit when the company goes public. Botazzi and Da Rin, (2002) argue that, as professional investors, venture capitalists devote significant time and effort into understanding technological and market developments, and this enables them to perceive promising investments. Kaplan and Strömberg (2004) pointed out that venture capital investors apparently perform a key coaching function to the benefit of portfolio firms, by providing advice to the portfolio companies in such areas as strategic planning, finance and accounting, marketing and human resource management. It is in these fields that most of the SMEs usually lack core competencies. Hellmann and Puri (2002) assert that venture capital investors prefer to recruit external managers, adopt stock option plans, and the revision of human resource policies by the benefiting portfolio company. This, they say, will contribute to professionalization of management. According to Bottazzi et al. (2004), the European venture capital companies helped portfolio companies in recruiting outside directors and senior managers in 40.8% and 48.4% respectively, of the deals they analyzed. In addition to that, Lindsey (2002) asserts that the portfolio companies stand to benefit from the network of social contacts of venture capital financiers with prospective suppliers, customers, alliance partners, and specialized service providers such as accounting, legal, head hunting, as well as public relation services. Stuart et al. (1999) suggested that it is easier for venture capital portfolio companies to get access to external resources and competencies that might be out of reach without the endorsement of the venture capital investors.

1.1.3 THEORETICAL FRAMEWORK: THE PACKING ORDER THEORY
The Pecking Order Theory (POT) of financing articulates that firms and individuals will make use of personal funds firstly before acquiring external debt and equity (Myers, 1984). Berger & Udell (2003) argue that POT is a framework for examining firm financing and it spell out that firms attempt to reduce information asymmetries and maintain ownership by first using internal financing, followed by external debt and equity. Although POT was originally devised to examine the financing of large companies, it has also been applied to SMEs. The POT of firm financing is one model that firms might rely on and use to address these agency problems (Myers, 1984). Myers and Majluf (1984) argue that in terms of the POT, firms do not aim for a target debt ratio, instead they select from sources of funds that lessen the cost of capital. In the case of the SMEs, personal sources are used first, external debt next, followed by outside equity. Equity is acquired last because the entrepreneur presumably has more information than the investor. Frank and Goyal (2003) postulate that the presence of significant information asymmetries causes the investor to charge a higher rate of return on equity than on debt. The same sentiments were echoed by Hall et al., (2000) who said that information asymmetry costs may be much higher for SMEs than for larger firms. Thus, the pecking order framework explains a great deal of financing behavior by entrepreneurs.

1.2 RESEARCH OBJECTIVES
- To explore the impact of venture capital finance on the performance of SMEs.
- To identify the constraints faced by SMEs as a result of employing venture capital financing.
- To ascertain the expectations of venture capitalists from SMEs before they commit funds.
1.3 METHODOLOGY
The researchers engaged thirty five respondents. Three officials from, the Ministry of Industry Commerce and Enterprise Development (MICED) - SMEs sector (01), Zimbabwe Investment Authority (ZIA) (01) and the Reserve Bank of Zimbabwe (RBZ) (01). Descriptive research design became the most appropriate design for this study due to the nature of the research objectives. Eight officials were drawn from VC investors as established by this research (08); and twenty four SMEs (24) who were involved with VC financing from the period 2013 to 2017 as was established through the Venture capitalists. It applied mixed approach, which took mixture of both statistical and non-statistical ways towards research. This population was endowed with experts who were chosen from the related groups because they are acquainted with the subject of the research study. Thus, the target population was thirty five (35). The target population was divided into three groups that are, the policy makers/regulators – MICED, ZIA and the RBZ, venture capital investors and SMEs. From a target population of thirty five (35) a sample size of twenty eight (28) was considered to be significant enough to conduct this study. Based on non-probability sampling, respondents for this study were selected on the basis of their availability in the population. The purposive sampling was applied in choosing SMEs. Two sources of data that were used in this study, namely primary (interviews) and secondary sources of data (SMEs and MICED records). The researchers used a self-administered questionnaire in which drop and pick system together with electronic mailing system were applied in an effort to ensure a higher response rate. Structured face–to–face interviews were conducted face to face with the experts from the venture capital investors as well as officials from MICED, ZIA and the RBZ. After making appointments with the relevant official, interviews were conducted according to the prior arrangements that would have been agreed, that is, either face- to- face or sending the interview questions by emails.

1.4 RESULTS
The study focused on firms that have accessed venture capital and data was collected on the before use of venture capital and after using venture capital finance. Thus, the results are presented on the capacity of venture capital financing to declining SMEs growth in Zimbabwe.

1.4.1 TABLE 1: RESPONSE ANALYSIS

<table>
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<th>Respondent(s)</th>
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<th>Response</th>
<th>Total</th>
<th>Response rate as percentage (%)</th>
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<td>1</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>ZIA</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>RBZ</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>Venture capitalists</td>
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<td>5</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>SMEs</td>
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<td>14</td>
<td>70</td>
</tr>
<tr>
<td>TOTAL</td>
<td><strong>28</strong></td>
<td><strong>22</strong></td>
<td><strong>22</strong></td>
<td><strong>78.6</strong></td>
</tr>
</tbody>
</table>
RESPONSE ANALYSIS

For this study a total of twenty eight (28) respondents were involved in the research. Of the twenty eight, three (3) respondents did not respond whilst three (3) of the instruments were discarded because they were not fully completed thereby rendering them ineligible for the study. This showed a response rate of 78.6% and was considered to be statistically sufficient for further analysis.

1.4.2 FIGURE 1: DEMOGRAPHIC ANALYSIS (DESIGNATIONS OF RESPONDENTS)

The majority of the participants were chartered financial analysts who constituted 27.27% whilst the economists and investment analysts were 22.72% each and the executive managers and finance officers constituted 13.64% each in this survey.

1.4.3 THE IMPACT OF VENTURE CAPITAL ON THE PERFORMANCE OF SMES.

The researchers used a number of variables to determine whether the use of venture capital by SMEs has any impact on their performance either financially or non-financially. These include variables to measure performance: annual sales, annual profits, net assets as well as the number of workers employed. The basis for the analysis of these variables was on a before and after use of venture capital financing.

1.4.3.1 ANNUAL SALES BEFORE AND AFTER USE OF VENTURE CAPITAL

Annual sales were used as a measure of the impact of venture capital on growth of SMEs. The respondents were asked to indicate how their firms performed in terms of poor, average, good and very good on the basis of before and after use of venture capital. The responses given were presented in figure below:
FIGURE 2: ANNUAL SALES BEFORE AND AFTER USE OF VENTURE CAPITAL

![Figure 2: Annual Sales Before and After Use of Venture Capital](image)

Source: Researchers’ own (2018)

From figure it is shown that 28.57% of the respondents reported that their companies were performing poorly in sales whilst 71.43% indicated that their sales performance was just average before using venture capital. None of the respondents reported that before using venture capital their sales were either good or very good. On the other hand after using venture capital, 28.57% of the respondents reported that their sales were good and 71.43% said that their sales were very good. None of the respondents indicated that after using venture capital their sales remained either low or average.

1.4.3.2 TABLE 2: SALES BEFORE AND AFTER USE OF VENTURE CAPITAL

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Co-Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales Before (US$)</td>
<td>14</td>
<td>664,966</td>
<td>6,069</td>
<td>2,894</td>
</tr>
<tr>
<td>Sales after (US$)</td>
<td>14</td>
<td>1,505,110</td>
<td>939,325</td>
<td>1,318,961</td>
</tr>
</tbody>
</table>

Percentage increase (%) 7.36%

SOURCE: RESEARCHERS’ OWN (2018)

Table above indicated that the total amount of sales increased from US$ 6,664,966 before use of venture capital to US$ 15,051,101 after the use of venture capital. From mean sales value of US$ 676,069 per each firm before using venture capital, this rose to a mean sales value of US$ 1,939,325 after using venture capital. This presents an incredible percentage increase in sales of 307.36%. It therefore shows that there was an improvement in sales resulting from the use of venture capital. This finding was consistent with the findings by Astrid and Bruno (2004), in a study on venture capital funded firms in the United States for the period 1970-2000, where they found that the sales more than doubled. The study also conformed to that of the United States Small Business Administration (1980) which also used sales growth as a key indicator of small business success and overall performance.
1.4.3.3 PROFIT BEFORE AND AFTER USE OF VENTURE CAPITAL
The respondents were asked to provide information about the profitability of their companies before and after using venture capital. They were asked to rate the performance in terms of poor, average, good or very good. The responses given were presented in figure below:

**FIGURE 3: PROFIT BEFORE AND AFTER USE OF VENTURE CAPITAL**

![Profit Before and After Use of Venture Capital](image-url)

In figure it is exhibited that, 42.86% reported that their companies realized poor profits whilst 57.14% realized average profits before using venture capital. On the other hand, upon use of venture capital, 28.57% reported that their firms realized good profits where as 71.43% indicated that they realized very good profits.

1.4.3.4 PROFIT BEFORE AND AFTER USE OF VENTURE CAPITAL

**Table 3: Profit Before and After Use of Venture Capital**

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profit Before</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(US$)</td>
<td>14</td>
<td>7,393</td>
<td>100</td>
<td>495</td>
</tr>
<tr>
<td>Profit After</td>
<td></td>
<td>8,738</td>
<td>7,767</td>
<td>4,835</td>
</tr>
<tr>
<td>(US$)</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage increase (%)</td>
<td>229%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Source: Researchers’ own (2018)**

As shown above, the total profit realized by the firms before using venture capital rose from US$ 407,393 to US$ 9,488,738, with the mean profit for each firm rising to US$ 677,767 up from US$ 29,100. This represented a massive 229% increase in combined profits. This finding is similar to that which was reported by Chaganti and Mahajan (1983) in their study of Indian SMEs that used venture capital. Thus, this finding implies that SMEs that use venture capital experience growth in profits. Brav and Gompers
(1997) do also confirm that firms that use venture capital experience an increase in profit which is often a result of better management teams and corporate governance structures that help these companies to perform better in the long run.

1.4.3.5 NET ASSETS BEFORE AND AFTER USE OF VENTURE CAPITAL

According to Barmes (1990), assets are particularly a useful indicator of the growth of an enterprise because their level does not fluctuate at a higher rate. As such, the researcher used assets as a measure of growth and presented the results in table that follows.

### TABLE 4: NET ASSETS BEFORE AND AFTER USE OF VENTURE CAPITAL

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Total</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Coe-Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net assets Before (US$)</td>
<td>14</td>
<td>547 219</td>
<td>39 087</td>
<td>14 312</td>
<td>0.37</td>
</tr>
<tr>
<td>Net assets After (US$)</td>
<td>14</td>
<td>1 371 339</td>
<td>97 953</td>
<td>36 696</td>
<td>0.38</td>
</tr>
</tbody>
</table>

Percentage increase (%) 1 520%

Source: Researchers’ own (2018)

The table revealed that the total value of net assets reported rose to US$ 1 371 339 after use of venture capital up from US$ 547 219. Before using venture capital the mean asset value stood at US$ 39 087, a value that rose to US$ 97 953 after use of venture capital by the SMEs. This exhibits a 1 520 percent increase in net asset value. This increase after use of venture capital is evident that there is significant growth. This is consistent with the assertion of Brigham and Houston (2001), who confirm that availability of funds can directly influence growth in assets for a firm as the business expands.

1.4.3.6 NUMBER OF EMPLOYEES BEFORE USE OF VENTURE CAPITAL

In this study, the researchers used employees as an indicator of growth for SMEs. This was in line with the study by Gompers and Lerner (2001) on the influence of VC on SMEs performance where they considered employees as a variable to measure growth. The findings were presented in table that follows.

### Table 5: Number of Employees before and after use of Venture Capital

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Total</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Coe-Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Employees Before</td>
<td>14</td>
<td>345</td>
<td>24.6</td>
<td>9.24</td>
<td>0.39</td>
</tr>
<tr>
<td>Number of Employees After</td>
<td>14</td>
<td>872</td>
<td>62.3</td>
<td>14.56</td>
<td>0.23</td>
</tr>
</tbody>
</table>

Percentage increase (%) 152.8%

Source: Researchers’ own (2018)

The data collected revealed that before using venture capital the SMEs were employing a total number of three hundred and forty five (345) a figure that rose to eight hundred and seventy two (872) employees after using venture capital. The mean before using venture capital was 24.6 and it increases to 62.3 after using venture capital. This represents a 152.8% increase in the number of workers employed by the SMEs. Because there was an increase in the number of workers employed, it implies that the use of venture capital led to the growth of the SMEs.
1.4.4 THE CONSTRAINTS FACED WITH SMES AS A RESULT OF USING VENTURE CAPITAL

With an open-ended question, the respondents were asked to provide information about the constraints that they encounter with the use of venture capital. The following are challenges were noted as the major constraints faced by SMEs in Zimbabwe as a result of using venture capital finance:

1.4.4.1 LOSS OF OWNERSHIP

All the respondents reported that the major challenge they face with using venture capital is dilution of ownership as the venture capitalists demand a controlling stake in the business and bring in new management. They indicated that venture capital may even expose them to mergers and take-overs which may not be in the best interest of the founders of the companies. This is consistent with the assertion of Jääskeläinen, (2012) and Metrick & Yasuda (2010) who do agree that after investing venture capitalists will be actively involved in managing their investments by way of getting board representation as well as being actively involved in the day-to-day management of the businesses.

1.4.4.2 CHANGE OF BUSINESS STRATEGY AND DIRECTION

Most of the SMEs feel that the coming in of venture capital finance is usually accompanied by change of business strategy and direction. The coming in of new management and the erosion of the power to make unilateral decisions by the founder results in the company taking a new direction that may be different from the vision of the founders. This is in agreement with Thollon-Pommerol (1990) who asserted that when incorporated into a group, a firm drastically changes its strategic behavior and its development. Given such a scenario most SMEs are unease with venture capital financing.

1.4.5 EXPECTATIONS OF VENTURE CAPITALISTS FROM SMES BEFORE COMMITTING FUNDS

The study sought to find out what the venture capital financiers expect to be in place in an SME before they make the decision to fund one. Interviews conducted with the various venture capital investors reflected expectations that were noted and these are:

1.4.5.1 VIABILITY OF THE BUSINESS

The business of the SME should be economically viable and worth of investing in the basic cost benefit analysis is done to see if the returns from the investment can outweigh the costs of investing. The business prove that it can generate sufficient cash-flow for self-sustenance and have the capability to be profitable enough. This goes along with what was said by Bender and Ward (2009) and was also supported by Li and Zahra (2012) who asserted that because venture capital investors private companies, their accessibility is therefore limited to a few people with projects that demonstrate the potential of generating returns. Where the business may not be making profit yet, the respondents concurred that the business should be in a position to demonstrate strong turn-around potential.
1.4.5.2 POTENTIAL TO ATTRACT INTERNATIONAL INVESTORS
The respondents indicated that they also consider the capacity of the business venture to attract international investors. Whilst venture capitalists consider the returns that they get from their investment, the other issue that was highlighted was the exit strategy. It was revealed that a business which cannot attract international investors is considered less appetizing and given an option, it is less likely to attract venture capital.

1.4.5.3 GROWTH POTENTIAL
The business has to have great potential to grow both locally and ultimately into the international market. The venture capital investor consider the existing customer base of the business and then look at its potential to grow its customer facing. The customers are a good indicators of whether the business has a potential to grow, remain stagnant or even failing. This strengthen the corporate brand image (Nyagadza, Vingirai and Chodeva, 2018). Thus, venture capitalists expressed that they do not put their money into a business that has no potential to grow and generate more returns for them.

1.4.5.4 COMMITMENT OF THE OWNERS OF THE SMES
Most of the respondents pointed out that the commitment of the business owners to their business is one such important aspect when assessing whether to invest in a business or not. The quality of expertise that the firm invests in is the major indicator of the level of commitment to the business by its owners. “If an owner of a business believes in his vision he demonstrates that by committing himself both financially and even non-financially”, said one of the respondents. As such, companies that exhibit a higher degree of commitment stand a better chance of accessing venture capital.

1.5 CONCLUSION
The research established that venture capital financing contributes to the growth of SMEs in Zimbabwe in terms of revenue, profitability, net assets as well as the number of workers employed. This is largely due to the active involvement of venture capitalists in the management of the portfolio SMEs which facilitates the bringing in of competent management team and enabling the re-skilling of the existing staff. The study found out that by employing venture capital, SMEs owners are prone to losing ownership and power over their businesses. The coming in of venture capital also exposes firms to changes in the scope of their businesses. This is so because the venture capitalists demand to have a controlling stake in the affairs of the business. It was also established that, before venture capitalists commit themselves to funding a SME, they do due diligence to ascertain viability of the business and the potential of the business to grow into a scalable entity. They are interested in the seriousness of the incumbent management to drive the business forward. They look at its potential to give them a good return for their investment. They also consider their exit from the business by assessing its potential to attract international investors. This is because they are into business and would be concerned about their return on investment. Venture capital finance comes into a SMEs as a package which, apart from the funds invested brings with it, experienced expertise, technical training and reskilling of the staff for capacity building as well as exposing the firm to greater opportunities through networking and marketing. Quality supervision is another contribution that SMEs stand to benefit through venture capital finance. Venture capitalists face some barriers in their efforts to finance SMEs in Zimbabwe. These range from poor corporate governance, lack of systems, and incompetent management
to ignorance about how venture capital works. This could be the case because venture capital has not yet
developed much in Zimbabwe.

1.6 RECOMMENDATIONS
In the light of the findings of this study, the following recommendations are made to the relevant
organizations:

1.6.1 GOVERNMENT OF ZIMBABWE
Considering the vast contribution that SMEs make to the country’s GDP, it is recommended that targeted
government intervention be implemented to promote the venture capital market in Zimbabwe. The
government should consider the following:

Enactment of venture capital investment-friendly laws and policies. It is recommended that the
Government of Zimbabwe should enact laws that encourage venture capital investment in Zimbabwe.
Legislation that allows for limited partnerships should be enacted to enhance investment. It is also
expedient that laws that guarantee protection of private investments be put in place. This will also go a
long way in attracting international investors. Offer incentives for venture capital investor. To promote
investment into SMEs, it is recommended that the government of Zimbabwe should consider offering
incentives to venture capitalists. Such incentives may be in the form of tax breaks and concessions as well
as capital allowances for investors who invest in high risk business start-ups and SMEs. This will boost
the supply side of venture capital finance. Creation of a fund of Funds. A recommendation is hereby made
that the government should come up with fund sourcing in which corporations are to pour in money that
will be used as venture capital for SMEs in Zimbabwe. Thus, it is further recommended that the
government should consider resuscitating the Venture Capital Company of Zimbabwe to take care fund
sourcing through which the government should sponsor funds to invest in new start-ups and SMEs.
Regulations concerning pension and insurance funds. Pension funds are large potential providers of funds
to the venture capital industry because of their higher liquidity. In order to promote the supply side of
venture capital financing, it is recommended that the government should come up with regulations to
encourage them to invest in start-up businesses and SMEs. For example, by putting in place regulations
that would allow them to invest up to certain percentage of their assets in venture funds.

1.6.2 MINISTRY OF INDUSTRY COMMERCE AND ENTERPRISE DEVELOPMENT
(MICED).
SMEs need to be capacitated and aligned to the expectations of venture capital investors. As such it is
recommended that the MICED should be involved in creating SMEs with the capacity to attract venture
capital. This may be done through trainings on business systems and management. A special department
that deals with venture capital finance for SMEs should be established to take care of this industry. This
will improve the venture capital market in Zimbabwe.

1.6.3 ZIMBABWE STOCK EXCHANGE (ZSE).
Establish a developmental financial market. Availability of a strong and efficient stock market activity as
well as the availability of trade sales are vital foundations to promote venture capital activity in the country.
Therefore, it is recommended that the ZSE should establish visible exits by putting in place a second tier
stock market to cater for SMEs to raise funds. Stock market introductions are important for
venture capital financiers as a way of raising their funds back.

1.6.4 SMES OWNERS AND MANAGEMENT

*Growth Oriented Entrepreneurial activity.* High growth potential is a key factor to venture capital finance. Therefore it is recommended that SMEs in Zimbabwe be involved in more high growth focused entrepreneurial activity in order to attract venture funds. *Implementation of proper business systems.* The development of standard business systems is pertinent in order to stand better chances of attracting venture capital. Hence it is recommended that SMEs managers and owners priorities the establishment of professional business systems within their firms. This can be achieved by employing competent personnel within the SMEs. Venture capital gives them the impetus to realize their full potential, that is, if they meet the expectations by financiers.

1.6.5 VENTURE CAPITAL INVESTORS.

It is recommended that venture capitalists come up with an industry body in the form of an association. The body is to act as the public policy advocate for the venture capital industry in Zimbabwe; to promote the venture capital industry to the entrepreneurs, government and the international investors; to provide guidelines and standards for the industry for self-regulation; and offering relevant training to member organizations. This will help the industry to secure enough recognition from the public, government and other policy makers.

1.7 AREA FOR FURTHER RESEARCH.

An investigation should be conducted on the sustainability of growth of the SMEs financed by venture capital in order to establish how long the growth that they have experienced lasts.

1.8 AUTHORS’ CONTRIBUTIONS

The authors participated extensively in the Research Design, and Theoretical drafting of the final article, save for the conception of the Study Area, Literature Review and Data Analysis, and Interpretation.

1.9 COMPETING INTERESTS

There is no interference on how the results were presented, due to the fact that the authors had no experiences with the organisations involved in the study.

1.10 ETHICAL CONSIDERATIONS

We assured the participants that their identities would not be revealed to the reader (Nyagadza, Chodeva and Vingirayi, 2018; Dumbu, 2014), by not allowing them to sign or write their names on the questionnaires and raw data collected would not be released to any third party. Moreso the researchers did not put participants in a situation where they were exposed to risk of harm after they have expressed their views concerning. The principle of voluntary participation was taken into consideration, thus participants were not be coerced into participating in research (Nyagadza, Chodeva and Vingirayi, 2018).
ACKNOWLEDGEMENTS

We wish to thank the management and employees of the concerned corporations and ministries for their assistance.

REFERENCES

A THEORETICAL FRAMEWORK DEVELOPMENT OF EMOTIONAL LABOUR EFFECT ON SERVICE QUALITY.

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ABSTRACT
This paper seeks to establish the important elements of service quality based on emotional labour theoretical framework or approach. Methodology used in this research is based on literature review of theories and advances of emotional labour. A systematic literature search was conducted in order to seek for the relevant theories to the study. The author suggests a theoretical framework for building and fostering robust service quality, through enhanced emotional labour, which will lead to the ease of testing statistically the applicability of emotional labour on service quality effectiveness and banking activities. As a theoretical review paper, the author addresses and justifies the logic behind adoption of the suggested theoretical framework. The appraisal theory is based on the premise that emotions are elicited by appraisals, or evaluations, of events and situations, leading to service quality excellence, in industries such as banking.

Key words: Service Quality, Banking, Dramaturgy, Burnout, Work Efficiency.

Paper type: Theoretical Review Paper
1 INTRODUCTION
The global business banking arena is experiencing a paradigm shift. The shift is a movement from a manufacturing dominated economy to service-based economy (Kim, 2013). Analysing the impact of the shift on employee output of work, prior research has emphasized that employees are now expected to be the face of their jobs Koval et al (2015), since the relationship between front line employees’ specific behaviour and customer satisfaction is significant in service quality and strategic marketing in banks.

1.1 THE ZIMBABWEAN BANKING SECTOR
As of December 2016 there were 19 registered operational commercial banks in Zimbabwe, among them Agribank, BancABC Limited, Barclays Bank of Zimbabwe Limited, CBZ Bank Limited, Ecobank Zimbabwe Limited, FBC Bank Limited, Nedbank Zimbabwe Limited (formerly MBCA Bank Limited), Metbank Limited, NMB Bank Limited, Stanbic Bank Zimbabwe Limited, Standard Chartered Bank Zimbabwe Limited, ZB Bank and Steward Bank Limited (RBZ, 2018). In an extremely competitive environment, such as the banking sector, service employees’ emotional display plays a critical role in maintaining loyal customers according to Chung (2017). Frontline employees are expected to manage their emotional display during the service interaction, as employee cooperation and service quality are related (Karapate, 2010). According to Grandey (2000), emotional labour strategies have a strong effect on perceived customer orientation and perceived service quality in service industries and subsequent customer loyalty, thus management of emotional display determines whether or not the customer stays or leaves (Tsai, 2009). The Zimbabwean banking sector is not an exception in terms of customer switching. The sector players are experiencing high customer switching problems. According to the NMB Bank Limited (2016), more than 3,000 account holders have switched from NMB Bank to other banks like CBZ, while ZB Bank’ (2016), second quota report states that nearly 17,800 account holders have switched to other banks during the same period. This could be due to the inseparability nature of banking services, whereby interaction between employees and consumers is becoming a critical element in determining consumers’ perceptions of service quality (Devi, 2016). This has led to the investigation of the impact of emotional labour on service quality. Not a complete statement) Basing on these past findings the researcher noted that the aspect of emotional labour is being over-looked within the banking sector, as most banking sector players are concentrating more on other elements of service quality that is reliability, tangibility, assurance and responsiveness. They are not considering the emotional aspect of service quality (empathy), which authors agree that emotional labour relates to the dimensions of empathy (Groth et al., 2009). This was reflected in the CBZ Report (2016), where it stated that CBZ Bank has managed to create customer value through improved service quality. Due to inseparability nature of banking services, interaction between employees and customers has become a critical element in determining customers’ perceptions of service quality. Currently the Zimbabwean banking industry is facing an extremely high customer switching rate, resulting to the creation of a more difficult environment to operate than any other industry has experienced. Most banks around Zimbabwe are struggling to avoid customer switching. Therefore it can be questioned to what extent emotional labour has an effect on banking service quality.
1.2 OBJECTIVE

The main aim of the present study is to conduct a literature review on the theoretical approach and studies focusing on the theoretical framework development of Emotional Labour effect on service quality.

1.3 BRIEF LITERATURE SURVEY

1.3.1 Defining Emotional labour

Hochschild (1983) coined the term ‘emotional labour’, and defined it as the management of feelings to create a publicly observable facial and bodily display via voice-to-voice or face-to-face interpersonal interactions; emotional labour is sold for a wage and therefore has exchange value. Globally, the banking industry is facing extremely high customer switching rate, resulting to the creation of a more difficult environment to operate than any other industry has experienced (Ogut, Cagliyan and Findik, 2013). According to Grandey et al (2002), emotional labour has 3 basic components namely, surface acting (displaying emotions that are not felt through staging of verbal and nonverbal cues) deep acting (experiencing or feeling the emotions that are required) and genuine acting which occurs when employees’ felt emotions are congruent with expressed emotion and display rules. Surface acting: Surface acting is an emotional labour strategy that contains complying to organizational display rules by managing and hence simulating emotional expressions that are not actually felt by the employee. This also contains repression and hiding felt emotions, which would be inappropriate to demonstrate (Hochschild, 1983; Grandey, 2000). Deep acting: Deep Acting is an emotional labour strategy wherein the employee makes a cognitive effort to produce the needed emotional display by changing both expressions and feelings that match the particular situation hence aligning their true feelings with the desired emotions possibly by concentrating on positive thoughts or re-evaluating the situation (Hochschild, 1983; Grandey, 2000).

1.3.2 Defining - Service quality

Lewis and Mitchell, (1990) defines service quality as the extent to which a service meets customers’ needs or expectations. The concept of service quality began to receive significant attention in the early 1980s with the writings of Gronroos (1984) and Lehtinen and Lehtinen (1982). Parasuraman et al. (1985) identified ten dimensions of service quality, including; reliability, responsiveness, competence, access, courtesy, communication, credibility, security, knowing the customer, and tangibles. However, these dimensions are reduced to five dimensions that are: reliability, assurance, tangibles, empathy (Parasuraman, 1998). Dimensions of service quality measured using a 22-item scale named “SERVQUAL”. SERVQUAL used for measuring the quality of service in different service contexts that include appliance repair and maintenance firms, several retail banks, a long distance telephone provider, a security broker and credit card companies; such multi-perspective validation of service quality dimensions helped in developing and designing a relatively standardized scale which could be applied for the measurement of service quality of different types of services organizations. Though the scale has seen only a limited application in the financial services context, it nonetheless remains one of the many areas where SERVQUAL has been applied for measuring service quality.
1.3.3 A pragmatic experience of service quality in the banking industry

Service quality is gaining more significance in the banking industry and the value of improving service quality should be determined. Berry and Thompson, 1982, in Muhammad, Bhukari and Iqbal, 2011), suggest that developing strong relationships between customers and financial institutions serve as incentives for customers to remain loyal and thus provide financial institutions with a source of differential advantage. Similarly Teas (1993) finds that a centrally important aspect of a commercial customer’s dealing with a bank is the quality of the long-term relationship that develops with the bank. Tilston (1989) believes that a few initiatives have “had any significant impact, either on customer perceptions or on commercial results”. Teas and Wong (1991) quoted Muhammad, Bhukari and Iqbal (2011), developed a measure of concepts related to retail bank customer’s perceptions of retail bank service delivery systems. The results of their research noted four potentially important aspects of the retail bank service delivery systems; general bank personal service, teller personal service, reaction capacity, and location convenience. The research results support the hypotheses that retail bank customer’s perceptions of these issues may be related to customer satisfaction and intentions to do business with the bank in future. These include intentions to purchase additional products and intentions to give the bank a larger percentage of the customer business. For example, in Singapore (Kwan and Hee, 1994) examined measuring service quality in Singapore retail banks using a SERVQUAL instrument developed by Parasuraman (1998), according Muhammad, Bhukari and Iqbal (2011).

1.3.4 Service quality effects.

Customer positive affect. The hypothesis is that an increase in customer positive affect as a result of employee emotions will influence customers’ perceptions of their rapport with the employee (Gremler and Gwinner, 2000). Specifically, when a customer is “infected” by an employee’s positive emotions as a result of a service interaction, the customer likely will enjoy the interaction with the service employee to a greater extent (Gremler and Gwinner, 2000). Because an enjoyable interaction is a key characteristic of customer–employee rapport (Gremler and Gwinner 2000), an increase in customers’ positive emotions should ultimately lead to higher levels of rapport. Satisfaction with the Transaction. The services literature also indicates relationships among customer–employee rapport, customer satisfaction with the transaction, and future loyalty intentions (Gremler and Gwinner, 2000). The argument by Gremler and Gwinner (2000), that rapport is positively related to customer satisfaction because an enjoyable interaction with a high degree of customer–employee rapport is usually one in which customers reveal personal information, which enables employees to customize the service offering to the customer’s needs (Gremler and Gwinner, 2000). Both of these elements are considered integral parts of customer satisfaction. Future Loyalty Intentions. Furthermore, it is expect that customer satisfaction is positively related to customers’ future loyalty intentions through the creation of positive attitudes toward the service provider (Yi, 1990), a claim we base on both attitude theory (Fishbein and Ajzen, 1975) and exit-voice theory (Hirschman 1970). Finally, because customers who personally like a service employee and have rapport with him or her can be expected to form positive expectations about a future service experience with this employee (Gremler and Gwinner, 2000), propose that customer–employee rapport has a positive relationship to customers’ future loyalty intentions.
1.4 Emotional Labour

Although no empirical work has tested whether emotions mediate the relationship between emotional labour strategies and customer service quality outcomes (i.e., customer satisfaction), theory suggests that this would be the case (Richard, 2006). For instance, Grandey and Brauburger (2002) cited in Richard (2006), suggested that affective reactions (e.g., felt emotions) have a direct influence on customer-focused affective behaviour (e.g., expressions of emotions to the customer). These authors (and others; e.g., Brotheridge & Grandey, 2002; Brotheridge & Lee, 2002; Diefendorff, Croyle, & Gossenrand, in press; Grandey, 2000; Hochschild, 1983; Richard, 2006) suggest that it impacts felt emotions. Thus, cognitive change strategies of emotional labour regulation should have their effects on service behaviour through felt emotions (Richard, 2006).

1.5 METHODOLOGY

Several methods were used to collect and analyse the literature. The research was conducted using the Google search engine. This theoretical review paper is based solely on a review and analysis of research and data from the literature. The words such as brand story telling and internal stakeholders’ corporate brand perceptions were used to guide the search process. The highly vital literature was from Richard. E. M (2006), with a paper titled, “Applying appraisal theories of emotion to the concept of emotional labour”. These literature pieces contained results of surveys that collected data on the brand story telling and corporate brand perceptions. Furthermore, the research on three databases pertaining to brand story telling and internal stakeholders’ corporate brand perceptions were examined. The databases were Scopus, Springer Link, Emerald Insight through the several catalogues, Wild Cat, Taylor and Francis abstracts. Books on the topic for this conceptual paper were searched using the Midlands State University catalogue. The same terms used in the database search was used to find books related to the topic. Three books were deemed useful and were borrowed from the library for further reading.

1.6 RESULTS/FINDINGS

1.6.1 The Appraisal Theory as the suggested theoretical framework.

Arguably one of the most influential theories of emotional labour, Appraisal Theory is based on the premise that emotions are elicited by appraisals, or evaluations, of events and situations (Richard, 2006). Previous theories of emotion have claimed that emotions can be elicited by events themselves (e.g., stimulus-response theories), by physiological processes (e.g., patterns of neural activity in the brain; facial expressions or other behaviours), or by motivational processes (e.g., hunger leading to an infant’s distress). According to Roseman and Smith (2001), (cited in Richard, 2006), appraisal theory was developed to explain phenomena that were not adequately explained by previous models of emotion. First, several previous theories do not account for the many distinct emotions that are experienced by human beings. For example, early behavioural theories viewed emotion as an undifferentiated, unidimensional concept (i.e., emotionality), ranging from low arousal to high arousal. Furthermore, Roseman and Smith (2001) note that these theories fail to account for the growing body of evidence for various distinct emotions (such as joy, sadness, fear, and anger) that are observable across cultures, and they leave us with questions regarding what produces these distinctive patterns of emotional responses. Second, previous theories do not adequately account for the fact that the same event or situation often elicits very different emotional responses both across people and within the same person over time ( Richard, 2006). Third, a problem with theories claiming
that emotions are unconditioned responses to certain events, or that they are learned via associations or generalizations, is the fact that these theories make it virtually impossible to account for all possible elicitors of a specific emotion (Ibid). Roseman and Smith (2001) give the example of the emotion of sadness, explaining how it can be elicited by an endless number of events, even those never before experienced nor paired with existing elicitors. Fourth, a limitation of theories claiming that emotions are elicited by specific physiological events, expressions, or behaviours is that these theories fail to explain what starts the emotion process. Fifth, previous theories of emotions do not speak to the situational appropriateness of certain emotions. For example, emotions are now believed to have adaptive value if they are appropriate for the situation (e.g., sadness at the death of a loved one; angry protests in response to harm inflicted by another person), but they can be maladaptive if they are not appropriate to the situation (Richard, 2006). Sixth, many previous theories of emotion are unable to account for the irrational aspects of emotions. A seventh and final limitation listed by Roseman and Smith (2001) is that developmental and clinically induced changes in emotion cannot fully be explained by theories that claim emotions are elicited by events.

Roseman and Smith (2001) explain how the assumptions of appraisal theory address the limitations of previous theories of emotion and emotional labour. First, appraisal theory assumes that emotions are differentiated by specific patterns of appraisal. That is, each distinct emotion is elicited by a distinctive appraisal pattern. Second, individuals who appraise a situation in different ways will feel different emotions, and the same individual who appraises a situation in different ways over time will feel different emotions over time in response to the same event (Richard, 2006). Third, a common pattern of appraisal is used to explain the many different situations that evoke the same emotion. That is, all situations to which a specific pattern of appraisal is assigned should evoke the same emotion. Fourth, appraisal theories assume that the emotion process is started when an appraisal is made; that is, appraisals precede and elicit the physiological, expressive, and behavioural states that make up the emotion episode. Roseman and Smith (2001) quoted in Richard (2006), emphasize that emotions are generated by current appraisals).

1.7 DISCUSSION
Research has shown that the degree to which individuals are required to interact with others on the job is positively related to pressure to express positive emotions and suppress negative emotions (Diefendorff & Richard, 2003; Diefendorff, Richard, & Croyle, n.d.; Schaubroeck & Jones, 2000; Richard, 2006). Service employees, in particular, are expected to display integrative emotions such as friendliness and sympathy (Grandey & Brauburger, 2002; Parasuraman, Zeithaml, & Berry, 1985; Richard, 2006). There is evidence that customers can “catch” the emotions of the service employee during the interaction, in a process commonly referred to as “emotional contagion” (Hatfield, Cacioppo, & Rapson, 1994; Pugh, 2001). Therefore, the goal behind employee positive displays is to create positive emotions in the customer so that the customer will form a positive view of the organization (Grandey & Brauburger, 2002; Richard, 2006). As a result, service employees report feeling pressure to express positive emotions and suppress negative emotions in order to provide “service with a smile” (Brotheridge & Grandey, 2002; Richard, 2006). In order to tap both aspects of service employee emotional display requirements, the training was developed to target the reduction of negative emotions and the increase of positive emotions. Grandey et al. (2005) found that customers are able to perceive the difference between faked and authentic displays of positive
emotion. An important expected outcome of the was that service employees, such as those in banks would be able to actually feel the positive emotions they are required to express, leading to authentic (rather than faked) displays of positive emotions (Richard, 2006). Grandey et al. (2005) theorize that authentic displays of positive emotions are viewed by customers as “extra-role” behaviours that go above and beyond requirements and therefore increase satisfaction with the service encounter (Ibid). Grandey et al. (Study 2; 2005) also found that customer perceptions of authenticity predicted customer ratings of overall satisfaction above and beyond employee experience, perceived attractiveness, task performance, and perceived friendliness. These findings are consistent with Hochschild’s (1983) idea that, because customers have become so accustomed to “service with a smile,” they now recognize inauthenticity in such smiles and value authentic smiles to a higher degree than in the past (Ibid).

1.8 CONCLUSION
In conclusion, when service employees experience stress/emotions, their performance is affected, not only indirectly, through reduced cognitive resources, but also directly through negative emotional displays or inauthentic positive displays. This shows emotional labour has a direct impact on service quality for an organisation. The primary purpose of the paper was to come up with a theoretical framework based on appraisal theory for improving the emotional labour and well-being of service quality through employees and the satisfaction of customers. On the case of service quality, SERVQUAL has been used by different research studies conducted in various settings such as the quality of service offered by a hospital (Babakus and Mangold, 1989), banking (Cronin and Taylor, 1992; Spreng and Singh, 1993), a business school placement center, tyre store, dental school patient clinic and acute care hospital (Carman, 1990), discount and departmental stores (Finn and Lamb, 1991; Teas, 1993; Dabholkar et al., 1996) and others.

1.9 FUTURE RESEARCH
1.9.1 Data Collection and Data Sources for Future Research
This is a theoretical framework review paper that is based on investigating the literature on a theoretical framework development of emotional labour effect on service quality. For future research a qualitative study would be conducted to obtain data on the emotional labour effect on service quality issues. A qualitative method would be used because the research question would be a subjective one. The sample population for future research study would include 60 to 70 non-listed companies irrespective of size or scale of operation. Involving people with potential knowledge of brand story telling can be add value to the research quality. Incentivising respondents can give higher chances of getting accurate results. For the purposes of research ethical stance, an informed consent document is also to be given to all the participants to ensure that they know that their involvement in this study will be entirely voluntary and that they had the right to withdraw from the study as and when they saw fit (Ryan et al, 2007; Dumbu, 2014). This consent document is also to be used to inform the participants that their involvement in the study would be entirely confidential. The privacy and anonymity of participants will be guaranteed (Fox, 2009; Dumbu, 2014).

1.9.2 Data Analysis Strategies for Future Research
Due to the reason that the future research will be based on qualitative inquiry strategies for data analysis would be to separate the data collection amongst non-relevant respondents with those who understand emotional labour effect on service quality issues. For the ease of data analysis, content
analysis, discourse analysis and creating verbatim can be used to record the data. From the responses, conclusions will be made about on whether there is a link between emotional labour effect and service quality.

1.9.3 Strategies for Minimizing Bias and Error

1.9.3.1 Strategies Related to this Inquiry
Specific terms related to the topic were searched on a number of databases. In order to reduce bias related to this inquiry a number of aspects to the topic was explored before writing the report. Disciplines such as Human Resources, Services Marketing, Health, Psychology, Business management, theses and dissertations were the databases used. To reduce the amount of bias topics that consistently showed up in literature were included in the paper.

1.9.3.2 Strategies Related to Future Inquiry
The researcher(s) need to take cognisance of response bias when conducting future research. This is so due to the fact that, respondents may be biased to give responses that do not reflect their true beliefs. Respondents may deliberately try to manipulate the outcome of a poll by advocating a more extreme position than they actually hold in order to boost their side of the argument. The researcher(s) will have to seek for truthfulness from responses from the targeted respondents. Respondents may also feel under social pressure not to give an unpopular answer. In order to minimize these possible biases, the researcher will not inform the participants of her hypothesis. Asking a variety of questions can be good enough to reduce the potency of bias.

1.9.4 Ethical Considerations for Future Research
To ensure that the current research is to be conducted within the appropriate parameters, an ethical clearance is be obtained from the ethics committee or responsible authorities. To make sure that the research will be open and democratic, participants and institutions will be given their informed consent to take part in the research and individuals shall be consulted and agree on what data are to be collected and included in the research as posited by Ryan et al (2007) cited in Dumbu (2014). An informed consent document is also to be given to all the participants to ensure that they know that their involvement in this study will be entirely voluntary and that they had the right to withdraw from the study as and when they saw fit (Ryan et al, 2007; Dumbu, 2014). This consent document is also to be used to inform the participants that their involvement in the study would be entirely confidential. The privacy and anonymity of participants should be guaranteed (Fox, 2009; Dumbu, 2014). In this study, participants shall not be coerced or obliged to disclose or provide data under any circumstances, time or extent except on their own will after making reasonable judgments to do so (Saunders et al., 2009).
REFERENCES


ABSTRACT

The purpose of this paper is to identify the important elements of financial inclusion basing on literature review and successful banks’ case study on agency banking in Zimbabwe. The paper explores and applies literature review findings and utilises a case study approach, notably of renowned banks in Zimbabwe, to illustrate the importance of financial inclusion through enhanced agency banking in competitive markets. It suggests a framework for building and fostering financial inclusion through agency banking. Findings show that financial inclusion needs to be aligned to the corporate needs and processes to help deliver customer or depositor promises. The level of consistency along the financial inclusion through agency banking, targeted towards the customers or depositors is critical to the success of agency banking by any banking or financial institution.

Key Words: Financial Strategy, Inclusion, Customer Engagement, Sustainable Profitability

Paper Typology: Conceptual Paper
1.1 INTRODUCTION
The main principles that govern financial inclusion are effective use, a wide range of products and services, quality, accessibility, fairness and transparency, formal regulated entities as well as sustainability. In the past decade, financial inclusion has been the epicentre of development strategy. Underlying this consensus is the belief that the access to financial services is a powerful tool for poverty eradication (Donner, 2016). The main notion behind financial inclusion, through agency banking is on ensuring that a nation populace has an inclusive financial system which is responsive to their needs. Financial inclusion therefore facilitates the usage of quality and affordable financial services by the entire populace as well as to minimize financial exclusion, as in agency banking. Financial exclusion is the inability by individuals to access basic financial services as a result of the challenges that have to do with access conditions, prices, marketing as well as self-exclusion in relation to discouraging experiences or perceptions of individuals (Kiriuki, 2015). On the other hand, according to Beck (2017) agent banking is a latest innovation which banks are using to provide services to the un-banked and under-banked at a cheaper fare. With this concept customers are taken out of the brick and mortar banking halls, to kiosks and villages (explain this), as shown in this paper.

1.2 DEFINITION OF KEY TEAMS
1.2.1 Financial Inclusion
The World Bank (WB) (2008) puts forward that financial inclusion is the absence of price or non-price barriers in the use of financial services. It further states that poor individuals and small entrepreneurs have to rely on informal sources to invest in between opportunities because of its timely availability and easy accessibility but at a much greater interest burden. Financial inclusion is the universal access to a wide range of financial services at a reasonable cost. These include not only banking products but also other financial services such as insurance and equity (Beck, 2009). According to the UNDP (2010), financial inclusion is the process of ensuring access to financial services and timely and adequate credit where needed by vulnerable groups such as weaker sections and low income groups at an affordable cost. In Regan and Paxton’s (2013) view financial inclusion as a continuum. Opening a bank account, though a positive step does not move from being excluded to include. In this manner Regan and Paxton (2013) states that financial inclusion is not about the access to financial products but also the quality of engagement with whose products and the need for individuals to develop skills and confidence to make informed decisions. Leeladhar (2015) is of the view that there are multiple levels of financial inclusion. At one extreme, there are customers who are actively and persistently courted by the financial services industry and who have at their disposal a wide range of services and products. These are super included. On the other extreme, there are financially excluded people who are denied access to even the most basic financial products. In between are the ‘under-included’ who use the banking services for deposits and withdrawal of money. These have only restricted access and may not enjoy the flexibility of access offered to the more affluent customers. Sarma (2009) notes that financial inclusion is measured with the use of three comparable dimensions thus accessibility, availability and the use of banking services.

1.2.2 Agency Banking
Shiraki (2011) suggests that agent banking is where banks are given the permission to engage third parties that provide certain banking services. In this view, agent banking can only be, when permission has been granted. Roberts, (2013) then explains that agent banking is conducting and offering of financial services to clients of a financial institution, mostly a bank through third party contracted by the institution to conduct business on its behalf under the normal traditional agency arrangement in which the bank is the
principle. Roberts (2013) brings the notion of the agency theory as he portrays the bank to be the agent. According to Atieno (2011) agent banking is a retail of postal outlets contracted by the financial institution or a bank network operator that processes the transactions of the clients. Rather than a brick and mortar branch teller, the owner of the agency conducts the transactions and allows the clients to deposit, withdraw, transfer funds, pay bills as well as make balance enquiries. Morrison (2016) points out that agent banking is convenience banking that benefits both the customer and the bank. He further explains that the client benefits from agent banking include the lower transaction costs, having the service closer to the home, as well as the longer hours of operation. The benefits of agent banking include offering of lower transaction costs, it has longer hours of operations, shorter lines than the branches, and more accessible to the illiterates and the very poor that might be intimidated in branches. For financial institutions, agent banking reduces costs of constructing bank premises and leasing costs, it enhances the name of the organization and its publicity besides sharing in the banks commissions on transactions done at agent premises (Morrison, 2016).

1.3 ESTABLISHING FINANCIAL INCLUSION THROUGH AGENCY BANKING
Chan and Gupta (2007) perceived usefulness as the extent to which an individual believes that using agency banking will be useful. Kim (2009) argues that an individual usually makes an evaluation of the consequences of his/her behaviour then decides with basis on desirability of the usefulness. Perceived usefulness with therefore influence one’s intention to adopt a system. In the agency banking context, one of the core objectives why people use agency banking is because the system is useful in making the transaction and it saves times. Bhati (2010) goes on to say that the benefits are seen by banks in the manner of a declined number of branches which further minimizes the cost per transaction. According to Wang (2013) perceived usefulness is the most significant factor that has an influence of one’s intention to use agency banking. This then suggests that agency banking has to be seen as useful as well as a quicker way of making bank transactions in comparison to the traditional banking system for it to be accepted by users. Luarn (2015) also points out that perceived useful is an important factor which determines the customer usage of agency banking. Wang (2013) concurs that customers opt for agency banking as a result of the relative advantage it has to offer. On another note, Suoranta (2013) postulates that the lack of awareness of agency banking usefulness as well as the realization of the benefits it has are the main factors that hinder the acceptance of agency banking. Relative advantage has to do with the comparative benefits that a agency banking use may get which could not be accessed from the traditional banking services as pointed out by (Pikkarainen, 2004). Furthermore, Pikkarainen (2004), explains that consumers are more likely to make use of a service agency banking when there are more benefits to gain in comparison to brick and mortar means like ATM as well as non-mobile internet banking, this also includes the cost and time. Moreover, another research carried out by Bhoomika (2014) found that 75% of the banking organizations represented pointed out that they had made significant improvements in the areas related to financial viability, financial profitability and competitiveness, all as a result of agency banking. However, According to Littler (2016) malfunction issues of banking server minimizes the willingness to make use of banking services and the same notion is apparent in agency banking. Security/privacy risk: is the potential loss incurred by the customers as a result of system hacking or fraudulent activities which compromises the security of the agency banking consumer. In a similar research Luarn (2015) used perceived credibility, which is the extent to which an individual believes the use of agency banking has no privacy or security threats. Time/convenience risk: this is the loss of time as a result of an inconvenience incurred due to payment delay or navigation difficulty (Lee, 2009). Social risk: this is the probability that the use of agency banking can be disapproved by family and colleagues.
Financial risk is the potential of monetary loss because of bank account misuse or transaction errors (Lee, 2009). Lee (2009), Lee and Kim (2015) gathered that all the risk factors are negative in the adoption of agency banking.

1.4 THEORETICAL FRAMEWORK

1.4.1 Agency Theory

Agency Theory is a theory which shows agreements between the owners of economic resources and the managers that are charged with the use and control of the resources given by the Principal (Lambert, 2002). In the early 1960s and 1970s economists explored the sharing of risks among individuals as well as groups. Agency theory widened the risk sharing idea. The agency theory is mainly about an omnipresent agency relationship in which The Principal gives work to The Agent who conducts the work. The Agent theory is cemented on the premise that agents have more information than the principals (Ibid). This asymmetry of information has an effect on the ability of the principal to carefully monitor their wealth hence the need for the agent. The theory is also of the assumption that principals and agent work hand in hand (Brigham & Gapenski, 1993). With the agency model, the organization is basically reduced to two contracting characters, thus the principal and the agent. The principal supplies capital, bears the risks, construct incentives as the agent makes the decisions on behalf of the principals as well as risk bearing (Lambert, 2002).

1.4.2 Bank led Theory

The basic version of the bank-led theory which is a branchless banking mechanism, licensed financial institutions thus bank deliver the financial services they offer through an agent. This means that the bank develops financial products or service and distributes them with the use of an agent who is in charge of customer interaction (Lyman, 2016). The bank becomes the ultimate financial services providers and the institution that maintains customers’ accounts. Retail agents only have face-to-face interactions with customers as they conduct cash-in/cash-out functions, more like a teller in the brick and mortar branch would accept deposits as well as process withdrawals (Ibid). The theory as recently expanded to include retail agents that handle the account opening procedure and in some instances they identify as well as service loans taken by customers. Any outlet that handles cash and is located near customers would potentially work as a retail agent. Whatever the understanding with the bank, every retail agent communicates with the bank it is working with electronically (Lyman, 2016). The equipment that is usually used by agents are mobile phones as well as electronic points of sale cards (Ibid). The bank-led model presents a distinct alternative to conventional branch based banking as customers can carry their financial transactions at a wide range of retail banking agents instead of going to the brick and mortar bank branch (Lyman, 2016). The model gives assurance of the potential to increase financial services outreach with the use of varying delivery channels, a different trade partner as well as having experience and a target market that is distinct from the traditional banks, agent banking may be significantly cheaper than bank based alternatives. With this model, the consumer account relationship lies in the control of the bank (Tomaskova, 2010). Errard (2012), suggests that with the bank led technological model the physical infrastructure of the agent is used to provide the basic banking needs like the enquiry of a balance, fund transfers between accounts, payments of goods and services at merchant outlets with the use of bank accounts (through ATM/Debit Card/Phone SMS etc). A number of services that are offered by agents were already being provided by banks and are operated under existing regulations; hence the bank-led model had no specific regulatory issues. Agent banking has been documented to lower the delivery costs.
to banks, which entails the costs of building as well as maintaining a delivery channel as well as the access to customer services (Pickens and Porteous, 2012). For instance in Brazil private as well as state-owned banks deliver financial services with the use of retail agents that include supermarkets, lottery kiosks, post offices, pharmacies as well as schools (Kumar et al, 2016).

1.4.3 Technology Acceptance Model
The theory was initiated by Fred Davis in 1986 and has gone through a series of validations and modifications. The purpose of the theory is to give a description of factors that govern the acceptance of technology, information technology behavioural usage as well as to give prudent theoretical explanatory model (Bourchard, 2010). The model is an extension of the Theory of Reasoned Action (TRA) by Ajzen and Fishbein (Kumar, 2013). Ducey (2013), posited that the variables covered in the Technology Acceptance Model (TAM) are Perceived Ease of Use and Perceived Usefulness; these are critical success factors on the technology acceptance as well as user behaviour. Teo (2013) observed that several factors promote the use and acceptance of technology. To add Teo (2013), explained on explained of the individual differences, the beliefs, the attitudes, the social influences as well as the situational influences as determinants, which foster the interaction of the usage of technology as well as the promotion of the acceptance or rejection to technology. Teo (2013) also insulates that individual behaviour is influenced by an intention to accept or reject technology usage. Therefore, the intention to use technology is because of the behavioural intention to accept or reject technology.

1.4.4 Innovation Diffusion Theory
The Innovation Diffusion Theory has five innovative characteristics namely relative advantage, compatibility, complexity, trial-ability and observability. The innovative variables look very different from others; however, they have a lot to do with each other in context of information systems. Moore (1991), shows that it was gathered that PU and relative advantage denotes the same thing whilst PEU captures complexity of the Innovation Diffusion Theory, in as much as the variables sound different. Kotler (2000), put forward that adopters often have different perceptions of the characteristics of the Innovation Diffusion Theory in comparison to non-adopters. According to Keller (2003) the characteristics of an innovation has an effect on the adoption rate. Some products are readily accepted while others take some time to be adopted (Keller, 2003). Ching and Ellis (2004), postulate that if an innovation is said to be of relative advantage thus better than the existing system, comparable thus consistent with the needs of consumers as well as with a decent measure of complexity thus being easy to use and understand it will most likely be favourable to the customers and will be easily adopted. Lee (2015) says that the perceived relative advantage, complexity and compatibility of innovations play an essential role in the adoption of agent banking. Combs and Vij (2009) and Lin (2011) discussed the Innovation Diffusion Theory by Rogers (2003) with attributes namely complexity, compatibility, relative advantage and triability and found that relative advantage, compatibility as well as perceived ease of use to be significantly related to the attitude to use agent banking. The researchers also suggested that compatibility has a positive relationship with the adoption of agent banking. They further state that customers often have a favourable perception on agent banking services when they positively view the relative advantage of agent banking.

1.4.5 Using Technology Acceptance Model as the theoretical framework
For the purposes of this conceptual paper, the Technology Acceptance Model is applied as the theoretical framework, in deriving the link between financial inclusion and agency banking. The Technology
Acceptance Model is a well-known theory which aims on investigating the factors which influence the technology adoption. Ducey (2013) also described this theory as a thrifty theory of adaptation to technology in a given context that postulates individual responses towards technology and can result in the intention to use of how to use, consequently having an effect on the actual technology usage (Suhartono, 2012). The intention to use technology is determined by three factors namely: personal one which is shown by human attitude, the subjective norms that reflects the social influences and finally the perceived behavioural control.

1.5 MODELLING FINANCIAL INCLUSION THROUGH AGENCY BANKING

*Ease of use.* In Ben-Kuen’s (2013) empirical investigation perceived ease of use has a strong significant on the acceptance agency banking. His findings suggest that customers look for a simple, easier and faster process and environment to conduct banking transactions. The findings also showed that perceived ease of use is a critical factor in determining the factor that explains the different in attitudes of the agency banking adopter and non-adopter.

*How triable.* According to Rogers (1995) this is the extent to which the innovative service can be tried on a limited basis. In Rogers’ thinking, there is a quick adoption of innovation when the innovation is tried before it is fully implemented when adoption seem to be slower in which pre-trial is not possible (Puscel, 2010). Tan and Teo (2010) asserted that when given the chance to make an evaluation of innovation, customers minimize their concern for the unknown service or product which ultimately leads to acceptance. A repetition of an evaluation as well as assistance in the use of agency banking during the trial period will then minimize the risk of negative perception towards agency banking; this then creates a positive customer attitude to the use of agency banking.

*Complexity.* Rogers (2003) suggests that complexity is the extent to which an innovation is perceived easy to understand and use. The adoption to innovation will be minimized if the innovation is said to be of complex to use (Ibid). Zmund (2013), proposed that complexity has a strong relationship with ease of use, as both constitutes mean the same thing.

*Compatibility.* According to Chen (2014) compatibility is the extent to which a service is said to be consistent with the existing values, habits, beliefs as well as the experiences of users. Rogers (2003) adds on by stating that compatibility is the extent to which an innovation is said to be consistent with the value of customers, their past experiences as well as the needs of the people that will likely adopt the system. An innovation can therefore be compatible with the socio-cultural values as well as beliefs of the customers, as well as that of a previously introduced innovation or with the innovation needs of the customers.

1.5.1 The Research Model

In reference to the reviewed literature and related theoretical analysis, the following conceptual has been formulated. It is showing that financial inclusion and agency banking stand as independent variables, mediating variables include human attitude, subjective norms and perceived behavioural control and lastly, the explanatory variables include intention to use agency banking, acceptance and adoption.
Proposed Conceptual Framework

H1: There is positive relationship between human attitude and intention to use agency banking.
H2: There is positive relationship between subjective norms and intention to use agency banking.
H3: There is positive relationship between perceived behavioural control and intention to use agency banking.
H4: There is positive relationship between perceived intention to use agency banking and agency banking acceptance and adoption.
H5: There is positive relationship between ease of use, how triable, complexity and compatibility of agency banking and, its acceptance and adoption.

In sync to the above research model the simple regression model below has been used to determine the linear relationships between variables:

\[ Y_{1,2} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + u_t. \]

Where \( Y_1 = \) Intention to use agency banking and,
\( Y_2 = \) Agency banking acceptance and adoption.
\( X_1 = \) Human Attitude.
\( X_2 = \) Subjective Norms.
\( X_3 = \) Perceived Behavioural Control.
\( X_4 = \) Intention to Use Agency Banking.
\( X_5 = \) Agency Banking Qualities.

Source: Authors’ own conception (2018). With the stated schematic conceptual model, the following propositions can be formulated, in sync to customers’ expectations;
\[ u_t = \text{Unobserved error term.} \]

* \( Y_1 \& 2 \) are the Dependent/Response Variables.

*From \( X_1 \) to \( X_5 \) represent the Independent/Explanatory Variable.

### 1.6 Zimbabwean agency banking trajectory towards financial inclusion case study

Chidoko, et al (2011) cited in Chokuda-Santu (2017), noted that Zimbabwe’s fast growing informal sector is now the country’s largest employer as the economy is failing to absorb many job seekers into formal employment. The banking sector has 21 operating banks, including the People’s Own Savings Bank and 146 microfinance institutions (POSB) (RBZ, 2014; Chitokwindo et al., 2014). Contribution to total bank assets are 82.69% by commercial banks, 1.35% by savings bank, 13.65% by Building Societies and 2.31% by Merchant banks (Ibid). The country adopted a multicurrency system in February 2009 and since then, banks have been operating with price structures that the RBZ view as not affordable to the poor people. Most banks are represented in urban centres whilst only POSB, Agribank and CBZ bank have a strong rural presence despite the call since 2006 by the RBZ for banks to open branches in rural areas (Ibid). The same is true for the financial inclusion initiatives that the Bank has been pursuing through timely provision of targeted empowerment facilities to interest groups such as women, SMEs, the youth and the disabled. These facilities have had significant impact in supporting broad-based and inclusive growth for both local consumption and export generation. As part of the National Financial Inclusion Strategy, the Women’s Microfinance Bank and Empower Bank are now operational (RBZ, 2018). The RBZ came up with a framework for financial inclusion in 2007 which was premised on the following pillars:

- expanding the outreach of established developmental financial institutions such as People’s Own Savings bank (POSB), ZIMPOST and Agribank;
- expanding the outreach of established commercial banks and building societies;
- enhancing provision of microfinance services through establishment of microfinance banks (MFI Banks) or Financial Inclusion Centres (FICs);
- urging relevant authorities to ensure provision of adequate infrastructure including roads, telecommunication coverage and provision of electricity;
- Provision of appropriate incentives to financial institutions engaged in rural banking; and
- engaging other stakeholders to facilitate the provision of other incentives.

**Source:** RBZ (2006:56) and Chitokwindo et al., (2014).
However, the beginning of agency banking in Zimbabwe dates back to 2013, with the Steward Bank. The innovative bank was migrating from the TN Bank to Steward Bank after agency conflicts arose. After the lessons learnt from TN Bank, Steward Bank wanted to operate on a low cost strategy whilst tapping the vertical segment of the populace. Moreover, Agent Banking was seen as the best strategy to execute, considering the nation is aiming to ensure that 70% of the under-banked population is included in the financial sector. The everyday banking for everyday people bank cut down from the 32 TN Branches to 7 Steward Bank branches in the Harare after being absorbed by Econet Wireless. The ever dynamic bank wanted to shift focus from the brick and mortar to agent banking. With such a strategy the bank required agencies that would help it fill up the nation with Steward Bank account holders, thus mass banking. The prospective agents had to be Ecocash Agents as well as people that had businesses which were giving them cash on a daily basis. The bank tried to mitigate the risk of giving agents cash, be making Ecocash agency and the existence of a thriving business a prerequisite. Moreover, Steward Bank also engaged corporates like the sister company Econet and has agents in each Econet outlet. Zimpost is another corporation that received fund advancement as well as branding material which was distributed to 227 Zimpost outlets nationwide. The innovative bank made so much noise about the agent banking to a point that everyone wanted to become an agent. Numerous people opened accounts and others became banking agents. To this day Steward Bank boasts more than 3 000 agent banking outlets, though the banking institution had a target of 5 000 agents. When making use of an agent bank retailer customers are able to open an account, transact, deposit and withdraw their funds. The agent bank is not a brick or mortar but just a tablet where all the details are entered and immediately updated in the banking system, through the Steward Bank network. This would enhance customer based brand equity when the customer has high level of awareness and familiarity with the brand, the customer will hold strong favourable and unique bank’s brand association in memory (Nyagadza, Chodeva and Vingirayi, 2018). Steward Bank continuously improves the product, updates the system as well as well as trains the agents to ensure that they deliver quality services to the customer thus enhance financial inclusion. Due to the flexibility of Agent Banking numerous accounts have been opened in various areas.

1.7 DISCUSSION

In volume terms, more than 99% of payments are being made through electronic and mobile agency banking platforms with mobile banking constituting 84% (RBZ, 2018). This has significantly contributed to the increase in financial inclusion through mobile banking which now stands at more than 80%. In terms of regional comparison, it is pleasing to note that Zimbabwe is now amongst the leading countries in the use mobile banking products (Ibid). The Finscope (2014) quoted by Chokuda-Santu (2017), the survey on financial inclusion estimated that the informal sector had as much as $7.4 billion circulating outside the formal financial system. This presents both an opportunity and a challenge for banks, especially considering that the same survey highlighted the extent of financial exclusion in the economy. There is a significant 54% of the adult that are economically active that is unbanked or under-served by the formal financial system (Santu-Chokuda, et. al, 2017). With this, the suggested model can serve as guideline to commercial bank managers and management executives in understanding depositors’ needs, and building strong agency banking in competitive markets. Banks need to position their agency banking in the minds of depositors, so as increase the room for
higher acceptance. To achieve desired goals of their financial inclusion strategy through agency banking, commercial banks have to break the clutter by evolving innovative ways to attract the attention of the target audience. The managers or authorities responsible for agency banking need to make enough monitoring and tracking of the desired performance of the agency banking initiatives. The agency banking as a financial inclusion mode, enable companies to leverage the commercial banks to new banking products, and chart new growth paths, in specific markets.

1.8 CONCLUSION
The paper discussed the financial inclusion through agency banking model based on literature reviewed and Zimbabwean case study. The level of consistency along the financial inclusion through agency banking, targeted towards the customers or depositors is critical to the success of agency banking by any banking or financial institution. Banks need to ensure that their agency banking model is strong even in turbulent moments and offers value for money, congruent to the corporate missions and values. The independent variables, mediating variables include human attitude, subjective norms and perceived behavioural control and lastly, the explanatory variables include intention to use agency banking, acceptance and adoption, need to be enhanced to build a convincing agency banking for profit-oriented institutions such as banks.

1.9 COMPETING INTERESTS
There is no interference on how the literature review results were presented, due to the fact that the author had no experiences with the organisations involved in the study.

REFERENCES


AN INVESTIGATION INTO THE FACTORS DETERMINING THE SUCCESS OF BUSINESS INCUBATORS IN ZIMBABWE- THE CASE OF HARARE

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ABSTRACT
The main purpose of this study was to investigate the factors associated with the success of business incubators in Zimbabwe. For the past two decades Zimbabwe has been grilling with very high levels of unemployment coupled by very low economic growth rates hence the need to come up with effective business incubators to solve the country’s developmental and unemployment challenges. Thus the study sought to examine the services provided by business incubators to new businesses in Zimbabwe, to describe the challenges faced by business incubators in Zimbabwe and to understand the key success factors to enhance the effectiveness of business incubators in supporting new businesses in Zimbabwe. The research involved the use of mixed research methods making use of both quantitative and qualitative techniques of 5 business incubators managers and 3 officials from the relevant ministry. The research revealed that business incubators in Zimbabwe provide business consultant services, mentorship and coaching, networking and assistance with registration and licensing. The challenges they are facing include shortage of financial resources, technical skills and working space, lack of commitment from entrepreneurs, poor managerial effectiveness in business incubators, harsh economic conditions and inconsistent support from stakeholders. Thus the study recommended that business incubators should use strict screening methods, higher qualified managers, network with stakeholders, invest in ICT and use innovative business models while government should render consistent support to business incubators in the country.
INTRODUCTION

Business incubators have been heralded as a panacea for the successful establishment of new businesses that can solve a country’s developmental and unemployment challenges. Business incubators are institutions that support new and small businesses to survive and grow into self-sustainable and profitable businesses (Robinson, 2010). They promote entrepreneurship by helping the businesses overcome the liability of newness and the liability of smallness. Suk and Mooweon (2006) explain that the liability of newness refers to the limitations faced by new businesses which include lack of established relations with customers, lack of an established history and lack of legitimacy. On the other hand, the liability of smallness deals with the risks faced by small businesses like lack of financial, physical and human resources (Chanda and Silva, 2012). This study aimed at promoting business incubators in order to stimulate sustainable economic development in Zimbabwe.

The need for business incubators that help build sustainable businesses comes in the background of sustained low economic growth and high unemployment rates in Zimbabwe over the last two decades. The hyperinflationary environment of 2000-2008 had detrimental effects on major businesses in Zimbabwe as they failed to cope with an unstable currency, lack of foreign currency, depressed demand and a host of other challenges (Damiyano, Muchabaiwa, Mushanyuri and Chikomba, 2012). This resulted in massive company closures, reduced capacity utilization and the retrenchment of workers. According to Kanyenze, Chitambara and Tyson (2017) from 1999 to 2007 the country recorded negative economic growth rates between -2% to -11%. At the same time unemployment continued to increase at 130% per year with the Confederations of Zimbabwean Industries (CZI) (2007) reporting an 80% unemployment rate in 2007. After the introduction of the multicurrency system in January 2009 so stability was restored to the economy. However, the challenges of poor liquidity, low foreign direct investment, shortage of foreign currency and antiquated plant and equipment continued to affect the sustainability of businesses in Zimbabwe. As a result, the spat of company closures, poor capacity utilization and massive unemployment has continued to hound the Zimbabwean economy.

On the other hand, there has been an increase in the establishment of small and medium enterprises (SMEs) and informal businesses in Zimbabwe. Muponda (2012) attributes this trend to the massive unemployment that has forced people to start their own businesses. SMEs have been championed for their contribution to socio-economic development. In line with The National Institute of Micro, Small and Medium Enterprises of India (2011) SMEs contribute over 55% to Gross Domestic Product (GDP) in most countries. In Zimbabwe SMEs contribute to 60% of the GDP (Kutsaru, 2014). The
Fincsop Report (2013) further reveal that SMEs contribute to 70% of Zimbabwe’s employment. This therefore underscores the utility of promoting the establishment and growth of SMEs in the country.

However, SMEs in Zimbabwe have been threatened by a number of challenges which pose harmful threats to their sustainability and enhanced contribution to the national economy. This is concurred by Foster (2012) revealing that 57% of SMEs fail within 5 years of operation. A study carried out by Nyamwanza (2014) indicated that SMEs in Zimbabwe fail because of lack of managerial and leadership skills as well as poor planning needed to succeed in harsh economic conditions. Muponda (2012) also indicated that SMEs in Zimbabwe were failing to grow because of lack of access to financial markets. This is seconded by Sharma and Kumar (2011) highlighting that most SMEs fail to access credit from banks because of lack of collateral and inability to defend their project proposals. Thus these and many other challenges warranty the enrolment of such SMEs in business incubators so that they are given the requisite tools to survive and grow, thus contributing to sustained socio-economic development in Zimbabwe. It was therefore against this background that the study sought to investigate the promotion of business incubators for sustainable economic development in Zimbabwe.

2. **OBJECTIVES**

The study sought to investigate what needs to be done in order to establish viable business incubators that are effective in enhancing entrepreneurial development in the country. The specific objectives of the study were

- To examine the services provided by business incubators to new businesses in Zimbabwe
- To describe the challenges faced by business incubators in helping the sustainability of new businesses in Zimbabwe
- To understand the key success factors to enhance the effectiveness of business incubators in supporting new businesses in Zimbabwe

3. **METHODOLOGY**

This section describes and explains the methods used by the researchers in carrying out the study. The research was based on a pragmatist philosophy encompassing both quantitative and qualitative data. Neuman (2011) defines a pragmatist philosophy as a research philosophy that incorporates elements of positivism and interpretivism in order to fulfill the research objectives. The pragmatist philosophy was used because it enabled the study to employ a combination of methods to sufficient satisfy the research objectives. It made triangulation of quantitative with qualitative data to produce reliable...
findings. The research design was a descriptive survey. A descriptive research design is one that seeks
to describe in greater depth the research phenomena (Blumberg et al., 2011). It made it possible to
dig deeper into the services provided by business incubators, the challenges they are facing as well as
key success factor in enhancing their effectiveness. The target population was composed of 8 business
incubators in Harare with 72 managers and staff. These were chosen because by being employed in
business incubators it meant that they could give reliable responses regarding how their organizations
are operating. In addition, the research also made use of key informants from the Ministry of Small
and Medium Enterprises and Cooperative Development in Harare. These were able to give important
insights into what needs to be done in order to enhance the effectiveness of business incubators. Due
to the relatively small size of the population no sampling was required for the business incubator
population. On the other hand, a purposive sample of 3 key informants was drawn from the Ministry
of Small and Medium Enterprises and Cooperative Development. Purposive sampling was used
because it enabled the researcher to target those that were willing and had the necessary information
to answer reliably to questions posed to them.

The research made use of two main research instruments namely self-administered questionnaires and
semi-structured interviews. The questionnaires which had closed questions were administered to
business incubator managers and staff. This made it easy to collect large amounts of data that could
be analyzed using statistical methods. It also saved time and was a cheaper way of collecting data. On
the other hand, semi-structured interviews were held with business incubator managers and key
informants from the Ministry of Small and Medium Enterprises and Cooperative Development. They
made it possible to collect more detailed information on the dynamic of running business incubators
in Zimbabwe. The research could use follow up questions thus being able to probe deeper into the
perspectives of the respondents. Data analysis was composed of quantitative and qualitative
techniques. The qualitative techniques involved the use of mean scores and standard deviations which
helped summarize the responses. They also included the use of Mann-Whitney test p values in order
to test the significance of the results. On the other hand, qualitative data was transcribed and coded
based on the study objectives. The research observed ethical considerations in carrying out the study.
The researchers showed respondents a print out of the e-mail from the Research Council of Zimbabwe
(RCZ) authorizing her to undertake the study. She also explained clearly the purpose of the study to
the respondents and how the respondents would help in the process. In addition, the researcher
maintained confidentiality of the responses and assured respondents that their responses would remain
confidential and used for research purposes only.
4. RESULTS

The research obtained data from self-administered questionnaires from business incubators managers and staff as well as semi-structured interviews with business incubator managers. Table 1 below shows the response rate.

**Table 1: Response rate**

<table>
<thead>
<tr>
<th>Respondents</th>
<th>Questionnaires administered/Interviews sought</th>
<th>Questionnaires received/Interviews held</th>
<th>% Response rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Managers</td>
<td>8</td>
<td>5</td>
<td>62.5</td>
</tr>
<tr>
<td>Staff</td>
<td>64</td>
<td>39</td>
<td>60.9</td>
</tr>
<tr>
<td>Key informants</td>
<td>3</td>
<td>3</td>
<td>100</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>75</strong></td>
<td><strong>47</strong></td>
<td><strong>62.7</strong></td>
</tr>
</tbody>
</table>

Table 1 above indicates managers had a 62.5% response rate, staff had a 60.9% response rate and key informants from the Ministry of Small and Medium Enterprises and Cooperative Development had a 100% response rate. Thus key informants had the highest response rate. This could be attributed to the purposive sampling technique used which ensured the selection of those who were willing to participate in the study. Overall the research enjoyed a high response which thus enhanced the reliability of its findings.

4.1 Services provided by business incubators to new businesses in Zimbabwe

The first objective sought to examine the services provided by business incubators to new businesses in Zimbabwe. Thus the managers and staff who took part in the study were asked questions regarding the services provided by their organizations to new businesses. Questionnaire respondents were asked to indicate by a tick the services that are provided by their organizations to incubatees. Fig 1 below illustrate the results from the questionnaire responses.
Fig 1: Services provided by business incubators in Zimbabwe

SOURCE: QUESTIONNAIRE RESPONSES

According to Fig 1 above 36.4% of the respondents indicated that their organizations provide working space and infrastructure to their clients. These results showed that the majority of the respondents indicated that working space and infrastructure was not among the services provided by most of the business incubators. The findings also showed that business plan development had a response rate of 100%. This shows that all respondents highlighted that this service was provided by their organizations. 77.3% indicated that their organizations provide marketing and financial management advice to their clients. Hence the majority of the respondents agreed that marketing and financial management advice is provided by their organizations to new businesses under incubation. In addition, 84.1% of the respondents showed that their business incubators provide assistance with registration and licensing to their clients. This indicated that most business incubators managers and staff who participated in the survey indicated that their organizations assisted new businesses with registration and licensing.

On the provision of financial resources only 27.3% indicated that the services are provided to new businesses by their organizations. These results showed that most respondents indicated that their organizations do not provide financial resources to new businesses. On the other hand 100% of the respondents showed that mentoring and coaching with experienced business people is provided by their organizations to incubatees. Hence this indicated that mentoring and coaching services are
provided by most business incubators in Zimbabwe to a greater extent. This agreed with findings from most of the interview respondents who highlighted that they often hire established entrepreneurs to give inspiration to the incubatees. The results indicated further that the business incubators provide new businesses with networking to boost business links and relationships as shown by the 88.6% of the respondents who ascended to the notion. These findings agreed with most of the interviewees who cited networking services as being among the services they provide new businesses to enhance their growth and sustainability. In the words of one interviewee, “we also offer psychological support to our clients by providing an environment in which they can interact and share experiences with others having the same entrepreneurial dreams”. Hence the study pointed out to networking as being among the key services offered by the business incubators in Zimbabwe.

4.2 Challenges faced by business incubators in Zimbabwe

Describing the main challenges faced by business incubators in Zimbabwe was among the main objectives of the study. In this regard the business incubators managers and staff responded to closed questions regarding how far they agreed to the existence of business incubator challenges in their organizations based on a Likert scale of 1= strongly disagree to 5= strongly agree. The data was also complimented by interview responses from business incubators managers. The results Table 2 below indicate the questionnaire responses summarized through mean scores, standard deviations and tested for significance using the Mann-Whitney test at 5% significance level.

Table 2: Challenges faced by business incubators in Zimbabwe

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Mean</th>
<th>St. deviation</th>
<th>P values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of financial resources</td>
<td>3.57</td>
<td>1.218</td>
<td>0.629</td>
</tr>
<tr>
<td>Poor managerial effectiveness</td>
<td>2.63</td>
<td>2.114</td>
<td>0.076</td>
</tr>
<tr>
<td>Lack of technical skills</td>
<td>2.82</td>
<td>1.232</td>
<td>0.769</td>
</tr>
<tr>
<td>Inadequate space</td>
<td>3.44</td>
<td>1.633</td>
<td>0.162</td>
</tr>
<tr>
<td>Uncommitted entrepreneurs</td>
<td>2.68</td>
<td>1.581</td>
<td>0.194</td>
</tr>
<tr>
<td>Harsh economic conditions</td>
<td>4.21</td>
<td>1.743</td>
<td>0.282</td>
</tr>
<tr>
<td>Inconsistent support from stakeholders</td>
<td>3.06</td>
<td>1.814</td>
<td>0.640</td>
</tr>
</tbody>
</table>

Source: Questionnaire responses
Table 2 above indicate that lack of financial resources had a mean score of 3.57 with a p value of 0.629. This result showed that the majority of the questionnaire respondents were in strong agreement with the notion that lack of financial resources is hindering the effectiveness of business incubators in helping the sustainability of new businesses. The p value was above 0.05 showing that the result was significant at 5% significance level. These findings were also supported by interview respondents who lamented the shortage of financial resources in their organizations. One of them explained that, “the major challenge that we face here is insufficient funds to pay for our operating expenses. As a result, we are forced to limit the number of clients that we can accommodate”. The results also indicated that poor managerial effectiveness had a mean score of 2.63 and a p value of 0.076 hence showing that most respondents agreed that poor managerial effectiveness is among the main challenges affecting the effectiveness of business incubators in Zimbabwe. The respondents further agreed that their organizations lacked sufficient skills to provide relevant services to entrepreneurs as shown by the mean score of 2.82 which was above 2.5. The findings indicated that the mean score for inadequate space was 3.44 with a p value of 0.162 showing that most respondents were positive that inadequate space was also hindering the effectiveness of their organizations in promoting new businesses. Business managers who were interviewed by the research also indicated that shortage of space to provide incubatees was also a challenge. In the words of one interviewee, “space is a major impediment to our operations at this facility. If we could get more space we would be able to provide better services to our clients”. Uncommitted entrepreneurs had a mean score of 2.68 and a p value of 0.194 showing that the respondents agreed that it was negatively impacting the effectiveness of their organizations. The findings further indicated that harsh economic conditions had a mean score of 4.21 and a p value of 0.282. This indicated that the majority of the business incubators managers and staff were very positive that the success of their organizations was severely impeded by the hostile economic environment. These sentiments were also echoed by the interviewees. “We are in turbulent economic times and it is not a secret that most organizations are struggling. We can’t get loans from banks because of the stringent liquidity situation in the country”, lamented one of the managers. Furthermore the respondents agreed that their organizations are suffering from inconsistent stakeholder support as indicated by the mean score of 3.06 and a significant p value of 0.064.

4.3 Key success factors to enhance the effectiveness of business incubators

The last objective of the study was to understand the key success factors to enhance the effectiveness of business incubators in helping new businesses in Zimbabwe. Data on what needs to be done to improve business incubators was mainly qualitative obtained from semi-structured interviews with 5 business incubator managers and 3 key informants from the Ministry of Small and Medium
Enterprises and Cooperative Development. The results of the study produced a number of key success factors that should be considered by business incubators and key stakeholders for business incubation to be more effective in the country. These are illustrated in the diagram in Fig 2 below.

**Fig 2: Key success factors to enhance the effectiveness of business incubators**

**SOURCE: INTERVIEW RESPONSES**

Among these most of the interviewees identified the quality of entrepreneurs as a major success factor in enhancing business incubator effectiveness. They concurred that business incubators should select entrepreneurs who are business minded, have the ability to take calculated risk and are motivated to succeed. One business incubator manager explained that, “The nature of the entrepreneurs incubated has a significant bearing on the success of the incubation exercise. Entrepreneurs with good managerial and technical skills are better able to utilize the services offered by the business incubator”. Another interviewee pointed out that business incubators must select entrepreneurs with a desire to succeed for self-motivation is crucial to commitment to the incubation process. Hence the results of the study indicated that the quality of the entrepreneur improves commitment to the incubation process as well as the ability to fully exploit the services offered by the incubator thus enabling the entrepreneurial venture to grow faster and become self-sustainable. They also emphasized that business incubators should employ careful selection methods that ensure that they obtain quality entrepreneurs who can best benefit from the incubation process. The versatility of a careful screening method has been highlighted in Start-upLab a Norwegian business incubator.
established in 2012. In line with Bjercke (2015) the business incubator employees a strict screening process which include identifying whether the start-up is in the technological sector focusing on software, viability of business concept, entrepreneurial commitment, passion and enthusiasm and appreciation of teamwork. To date the business incubator has produced at least 130 successful start-ups.

In addition the majority of the interviewees concurred to the importance of skilled and experienced management in enhancing business incubation success. One of them from the Ministry of Small and Medium Enterprises and Cooperative Development said that, “business incubators need to be run in an efficient and effective manner. Therefore it is crucial to have sufficiently trained and experienced managers who are able to design and implement strategies to ensure the viability of the business incubator”. This was also agreed upon by one business incubator manager who added that, managerial skills enable managers to identify the appropriate ingredients needed by entrepreneurs to grow their businesses. She explained that, “Managers should also have important connections with established businesses and potential investors so that they are able to connect their incubatees, linking them to partners and investors”. Thus the results of the study showed that business incubator managers should have the necessary skills and experience as well as connections with key stakeholders.

At the same time most business incubator managers pointed out to the crucial role played by government support in enhancing the success of their organizations. According to one manager, “sufficient support from government would enable us to obtain the much needed funding for sponsoring the entrepreneurship ventures of our members”. This was concurred by most interviewees who said that government can negotiate sponsorship programs for incubatees from various stakeholders from governmental, nongovernmental organizations to multilateral institutions. “Sponsorship can also be used to bankroll the activities of the business incubator so that it can provide the needed infrastructure to entrepreneurs and finance its day to day running operations”, said one business manager. Apart from funding some interviewees highlighted the importance of supportive government policies aimed at addressing the economic challenges and creating a business friendly environment. They also pointed out to favourable policies aimed at encouraging innovation and the growth of the small and medium enterprises sector.

On the other hand key informants from the Ministry of Small and Medium Enterprises and Cooperative Development emphasized on the self-sustainability of business incubators. They highlighted that business incubators should come up with ways of sustaining themselves for them to be able to effectively contribute to entrepreneurial success. One interviewees said that, “business
innovators should lead by example by producing innovative business models that would not only finance their operations but enable them to operate at a profit”. Another key informant also said that “business incubators should ensure they generate income to finance their everyday operations through charging membership fees, royalties and obtaining equity stakes in some of the incubated businesses”. Thus the key informants pointed out to the use of innovative business models to help produce revenue for business incubators so that they solve most of their financing challenges. In this regard a number of successful business incubators have relied heavily on their ability to create revenue in aiding the success of their operations. Digital Hub Region Bonn in Germany for example is registered as a private limited company and create value through investing in successful incubated businesses (Deimel, 2017). The author further revealed that Digital Hub Region Bonn’s registration as a company has made it easy to incorporate the interests of its collaborators which include entrepreneurial development, technical progress and knowledge transfer.

Apart from that the semi-structured interviews revealed that networking is a key success factor influencing the effectiveness of business incubators in supporting new businesses. The majority of the interviewees highlighted that business incubators should form networks with key stakeholders important in overcoming the liability of newness and smallness faced by new entrepreneurs. One interviewee pointed out that,

“business incubators should have long lasting relationships with key stakeholders including government institutions, universities, investors, established businesses and professionals. With such contacts, it would be easy for business incubators to mobilize funding for their incubatees as well as help the incubatees market their products and services”.

Other interviewees emphasized the usefulness of networking in making it easy for business incubators to obtain technological infrastructure from universities and mentoring and coaching services from successful business people thus helping in the efficient and effective provision of business incubation services to entrepreneurs. The Business and Technology Incubator in the Gaza Strip is one instance of a business incubator that has benefitted immensely from networking. According to Skaik (2013) the incubator networks with key stakeholders including private companies, universities, government institutions, investors and global developmental agencies thus being able to acquire services for its incubatees. The incubator has so far produced more than 30 successful companies running in the Gaza Strip.

On top of that interviewees from the Ministry of Small and Medium Enterprises and Cooperative Development urged business incubators to invest in information and communication technology
(ICT) as it is crucial in aiding innovation and communication effectiveness among the incubatees. They highlighted the importance of ICT in modernizing the operations of new businesses at a cheaper cost. In the words of one interviewee,

“ICT is an indispensable tool that can be used by new and small businesses to enhance their operations. For instance it paves way for cost effective marketing methods like social media marketing and customer relationship management making it easier for these ventures publicize and market their businesses”.

Some interviewees also pointed out to the usefulness of ICT in enhancing production and business planning thereby affording competitive advantage to the entrepreneurial ventures. Investment in ICT has also enabled the Graduate Enterprise Academy (GEA) in Kenya to enhance efficiency in providing useful services to its clients (Wanderi, 2017). The organization has been able to circumvent the shortage of skills and financial resources to higher qualified staff by providing digital mentorship and online training programs. Thus despite these shortages the business incubator has produced 9 established business in Kenya since 2013. Thus investment in ICT was heralded for its effectiveness in enhancing the success of incubated businesses.

At the same time document analysis has shown that collaboration with key stakeholders is a key success factor aiding the effectiveness of business incubators. For instance through collaboration with technological firms iHub in Kenya established in 2010 has been able to benefit from free internet access for its clients provided by Zuku and Safaricom thus extensively cutting operation costs. In the same vein most business incubators collaborate with universities, private companies and developmental agencies in spearheading their incubation programs. One example is The Digital Hub Region Bonn in Germany formed through the initiatives of Bonn University, Bonn-Rhein-Sieg University of Applied Sciences, Bonn/Rhein-Sieg economic development agency, the Chamber of Commerce, private investors, local firms and global developmental players. The incubator has thus had easy access to financial resources, cheaper mentorship and training services, technical and managerial expertise as well as opportunities for marketing its incubated businesses.

5. DISCUSSION

The results of the study were discussed with the help of literature in order to find out areas of agreement and disagreement. On the services provided by business incubators in Zimbabwe the majority of the respondents agreed that business incubators in Zimbabwe provide workspace and infrastructure for their clients. These findings disagreed with a number of scholars including Mireftekhari (2017) who underscored that provision of cheap working space and access to
infrastructure was among the main services offered by business incubators to their client. The results also showed that the practice in Zimbabwe is contrary to other business incubators in other countries including in Germany and Kenya where work space and infrastructure are the chief services offered to entrepreneurs (Deimel (2017); Wanderi (2017)). A possible explanation for this is that business incubators in Zimbabwe have limited financial resources to provide all the needed services to their client. This is concurred by Caleb, Olaopa and Siyanbola (2012) highlighting that most business incubators in developing countries lack the necessary physical and financial resources to support entrepreneurial development effectively.

On the other hand the results of the revealed that most business incubators in Zimbabwe work with business plan development. The findings were in line with Al-Mubaraki and Busler (2013) revealing that business incubators help their clients with a range of business advisory services which include the development of business plan. Kibuchi (2014) also add that business incubators train their incubates in designing quality business proposals so that they are better able to identify and exploit business opportunities effectively. In addition the majority of the respondents indicated that their organizations also provide marketing consultancy services to their clients. This is concurred by Wachira (2017) who study in Kenya found out that business incubators in the country helped their clients design and implement effective marketing strategies. In the same vein the study also indicated that the majority of business incubators in Zimbabwe help provide financial management training and advice to their clients. These findings were in line with Lose, Maziriri and Madinga (2016) who championed the provision of financial management skills to incubatees as crucial for their growth and development. Furthermore the business incubators managers staff revealed that their organizations assist entrepreneurs with registration and licensing requirements. These findings concurred with Altink (2009) who obtained similar findings while investigating the effectiveness of business incubators in Bosnia and Herzegovina. In the same vein case studies of business incubators across the world show that business consultancy is among the key services provided by business incubators to their clients including university business incubators in Latvia (Cirule, Grama, Ludviga and Kreituss, 2017). Thus the study showed that business incubators in Zimbabwe are providing a number of crucial business development consultancy services to help entrepreneurs grow their businesses.

However, the findings of the study indicated that most of the business incubators in Zimbabwe are not assisting their clients with the provision of funding for their ventures. These findings are contrary to a number of scholars citing Moraru and Rusei (2012) who indicated that business incubators help mobilize funding for entrepreneurs. Mireftekhari (2017) also found out that business incubators offer funding to help entrepreneurial innovation get established. Also according to Deimel (2017) business
incubators in Germany invest their own resources to promising ventures as well as mobilizing financial resources from key stakeholders to help operationalize their clients’ entrepreneurial ideas. A possible reason for the absence of funding in most business incubators in Zimbabwe is the shortage of financial resources as well as poor networking of business incubators which make it difficult for business incubators to mobilize resources from key stakeholders.

On the other hand, the findings showed that most business incubators in Zimbabwe provide mentoring and coaching of their clients with experienced business people. These findings concur with Cohen (2013) who identified mentoring and coaching as being among the key services offered by business incubators to their clients. Hoffman and Kelley (2012) further explain that business incubators provide mentoring and coaching services so that their clients get to learn from experienced business people as well as being inspired to succeed in their entrepreneurial ventures. Hence in terms of mentoring and coaching the business incubators in Zimbabwe are doing a great job in developing entrepreneurship.

In the same vein the bulk of the respondents indicated that the business incubators provide networking services to build business relationship for their clients. Networking services are among the most popular services offered by business incubators as evidenced by several scholars including Tambudze (2012). Networking is very crucial in fostering collaboration among entrepreneurs as well as facilitating marketing of the new business ventures at cheaper costs. This is concurred by Wachira (2017) underscoring the need for business incubators to organize seminars, workshops and conferences on a regular bases to spearhead networking of the clients.

The research went on to identify a number of challenges that are hindering the effectiveness of business incubators in Zimbabwe. Both questionnaire and interview respondents agreed that lack of financial resources is making it difficult for business incubators to finance themselves and mobilize funding for the incubates. The lack of funding has been found to be a major factor affecting the operations of business incubators in most countries. This was revealed by several scholars among them Tengeh and Choto (2015) who undertook a study on the benefits and challenges of business incubators in South Africa. However Koshy (2010) argued that the emergence of for profit and university funded incubators is helping in reducing the effects of funding challenges.

The research also revealed that business incubators in Zimbabwe suffer from poor managerial effectiveness. This is concurred by Bigirimana, Jagero and Mutiwayyuka (2015) whose study revealed that a business incubator established by the Catholic church in Rushinga failed due to unavailability of skilled and experienced managers to run business incubators efficiently and choose
the programs that are relevant to a lift the entrepreneurial development of incubates. In the same vein
the findings of the study showed that business incubators in Zimbabwe lacked technical skills to
provide effective services to entrepreneurs. Ernst & Young (2014)’s study also found lack of
managerial and technical skills detrimental to the success of business incubation in Russia. A possible
reason for this is that most business incubators do not have sufficient financial resources to offer
remuneration attractive to skilled and experienced managers.

In addition inadequate space was found to be a major impediment to the ability of business incubators
to provide effective services to entrepreneurs. Most interviewees lamented that they do not have
sufficient space to accommodate a critical number of entrepreneurs needed for sustainability. These
findings were in line with Caleb et al. (2012) who commented that lack of space was a common
challenge to business incubators in most countries. They also agreed with Choto, Tengeh, R. and Iwu
(2014) who highlighted that sufficient space for production and offices.

The findings of the study also indicated that the majority of the respondents considered lack of
commitment from entrepreneurs a key challenge hindering the effectiveness of business incubators
in Zimbabwe. These results agreed with Rolfe, Woodward, Ligthelm and Guimaraes (2010) who
explained that some entrepreneurs may enter into business for the sole purpose of survival while
waiting for formal employment thereby affecting their commitment to the long run survival and
growth of their businesses. Hence this situation calls for effective selection criteria for entrepreneurs
so that business incubators deal with those that have the necessary entrepreneurial skills and spirit.
The importance of selection criteria has been emphasized by many scholars including Khalid, Gilbert
and Huq (2012) arguing that business incubators must select those entrepreneurs who have the
necessary managerial and technical skills as well as motivation for success.

Above that harsh economic conditions were blamed by most respondents as being detrimental to the
viability and sustainability of business incubators in Zimbabwe. The impact of harsh economic
conditions on the performance of businesses and nonprofit organizations has been lamented by several
scholars. These include Kanyenze et al. (2017) who revealed that most organizations were failing to
access funding from financial institutions due to the low levels of liquidity in the Zimbabwean
economy. Skaik (2013) also explained that the success of business incubators varies with the nature
of the economic conditions under which the business incubators operate since economic condition
bear much on the success of entrepreneurial activities within an economy. Hence the results supported
the notion that there must be effective policy towards the creation of a sound business environment
in order to enhance the success of business incubators.
Furthermore the results of the study indicated that business incubators in Zimbabwe are negatively affected by insufficient support from stakeholders. This concurs with Tengeh and Choto (2015) who found inconsistent stakeholder support to be detrimental to the success of business incubators in South Africa. In the same vein Buys and Mbewana (2007) also explained that there is need for cooperation from stakeholders including government, large businesses and investors in order to ensure that business incubators are better able to fulfill their objectives, chief among them producing successful entrepreneurs who are skilled and well-funded. Thus the findings of the study pointed out to the need for sufficient support from stakeholders in order to help business incubators develop entrepreneurs in Zimbabwe.

On the key success factors to enhance the effectiveness of business incubators the interview respondents came up with a number of insights. The research revealed that the majority of the respondents identified the quality of entrepreneurs as being one of the key success factors to ensure business incubation success. These findings were in line with Buys and Mbewana (2007) whose study in South Africa found a strong positive correlation between entrepreneur quality and business incubator success. This therefore showed that business incubators must use effective selection procedures which ensure that they select entrepreneurs who are skilled and motivated so that they are better able to make use of the services provided to them to enhance their growth and sustainability. This agrees with Khalid et al. (2012) who emphasize on the proper selection criteria for incubatees. In this regard various incubators employ different selection methods to ensure quality of the incubatees. One successful business incubator the Graduate Enterprise Academy (GEA) in Kenya draws its incubatees from members of the Mount Kenya University alumni to ensure that they have important technical skills that can be used to create value (Wanderi, 2017). In addition the incubator also considers the viability of the business idea in order to ascertain whether an individual qualifies to be part of the incubation process. Considering the viability of the business idea is also used by a number of incubators including the Business Start-up Centre in Bosnia and Herzegovina which makes use of business plan competitions to select its candidates.

The research also found out that business incubators need skilled and experienced management for them to succeed. These findings concurred with Ebbers (2013) who identified management quality as crucial to the ability of business incubators to provide an environment in which incubated business can grow and be self-sustainable. Thus the findings pointed out that business incubators should recruit experienced and skilled managers who are well vested with the dynamics of running a business incubator as well as what is needed to develop successful entrepreneurs.
At the same time the results of the study indicated that the majority of the interviewees considered government support as an important factor in enhancing business incubation success. This agrees with a number of scholars including The Department of Trade and Industry (2014) which points out to the importance of government in funding business incubators and new entrepreneurs through a number of its programmes. The results also highlighted that the government must come up with policies that support innovation and small business as well as improving the business environment. This is also emphasized by Said, Adham, Abdullah, Hannienen and Walsh (2012) explaining the role played by the government in creating an environment that is encouraging and friendly small and new businesses. In the same vein business incubators in other countries have succeeded in producing viable businesses through collaboration with public universities. Among these the Digital Hub Region Bonn in Germany has succeeded in producing new digital business ventures and contributing to the digitalization of the local economy through a public–private partnership involving public institutions like the Bonn University, Bonn-Rhein-Sieg University of Applied Sciences, Bonn/Rhein-Sieg economic development agency, the Chamber of Commerce (Deimel, 2017). This has helped solve most the incubator’s funding challenges as well as facilitating knowledge transfer from academic institutions to the industry thus spearheading technological progress.

The interviewees also contended that business incubators should come up with innovative ways of creating revenue and sustaining themselves. Such innovations would help the incubators solve some of the funding challenges as pointed out by Tengeh and Choto (2015). These results agreed with Khalil and Olafsen (2010) underscoring the need for business incubators to come up with innovative business models like the charging of royalties, membership fees and equity stakes. However, the same authors also warn that business incubators should not be too absorbed into revenue creation as this might create distrust with the entrepreneurs. On this account investing in successful incubated businesses has become a popular way of raising financial resources for business incubators especially in the developed world. For example according to Bjercke (2015) Leiv Eiriksson Innovation (LEN) in Norway is among the oldest and most successful business incubator in the country. One of its success factors has been the synergies and resources obtained from investments in the businesses that were ones part of its incubation program. As a result the business incubator has invested loans and equity in 70 companies in Norway. This helps the business incubator to generate revenue as well as easily obtain mentorship services, collaborations and market opportunities for its incubatees thus ensuring the success of its incubation programs.

At the same time the results of the study pointed out that business incubators should network with key stakeholders including government, universities, investors, professionals and captains of industry.
They explained that this would enable them to create marketing opportunities, mobilize funding and obtaining mentoring services for their incubatees. These findings concurred with several other scholars which included Whitt (2014) arguing that business incubators must form multiple relationships with a variety of stakeholders in order to enhance their usefulness in supporting new entrepreneurial ventures. Business incubator networking has also been uncovered as an instrumental factor in the success of business incubators in most countries. For instance the Business and Technology Incubator (BTI) in the Gaza strip owes its success in producing over 30 companies to its effective networking strategy which has enabled it to command attention and interest among key stakeholders in the Gaza Strip (Skaik, 2013). The networking activities of the BTI include membership to important associations like Science Parks, infoDev's iDisk Global Network, and the Innovation Centers Experts Group, providing Gaza Strip entrepreneurship information to developmental agencies as well as networking with other business incubators in the region.

Above that the results of the research also revealed that investment in technological infrastructure was heralded as an important factor enhancing the effectiveness of business incubation. Findings by Gozali, Masrom, Zagloel and Haron (2016) also pointed out to technological support, high speed internet and system infrastructure as very instrumental in the success of business incubation. Quite a number of business incubators have succeeded in transforming incubatees into successful business owners through the effective use of digital technology. One example is the Graduate Enterprise Academy (GEA) in Kenya which has been able to cope with the difficulties of obtaining mentors and trainers through the use of digital mentorship and online training programs which are much cheaper and easily accessible to the incubatees (Wanderi, 2017). Since the incubator’s establishment in 2013 it has christened 9 businesses currently operating in Kenya. At the same time the success of iDea Hub in Nigeria in substantiating the digital entrepreneurship dreams of its incubatees is also attributed to the incubator’s investment in cheap internet facilities (Ikebuaku, 2016).

Hence from these findings discussed above the research produced the following framework for the success of business incubators in Zimbabwe.
Fig 3: Model for enhancing the effectiveness of business incubators in Zimbabwe

Source: Researchers
6. CONCLUSIONS

On account of the research findings analyzed and discussed above, the research came to a number of conclusions based on the research objectives. Regarding the services provided by business incubators to new businesses in Zimbabwe the research concluded that business incubators are offering a number of essential services designed to spearhead entrepreneurial development of their clients. These include business plan development, marketing and financial management training and advice, assistance with registration and licensing, mentoring and coaching services as well as networking services to help the new entrepreneurs build links and relationships with other businesses and key stakeholders. However most of the business incubators do not offer working space and financial resources to promote the start-up businesses. On the other hand, the study revealed a number of challenges impeding the effectiveness of business incubators in Zimbabwe. These encompass shortage of financial resources, insufficient working space, lack of commitment from entrepreneurs, poor managerial effectiveness in business incubators, shortage of technical skills, harsh economic conditions and inconsistent support from stakeholders. The research also came up with conclusions regarding the key success factors needed to enhance the effectiveness of business incubators in helping new business in Zimbabwe. Among the major success factors identified included the quality of entrepreneurs, skilled and experienced management, government support, self-sustainability of business incubators, networking of business incubators and investment in ICT infrastructure.

7. RECOMMENDATIONS

The research came up with a number of recommendation regarding what needs to be done in order to enhance the effectiveness of business incubation in Zimbabwe. Among these the study recommended that:

Business incubators must use effective selection criteria focusing on the entrepreneurial skills, technical skills and motivation for success of entrepreneurs in order to enhance the quality of entrepreneurs involved in incubation programs.

Business incubators should recruit skilled and experienced managers who know about the best practices of running business incubators as well as having the ability to adapt their programs to suit the needs of their clients. This would enable the efficient management of incubators and also facilitate the ability of business incubators to identify and tackle entrepreneurial development challenges faced by their clients.
Business incubators should come up with innovative business models aimed at creating revenue so that they become self-sustainable. Such models should include the charging of royalties, membership fees and acquiring equity stakes in successful entrepreneurial ventures among other models.

Business incubators should also form networks with key stakeholders including government institutions, investors, established businesses and professional services firms. Such a move would make it easier for them to mobilize funding for their incubates, create marketing opportunities form their clients as well as being cost effective in obtaining mentoring and coaching services from successful entrepreneurs.

Business incubators in Zimbabwe should invest in ICT infrastructure as this would afford their clients competitive advantage in terms of production, marketing and publicity.

Government to give active support to business incubators as their activities are crucial to entrepreneurial development hence socio-economic development in the country. Such support should come in the form of mobilizing funding for business incubators and their clients and also creating a conducive environment for the development of entrepreneurial activities in Zimbabwe.

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ABSTRACT

Zimbabwe’s economic performance and competitiveness remains suppressed despite the abundance of resources and the potentiality of tapping into academia-industry collaborations that are a critical component of an efficient system of innovation and economic growth. Therefore, sustainable economic development can be achieved through pushing forward the industrialisation and modernisation of the economy through application and maintenance of mutually beneficial functional and development-focused academia-industry relationships and linkages. Academia-industry partnerships create a more relevant quality higher and tertiary education curriculum, that is always up to date with the relevant technologies and skills industry requires. Applied research at universities and research institutions that solves real-life socio-scientific and technological issues simulates innovation and appropriate technology uptake by industry and related sectors of the economy for value-added results with respect to processes, products and services. To this effect, Dubey (2017) also notes that when industry and universities become powerful engines for innovation and economic growth if they work together to push the frontiers of knowledge. The present study utilised critical document analysis and empirical case references to fully capture the nature of the present status of the universities-industry relationships in Zimbabwe vis-à-vis their inherent potential and contribution to sustainable economic fortunes of the country. This research found out that Zimbabwe has legal and public policy frameworks that support research, innovation and enterprise development. However, there has been partial to non-implementation of some of the policies that promote active collaborations between academic institutions and industry as there are still some practice gaps though there are great potentialities of building sustainable academia-industry interfaces to catapult Zimbabwe to a knowledge-based and export supported upper middle class economy by 2030. The study also found out possible collaborative approaches to include: industry and commerce-driven curriculum, technology and business incubation, national research priority areas, intellectual property generation and commercialisation and innovation, and funding of academic research and programmes. Successful and potential case- models of innovations and collaborations in Zimbabwe and other best yielding collaborations from other countries are also reported with respect to their output and potential contribution to national GDP.
1. INTRODUCTION

Bercovitz & Feldmann (2006) note that universities and research institutions (academic institutions) are well placed and recognised for the creation, diffusion and deployment of pertinent knowledge and innovation that supports economic growth. Academic institutions-industry collaborations have been increasing as a recognition of the fact that academic institutions have long served as a source of technological advances for industry (Bercovitz & Feldmann, 2006) through skills, knowledge and technology transfer.

However, Slaughter & Leslie (1997) point out that the issues surrounding technology transfer have been challenging as private companies and academia have extremely different missions and often display mutual distrust. Besides that, academic institutions are being often regarded as holding key assets that could be leveraged for economic development. The presence of a local university or research institution may be necessary, but not sufficient, to guarantee that knowledge-based economic development takes place (Bercovitz & Feldmann, 2006).

A country’s sustainable economic growth is realised therefore, by its ability to generate knowledge and translate such into innovative products and services (Gadzirayi, Bongo, Ruyimbe, Bhukuvhani, & Mucheri, 2016).

The purpose of this article is therefore, to analyse economic, industrialisation and research and development policies with respect to the nature of academic institutions-industry collaborations beneficial to creation of knowledge-based economy for Zimbabwe in the view of her aspiration of becoming an upper middle income by year 2030.

1. OBJECTIVES

The objectives of the present research are to:

1. Describe the status and nature of academic institutions-industry collaborations in Zimbabwe.
2. Identify opportunities for the enhancement of academic institutions-industry collaborations for sustainable economic development in Zimbabwe.

2. METHODOLOGY

This research study used the critical analysis and interpretive methodologies. Policies and related documentation on economic development, industrialisation and research and development were reviewed. Desk reviews were also done in order to establish best practices in academic institutions-industry collaborations in other countries both in developing and developed countries for benchmarking purposes. The World Bank reports were also reviewed with respect to how much countries are investing in research and development in view and recognition of knowledge as key to a country’s economic growth.
The study also utilised empirical cases in Zimbabwe and other countries to validate claims with respect to the nature of academic institutions-industry collaborations and their relative economic contributions.

3. FINDINGS

3.1 Zimbabwe policy position(s) supporting academia-industry partnerships

The Government of Zimbabwe, according to GoZ (2012) identified four priority sectors as the pillars and engine for the Industrial Development Policy 2012–2016, namely agri-business, fertilizer and chemicals industry, pharmaceuticals, metals and electricals.

The qualifying criteria for prioritization for the above mentioned sectors included among others: the sector’s contribution to Gross Domestic Product (GDP), employment creation and retention; export earnings and potential for value addition as well as forward and backward linkages with other sectors of the economy (GoZ, 2012).

Zimbabwe’s Industrial Development Policy (IDP) 2012-2016 recognised technology transfer and research and development as key success factors for establishing a competitive and vibrant industry (GoZ, 2012) and major drivers of economic growth.

GoZ (2012) further proposed that technology transfer as a central element not only to ensure growth and development, but more critically to attain global competitiveness of goods and services and also facilitate private sector participation to enhance commercialization of research and development from the academia, through increased public-private partnerships for research, development and innovation.

The IDP (2012-2016) also proposed that industry invests in research and development on new processes and products which it views as resulting in competitiveness and cost effectiveness of products (GoZ, 2012). In order to achieve this, the IDP (2012-2016) set to raise and sustain a 2% of GDP as research and development expenditure. This was a deliberate realisation to support economic growth through research and development of innovative technologies to achieve global competitiveness.

However, it is regrettable that Zimbabwe’s contributions towards research and development are not noted on the World Bank database of world countries’ expenditure on research and development as in Table 1. This might mean that Zimbabwe’s expenditure towards research and development may be so insignificant that it does not warrant mentioning.
Table 1: Research and development expenditure 1996-2015 (Source: World Bank, 2018)

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<td>797</td>
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</table>

Key: LMI- Lower Middle Income   UMI- Upper Middle Income   HI- High Income
In its bid to transform into an upper middle income economy by 2030, it is imperative that Zimbabwe invests substantially in research and development. It can be observed from Table 1 that countries which are deliberately and consistently financing research and development have built strong and sustainable economies over the past 20 years and are now either in the upper middle or high income levels. It is clear from Table 1 that an expenditure of 2% of GDP towards research and development achieves a high income level economy.

Through its Research Act (Chapter 10:22), Zimbabwe established the Research Council of Zimbabwe (RCZ) in realisation of the contribution of research in the economy, with the mandate of coordinating research activities of national importance and interests in the country. RCZ also provides an exceptional forum for interaction and discussion for the mutual benefit of Government, academia and industrialists (Research Council of Zimbabwe, 2018).

After realising that the proposed 2% of GDP expenditure towards research and development as in the IDP 2012-2016 was not realised by the government, the RCZ and its key stakeholders that include industry and academic institutions advocated at least 1% GDP for a start to be channelled towards research and development. However, there has been some noted political pronouncements on the commitment to channel 1% of GDP towards research and development initiatives though not in the form of a blueprint government policy as yet.

Benchmarking with South Africa, Belarus and Malaysia from the World Bank data for the past twenty years in Table 1, it can be deduced that if the proposed 1% of GDP is effected as expenditure towards research and development, it may be enough to catapult the Zimbabwe economy to an upper middle class level. Currently, Zimbabwe is a low-income rated economy as rated by the World Bank.

It is envisaged that a new industrialisation policy (2018-2022) is to be launched soon superseding the IDP (2012-2016) (Mandizha, 2018). According to consultative briefings, the new policy centres on developing and facilitating linkages across all sectors of the economy in order to improve and harness the country’s competitiveness (Mandizha, 2018). The policy also seeks to strengthen research and academic institutions, a deliberate move to enhance collaborations between academia and industry for sustainable economic growth in working towards the attainment of knowledge-based and export supported upper middle level income economy by 2030.

The Zimbabwe Manpower Development Fund (ZIMDEF) Act is another legislative framework that encourages contributions and collaborations among academic institutions and industry. Through ZIMDEF, industry contributes 1% of companies’ monthly wage bills towards financing of academic institutions which produces specialised manpower for their industries. The move is a deliberate stance to produce critical mass skills that are needed in industry to stimulate production of value-added products which earn more on the global market. In view of the critical shortage of skills in the Science Technology Engineering and Mathematics (STEM) fields, ZIMDEF funded scholarships for secondary school students studying sciences in bid to increase uptake of STEM disciplines at tertiary education level (Bhukuvhani, 2018). However, there were reports, particularly in 2016 and 2017 of abuse of the ZIMDEF funds by political leaders managing the funds at the expense of the noble cause for which it was established.
3.2 Status and potential of academia-industry relations and partnerships in Zimbabwe

The school of Industrial Sciences and Technology at the Harare Institute of Technology, through its various departments has established or is in the process of establishing various partnerships with industry. The Food Processing Technology department currently runs a food processing plant. The plant operates as Instifoods which is a subsidiary of Institech Holdings, which is the university’s commercial arm ([www.hit.ac.zw](http://www.hit.ac.zw)). The Instifoods has managed to commercialise various food products. This was as a result research output from the departmental faculty and students’ projects.

The department is also in smart partnership with various companies. These include Dairibord Zimbabwe Holdings, with which the department is offering a Certificate in Food Science and Technology specialising in milk and dairy processing. The department also offers a certificate in Milk and Dairy processing (focusing on quality assurance) to Kefalos Private Limited staff at Mubaira. In addition, the university also offers certificate and diploma courses in beverage manufacturing to Schweppes Holdings staff. Other collaborations include those with Beitbridge Juicing (Private) Limited and Best Fruit Processors. The department is also a member of food processing organisations such as the International Union of Food Science and Technology and the European Federation of Food Science and Technology (EFFoST).

The University of Zimbabwe for example, has several industrial collaborations with local and international industries. Table 2 shows some of these collaborations.
Table 2: Examples of collaborations of the University of Zimbabwe with industry (Source: http://www.uz.ac.zw)

<table>
<thead>
<tr>
<th>Company</th>
<th>Country</th>
<th>Partnership areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centre for defence studies</td>
<td>South Africa</td>
<td>Research and development program on security service governance</td>
</tr>
<tr>
<td>Wildlife and Environmental society of South Africa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E-Learning solutions Zimbabwe</td>
<td>Zimbabwe</td>
<td>Collaboration on the integration of modern Information Communication Technology in education</td>
</tr>
<tr>
<td>African Economic Research Consortium</td>
<td>Kenya</td>
<td>Joint research and capacity development in student teaching</td>
</tr>
<tr>
<td>OSSREA</td>
<td>Ethiopia</td>
<td>Research and capacity building in social sciences</td>
</tr>
<tr>
<td>Southern African Research Innovation Management Associational (SARIMA)</td>
<td>South Africa</td>
<td>Collaboration in funding</td>
</tr>
<tr>
<td>Zimbabwe College of Music</td>
<td>Zimbabwe</td>
<td>Student exchange programs and training programs</td>
</tr>
<tr>
<td>HEDEC Consulting</td>
<td>Zimbabwe</td>
<td>Development of small livestock, research on enhancing family nutrition, technology transfer</td>
</tr>
<tr>
<td>Institute of aquatic Biodiversity</td>
<td>South Africa</td>
<td>Collaborations between post-doctoral students, joint student supervision, collaboration on knowledge transfer</td>
</tr>
<tr>
<td>National Museums Monuments of Zimbabwe</td>
<td>Zimbabwe</td>
<td>Research and education in culture, heritage, ethnography, museology and history</td>
</tr>
</tbody>
</table>
Table 2: Examples of collaborations of the University of Zimbabwe with industry (Source: http://www.uz.ac.zw) (continued…)

<table>
<thead>
<tr>
<th>Company</th>
<th>Country</th>
<th>Partnership areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Huawei Technologies Zimbabwe (Limited)</td>
<td>Zimbabwe</td>
<td>Joint research in ICT, human capacity building, joint trainings,</td>
</tr>
<tr>
<td>Civil Aviation Authority of Zimbabwe</td>
<td>Zimbabwe</td>
<td>Collaboration on aeronautic engineering, Resource person support, joint research and teaching,</td>
</tr>
<tr>
<td>Brazilian Centre of Strategy and International Relations</td>
<td>Brazil</td>
<td>Joint research in international relations, student and staff exchange</td>
</tr>
<tr>
<td>School of International Research</td>
<td>Iran</td>
<td>Student and staff exchange</td>
</tr>
<tr>
<td>Jiangsu Animal Husbandry Veterinary College (China)</td>
<td>China</td>
<td>Post graduate training in applied agriculture</td>
</tr>
<tr>
<td>POSCO TJ Park Foundation</td>
<td>Republic of Korea</td>
<td>Collaboration in postgraduate training</td>
</tr>
<tr>
<td>Hunan Institute of Parasitic Diseases</td>
<td>China</td>
<td>Exchange training on parasite control, information exchange on health experiences</td>
</tr>
<tr>
<td>Camoes Institute</td>
<td>Portugal</td>
<td>Lecturer exchange, training of interpreters</td>
</tr>
</tbody>
</table>
3.3 Best practices in academia-industry partnerships for sustainable economic development

Best practice is a standard method or set of methods used to accomplish any form of business (Cambridge, 2018). A best practice is known for yielding the most favourable results wherever and whenever it is applied. Best practices in academia – industry partnerships generate several benefits to the university, students and partner-company. According to Edmondson, Valigra, Kenward, Hudson, Belfield and Koekoek (2012), university – industry partnerships have impact on the following areas:

- Teaching and learning- curriculum for the university must be learner centred and equip learners with futurist economic development skills.
- Creation of new funding streams- self-sustaining business units (start-ups) must be realised. These enable students to begin to learn real world industry skills and attitudes at early stages of life. These start-ups also create jobs for several people.
- Role of research is expanded from basic knowledge creation to applied state that solves national and global challenges.

Academia- industry partnership is a business relationship between a research-focused educational institution (university) and an industry. Larsen, Bandara, Esham and Unantenne (2016) highlight the possibility of a “triple helix”. This is a situation where local or central government becomes a third partner in an academia-industry partnership. Whilst government is a partner that provides any agreed resources to the partnership project, it also plays a superior role of coordinating the triple helix. According to Salleh and Omar (2013) the central government reduces tax on companies that contribute to national economy through engagement in joint R & D activities with universities. An academia-industry partnership seeks to improve the quality of education and innovation realised by the collaborating university and industry respectively (Rai and Dubbey, 2017). Research and technical expertise from the concerned partners increase research and development (R & D) activities. Increased research and development activities enhance both national and global sustainable economic development.

According to Pertuze, Calder, Greitzer and Lucas (2010), Sebastian (2012) and Ndlovu (2017) a successful university-industry partnership can be achieved through the following best practices:

Each partner must first understand its vision and identify its strengths and weaknesses with regards to vision and current performance. The academia or industry’s identified strengths and potential act as a good barometer for selecting a partner that can effectively complement their ability to achieve vision. In order to prevent dissatisfaction, cheating and eventual project failure leaders of each partner must agree on the nature and purpose of the intended partnership.

The agreement entered into by the partners must enhance dual benefit. Proper timing of any transaction has to be ensured. This segment covers each partner’s roles, resources to be provided, expected quality and quantity of partnership output. The sole purpose of improving quality of education, research and innovation within university and industry must be clearly spelt. Both partners must strive for a long term partnership as opposed to short or medium term partnerships that prevail in some developing countries. Each of the concerned partners must provide experts who will work with those from the other camp towards achieving agreed project outcomes. Clear objectives of the
project must be laid down and explained to all participants. In line with clear objectives, assessment
guides for the project must also be put in place.

In order to make sure that project implementation is fast and accurate each of the partners has to
provide strong leadership that possesses both technical and non-technical skills. The selected persons
must have in-depth knowledge of technology needed in the execution of the task at hand. The selected
persons must have an understanding of culture and operational practices for both sides. They also
have to be acquainted with interdisciplinary research and design activities. Examples of such cases
are university professors with industrial work experience would work with industrial training officers
to write industrial research and training modules.

Each partner has to put in place organization-wide educational programmes that help every
department and their individual members to understand the need for the partnership. This helps to
motivate individual organizational players to do their best towards the success of the project.
Lecturers, students and administrative staff of the university must participate in the project. University
curriculum must embed real world skills and values that relate to the partnering industry.

Plan multi-year collaboration time frames and cultivate relationships with concerned partners. Begin
to send congratulatory messages to them through media and invite them to celebration gatherings.
Salleh and Omar (2013) suggest that the project must start small and be expanded gradually, so that
both partners have enough time to assimilate the new business culture.

Academia-industry partnership members must strive to establish strong communication linkages.
These include face-to-face communications in meetings, workshops and organizational
familiarization tours. Such communications help to make people understand their partners’ culture
and related pool of project resources. Alternative communication lines like emails and telephone calls
can be used. Communication must not be established and kept between organization managers only.
For it to grow and become effective it has to be procedurally relayed to several departments.
Furthermore, extended communication linkages like seconding university researchers on sabbatical
to company departments can be established. Company staff can also be given an opportunity to take
part-time lecturing slots in various university departments. University students will also be accorded
some internship training slots during agreed times.

The partnership project has to be supported from within the departments up to organizational
executives. Relevant material, financial, time and human resources must be availed. The resources
must be availed at the right time and in both quality and quantity. Where possible, management should
incentivise some of the project tasks. Both University and industry must ensure that some of their
facilities will be used. Sharing of partnership outcomes like patent registration costs and royalties
must be laid down in a document signed by project principals.

Academia-industry partnerships collaborations have shown reasonable success in different parts of
the world. Universities and industries have succeeded in conducting research that materialised into
registered patents, creating jobs, internship opportunities for students and producing publications in
engineering. Some of the successes of best practices in academia-industry partnerships are shown
below:
3.3.1 Novartis International AG collaborations with University of Basel and Harvard University

FMI was jointly founded as a basic research lab in 1970 by two of the three Basel-based drug companies, which eventually merged to form Novartis. Today, it receives roughly 70% of its funding from the Novartis Research Foundation and remains affiliated with the company’s in-house laboratory. Students at FMI take courses and receive degrees at the University of Basel, where FMI group leaders also teach and advise students as adjunct faculty. The collaboration score with the University of Basel is at 105.3 points. Novartis also collaborates with Harvard University at with a collaboration score of 46.2 points.

3.3.2 Samsung Group & Sungkyunkwan University

Sungkyunkwan University (SKKU) and Samsung are more than research partners: in 1996, the conglomerate acquired the university. It is worth noting that South Koreans sometimes refer to SKKU that was founded by the Joseon Dynasty in 1398, a premier institution of higher learning, as the Samsung University. Today, Samsung, which makes up 13% of the nation’s gross domestic product, reportedly invests 100 billion Won (US$88.4 million) in the university every year. The collaboration score is rated 56.2 points.

4. CONCLUSIONS

Zimbabwe’s legislative and operational frameworks in the form of the Research Act and the short-to-medium term economic and industrialisation policies have all been consistent and cognisant of the issues surrounding the need for facilitating linkages across all sectors of the economy which are the principally, industry and service sectors, these also include the knowledge creators in the academic and research institutions.

Through an effective system of academic institutions-industry synergies and partnerships, facilitation of knowledge and technology transfer is enabled, thereby creating a knowledge-based and export-supported economy with increased global competitiveness as an upper middle level economy by 2030.

Political will and contributions of industry and academia in advancing knowledge in national prioritised production and service sectors by consistent and sustainably funding research and development are capable of catapulting Zimbabwe’s economic status levels, thereby improving the lives of its general populace at large.

Collaborations among academic institutions and industries have succeeded in conducting research that materialised into registered patents, creating jobs, internship opportunities for students and producing publications in the respective fields.
REFERENCES


PRIVATE AND PUBLIC SECTOR PARTICIPATION IN STATE OWNED ENTERPRISES-IMPLICATIONS FOR THE SUSTAINABLE DEVELOPMENT OF TEACHER EDUCATION INSTITUTIONS

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ABSTRACT

One major challenge that has bedeviled Zimbabwe’s institutions of higher learning like teacher education institutions is lack of funding for teaching and learning resources as well as research. This calls for the invigoration of the PPPs policy and encourage private participation in state owned enterprises. This study therefore focused on analysing the forms of support and the extent to which private sector participation has encouraged implementation of teaching, learning as well as development programmes at a selected teacher education institution in Zimbabwe. A descriptive research design was used for the study where information was gathered through document analysis and interviews with key stakeholders in the private sector and personnel at the institution. The study showed that private sector companies supported mainly through the provision of services and goods only and very little “free funding” was provided. Little was done to sponsor any academic and developmental programmes at the institution. Little funding only came from non-governmental organisations many of which are fast losing faith in public institutions. It was also evident the PPPs strategy had failed to work in encouraging development of teacher education institutions. The study recommends a model of interaction which involves an increase of publicity of these private sector companies, engaging former students as Public-Public Partnerships and other similar public organisations as well as other channels and offering incentives like tax rebates.
1. INTRODUCTION

The participation of the private sector in the provision of goods and services or public goods and services which were traditionally and exclusively produced by the state led to the new initiative referred to as Private-Public Partnerships (10), what can be referred to as Triple Ps (PPPs) or P3especially in developing countries. This was a shift from the previously dominant public sector model (5). On a global scale, Goal 17 of sustainable Development Goals calls for partnerships in achieving the other 16 goals. According to Klein, the Director Private Sector Advisory Services Department of the World Bank (5)

“Governments have long recognized the vital role that modern infrastructure services play in economic growth and poverty alleviation. For much of the post-Second World War period, most governments entrusted delivery of these services to state-owned monopolies. But in many developing countries, the results were disappointing. Public sector monopolies were plagued by inefficiency”.

In other words the need to gain popularity from the people by suppressing prices and other undesirable economic policies caused financial losses and shortage of funds for services and development. It was further argued in the report that;

“By and large publicly owned utilities failed to expand services to meet rapidly growing demand and did not do a good job of providing service to poor and rural households. Fiscal pressures, and the success of the pioneers of the privatization of infrastructure services, provided governments with a new paradigm. Many governments sought to involve the private sector in the provision and financing of infrastructure services. The shift to the private provision that occurred during the 1990s was much more rapid and widespread than had been anticipated at the start of the decade.”(5)

This became a strong basis for Private Public Partnerships as well as Public-Public Partnerships (P3). At a global level there are legal frameworks or Concession laws that govern and regulate the PPPs in countries that are supported by the World Bank. For Zimbabwe, there are also laws that support and promote the PPPs strategy. These include the Public Procurement and Disposal of Public Assets Act (Chapter 22-23, 2017), the Joint Ventures Act (Chapter 22 22, 2016), the Procurement Regulations Act (Chapter 22 14, 2002) and the Procurement Act (Chapter 22 14, 2001). The Joint Ventures Act for example spells out the types of joint venture projects that can be done, the procurement procedures to be followed as well as penalties for violation of the law.

Organisations such as the National Manpower Advisory Council (NAMACO) have been established to support Private- Public Partnerships in programmes such as Science, Technology, Engineering and Mathematics (STEM) (13).

A study in 2016 of African Private Public Partnerships perceived this partnership as involving Governments and Multinational Corporations (MNCs) (2). The African Private Public Partnerships (APPPs) see it as a strategy to attract private sector investment an expertise for economic development. To APPPs lack of financial resources is the major influencing factor for this cooperation.
Over time the PPP concept has changed meaning to include cooperation between state enterprises themselves to become Public-Public Partnerships as well as cooperation between the local and national governments (10). These include private businesses, community groups, cooperatives, private voluntary organisations, non-governmental organisations (NGOs) and small enterprises.

Strategies that have been adopted include contracts and concessions, build-operate and transfer (BOTs) arrangements, public-private joint ventures, informal and voluntary cooperation and the deregulation of public enterprises. Governments They can also contract for services, manage production jointly, co-ownership and co-financing of projects.

At an international level, the PPP initiative covers several areas that include energy, utility networks and services, telecommunications and transport systems, social services like health and education, low cost housing, water and sewer systems, and environmental pollution among other areas. According to Klein (5) this change of policy by African governments had provoked different comments from commentators. Organisations such as the World Bank (3) have regarded this policy shift as an open admission by governments of failure to be self-sustaining in their development initiatives. In this way governments have been seen as using the initiative to abdicate its responsibilities of providing public goods and social services. The United Nations (2) has however seen this as a way of encouraging higher production in state enterprises by allowing them to compete with private players, while still others have seen it as a way of privatizing government institutions and companies. In other words P3 has acquired different forms and has been interpreted differently. Rodinelli (10) sees the PPPs. as an intermediate phase in the process of privatizing state enterprises.

The emergence of PPPs as a developmental initiative has been attributed to a number of factors that include lack of financial resources by governments. A United Nations report for 2015 showed that most municipalities in developing countries had a weak revenue base inadequate to extend sufficient social services to communities. The same report showed that most municipalities had a large debt burden. Whether this applies to educational institutions or not is a subject for discussion which this paper also tries to answer.

Another influencing factor to the adoption of PPs is what Rodinelli (10) calls economic globalization where private firms are pressurized to respond to demands of changing world markets. Joint ventures between the governments and private sector has also been a pre-condition for World Bank and the International
Monitory Fund (IMF) loans. Countries have to demonstrate a high level of such cooperation to access some of the loans.

Despite these different interpretations, the extent to which the PPP initiative has been successful has been a subject of much debate. This study adopts a localized approach of studying a single public educational institution of higher learning. While some of the findings may be unique to the context under study, other findings can be transferable to apply to similar public institutions.

It is argued that this private–public cooperation has advantages to both the private and public sectors as well as citizens and governments. The benefits include greater production in state enterprises emanating from the competition with private players. This can also increase efficiency in service provision, expanded coverage of services thus reducing costs of delivery (10). According to the British government the P3 strategy allows “Optimal spread of the overall risk between the public and private sectors”. Such an arrangement will increase the capacity to manage the risks. The cooperation can also bring new ideas and the sharing of ideas. The private sector can also benefit from incentives offered by governments from this cooperation depending on the model of cooperation adopted. So both the private companies and state owned enterprises will benefit. Overall governments will spend less money on the production of goods and services. There will be maximization of production and less waste.

This study assesses the extent to which an institution of higher learning in Zimbabwe has benefited from the P3 initiative and whether there is hope for sustainable development through the initiative.

2. Objectives

The study was guided by the following objectives;

i. To find out the level of cooperation between private sector and the educational institution,

ii. To analyze the ways through which the P3 initiative is implemented in the educational institution, and

iii. To assess the extent to which this cooperation can support the development of the institution

3. Methodology

This is a case study of one public educational institution in Zimbabwe. The case study design was used so as to get in-depth insights into the implementation of the P3 initiative by the institution and its partners. Information was gathered through in-depth unstructured interviews with the institution’s administration and staff members from key departments. Information was also gathered through documents such as policy
circulars that were analyzed. Observations were also used to verify certain information gathered through other methods thus allowing triangulation of information.

4. Findings

Findings show that there are a number of factors that affect the implementation of the P3 initiative as illustrated on the Figure 1.

Cooperation between the private and public sectors is affected by such factors as available resources, priority development areas which may attract the interest of private investors, the legal framework that govern P3 which determines the processes and procedures to be followed in implementing the programme. The unavailability of funds is one obvious challenge of the institution that makes it difficult to implement P3 in its different forms. Effective implementation is also dependent on the development priority areas of the institution that are normally set in the strategic plan. The nature of the priority areas determines the extent to which government institutions can attract private interest and investment. Priority areas include staff and students’ accommodation, students’ services center, infrastructural development, equipment recapitalization, educational materials and staff training.

The concept of the Private-Public Partnerships emerging from this study is cooperation through free provision of goods and services to the public educational institution by private players, the provision of goods and services to the private sector by the institution as well as hiring services from the private sector by the public institution. The study established a number of developments, projects and programmes that illustrate the above.

_Free provision of goods and services to the public institution by the private sector_
This was a very popular way of private-public cooperation for the institution. Interviews with the institutional buyers and administrative staff as well as procurement documents studied showed that the institution received teaching and learning materials for different private institutions. This included items like laptops that were donated as prizes for best students in different areas especially during Diploma Awarding Ceremonies. Although these items may be small or few, they go a long way in encouraging students and staff to perform well. In 2017, one lecturer got a laptop as the STEM award and each year best students in different areas get awards in cash and kind from private dealers especially those which do business with the institution. This confirms findings from studies already done (2, 3, 5, 11) that as long as business between the public institutions and these private companies continue, there is reason to believe that they will continue to reciprocate in this manner.

Interviews with the lecturing staff and the Human Resources personnel also showed that the institution also gets a lot of support for its teaching and learning programmes in the form of resource persons, materials and refreshments for workshops. Workshop reports showed that these workshops included staff development workshops by such organisations as VVOB (A Flemish Organisation for educational cooperation), training needs workshops and support for Life Skills workshops for students from organisations such as Nzeve (Deaf), Say What, AIDS Council of Zimbabwe to mention a few.

According to a report by the Ministry of Higher and Tertiary Education, Science and Technology Development other private players were the Zimbabwe Banking Cooperation and the Commercial Bank of Zimbabwe (CBZ) which have promised to support students through the provision of loans for tuition. Unfortunately this may not be sustainable because of the restrictive conditions that are attached to the loans.

The institution also benefits though indirectly from private funding of research conferences such as Research and Intellectual Outputs, Science, Engineering and Technology (RIOSET), International Research Symposium organised by the Research Council of Zimbabwe, Teacher Education Research Conference – Zimbabwe (TERCZIM), the Zimbabwe International Trade Fair (ZITF) and others which are privately organised and sponsored. However, the continued attendance at these research conferences cannot be guaranteed because it is dependent on the funds available to sponsor staff and students. So, the continuous interaction with these partners is dependent on the financial status of the institution as well as the policy of the institution’s administration on research.
THE PROVISION OF GOODS AND SERVICES TO THE PRIVATE SECTOR BY THE INSTITUTION

Interviews and documents also showed that the institution sometimes provided services to the local community. The institution is currently running a programme for the support of an orphan called Lean Muchekadzose and it is called the “Lean Project”. The sustainability of the project however is dependent on the good will of students and staff who give donations for the project. The College also occasionally carries out some cleaning campaigns of the local general hospital, the main green market as well as busy streets and avenues in town. Again this may not be very sustainable because it depends on the goodwill of the students and staff, funds and time to do the cleaning operations.

Hiring services from the private sector by the public institution

This is probably the most common strategy that shows cooperation between the institution and private sector companies which provide goods and services (8, 9). In most cases where the Department of Public Works does not have specialist services, the institution hires private companies and pays them. These provide construction of infrastructure as well as goods such as computers, utilities and other teaching and learning materials. However, sometimes tender procedures discourage the implementation of big projects due to the tedious nature of the processes. Non-teaching staff has also been sent for training and staff development programmes by organizations such as Ino-Tech for human resources management skills training. This is however dependent on the resources available to sponsor staff for such training.

Student teachers have also been attached to private schools like Early Childhood Development (ECD) Centers. This is a sustainable programme as long as the private institutions continue to exist and students continue to be trained.

Reports by the institutional buyer showed that the institution also hires tailors from the public who help in garment manufacturing where gowns for graduating students are sown. This is a vibrant project for the institution which has seen the institution being self-sufficient in gown manufacturing.

The provision of goods and services to and by the public sector by the institution

The institution cooperates with other public institutions like the Department of Prison Services where labour is often sourced to do different tasks at the institution like working in the nutrition garden where the College has been self-sufficient in the growing of tomatoes for the kitchen. This is however dependent on the good will of the prison officials and there is no guarantee of any continued support thus questioning the sustainability of such support.
Workshop reports also indicated that the institution spearheaded a staff training mentorship programme that saw it train mentors in Manicaland Province in 2014 and went even beyond the borders to Zambia to interact and exchange ideas with colleagues in 2017. This was a magnificent example of Public-Public Partnerships, another dimension of P3.

The College has also been involved in plans for an exchange programme with Mozambican Educational Institutions although this was affected by red-tape. The project still awaits approval by the Ministry of Foreign Affairs since its inception in 2016. Volunteer teachers continue to come to the College from Japan in a programme called Japanese International Cooperation Association (JICA). However, there are no guarantees that the programme will continue since it is dependent on the availability of volunteers.

The disposal of redundant assets by the College is done by the Department of Public Works which shows public-public cooperation.

**CHALLENGES FOR THE P3 INITIATIVE**

Interviews with key stakeholders such as suppliers of goods and services to the college and members of the college procurement committee indicated the following challenges;

*Bureaucracy or Red tape*

Any form of cooperation between the institution and any private player had to be sanctioned and approved by the Ministry. The procedure of applying to the Ministry and waiting for approval often took a very long time and in some cases some proposals never reached fruition due to this challenge. The industry, however, made efforts to invite educational institutions and possible private sector players to meet and discuss the modalities of cooperation (12). Such meetings have been held with organisations such as Edu-Loan which have helped in providing loans for tuition for students at the institution.

*LEGAL RESTRICTIONS*

The institution is guided by prohibitive labour regulations such as the Labour Relations Act on hiring casual labour. Also there are no circulars to support the initiative. While it is a noble practice and requirement for each educational institution to sign a Memorandum of Understanding (MOU) with partners, the pre-condition can take a lot of time and discourage any meaningful engagement if not executed properly. Overall, the effectiveness of the P3 initiative rests on the Ministry of Higher and Tertiary Education, Science and Technology Development because it approves the P3 contracts in consultation with other ministries and government departments.

*The absence of local supporting structures for P3*
While there are many committees that support other initiatives at the institution there is no structure that supports the P3 initiative. This implies that it is not considered as a critical developmental strategy even when the Ministry has it in its priority areas.

*Lack of confidence by possible investors due to depressive economic conditions in the country generally*

This was evident from the non fulfilment of several pledges made by private companies in past years. Some have argued that there is a very high possibility of corruption in the implementation of some P3 programmes. There was however no evidence to support this.

*Institutional sources for the P3 partners*

There are such options as waiting to be approached, approaching the partners or both. The institution however uses the first option more often of waiting to be approached. This presents challenges such as that partners may be hesitant due to the red tape or may not know areas where the institution needs support.

*Changing Ministers*

Interviews with the lecturing staff indicated that promises made by one Minister are not upheld by another who comes later even when a lot of follow-up is done. Each Minister comes with new promises and pledges which affects continuity of P3 programmes.

At some point the College made some efforts to acquire a farm through which it would attract some foreign investment but this did not reach fruition due to changes in the office of the Resident Minister in the province.

*Technological challenges*

Some P3 programmes require certain technical expertise which the institution may not have like ICT skills in all departments.

*Prohibitive monitory policies*

It is not easy to access government funding for P3 programme. The release of funds often goes through restrictive processes and procedures set by Treasury. Treasury instructions make it difficult for funds to be availed for P3 programmes.

*Unclear methods and strategies to assess P3 projects*

A study of college policy documents also showed that there were not established methods and strategies to assess the progress and benefits of the PPPs policy projects.
5. CONCLUSION (s)

The level of cooperation between the private sector and the institution is very high only in terms of hiring services and procurement of goods from private sector companies. The College receives very little support from the private sector in terms of infrastructural development. However some no-governmental organisations donate materials and resources for staff development and learning requirements for students. There is also a lot of public- public cooperation or partnership which adds another dimension to the PPPs initiative.

The institution is not making any meaningful efforts to promote the P3 initiative. While there is supporting legislation at national level, there are no regulations and structures at institutional level that support the P3 initiative. Sustainable educational development is therefore difficult to achieve without meaningful support for the Ps initiative by the institution.

Research world over has shown that the provision of goods and services can definitely improve with effective support from the private sector. The institution’s priority projects demand a lot of resources which can be provided with the assistance of the private sector. Such projects according to the institution’s strategic plan include the construction of students’ hostels, an administration block, a library as well as an Early Childhood Development Centre which require a lot of funding. Such cooperation will definitely promote sustainable development of the institution.

6. Recommendations

The following recommendations were made to the government and the institution under study;

1. Government should allow educational institutions to borrow money from banks for infrastructural development and the procurement of goods and services.

2. Government should offer incentives like tax rebates for participating companies, recognition through various fora, bonding and respect of property rights.

3. Government should amend the Labour Act to allow flexible engagement of casual labour by public institutions.

4. Efforts should be made to reduce bureaucratic procedures that affect the PPP initiatives.

5. The college should do the following:
   - Establish local structures like committees for the initiative.
   - Adopt clear methods and strategies to assess the PPP projects
   - Find strategies of attracting support and investment and not wait to be approached like reaching out to the private sector.
   - Make efforts to acquire relevant technology and staff development programmes
   - Adopt a shift in strategy from waiting to be approached to outreach or outsourcing.
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10. Procurement Act (Chapter 22 14, 2001) (Zimbabwe)


2. SUSTAINABLE ENVIRONMENT AND RESOURCE MANAGEMENT

ASSESSING THE TRENDS AND PERFORMANCE OF THE KAPENTA FISHING INDUSTRY USING LOCAL STAKEHOLDERS’ PERCEPTIONS, KNOWLEDGE AND HISTORICAL DATA IN LAKE KARIBA, ZIMBABWE.

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ABSTRACT

Freshwater fisheries are amongst the most important and productive fisheries in Zimbabwe. They are main primary sources of livelihood for many people including the local residents and beyond. Sustainability of these fisheries is however threatened due to issues like declining catches, illegal fishing and poaching, law enforcement and fishing access. A case study was conducted in the offshore kapenta fishing industry in Lake Kariba, Zimbabwe to assess local stakeholders’ perceptions and knowledge and historical data about the performance and the trend of the kapenta fishing industry. Both primary and secondary data was collected. Primary data on stakeholder’s perceptions and knowledge was collected using a semi-structured questionnaires administered between January and October 2016. A total of 100 respondents participated in the study including law enforcement staff and kapenta industry staff. Patrol effort and Catch per Unit Effort (CPUE) data was collected at Lake Kariba Fisheries Research Institute (LKFRI) and evaluated to assess the performance and the trend of the kapenta fishing industry. Results indicate a significant negative relationship between CPUE and time between 1974 and 2016, a significant difference in the stakeholders’ perceptions and knowledge towards the trend of kapenta fishing and its performance and a decline in patrol effort. Performance of the kapenta fishing industry in Lake Kariba, Zimbabwe is not sustainable as indicated by stakeholder’s knowledge and negative perceptions and this was supported by secondary data on kapenta CPUE and patrol effort. Our study recommends inclusion of local stakeholders’ knowledge and enhancing stakeholders’ participation in major decisions in order to achieve sustainable fisheries.
1. INTRODUCTION

The offshore kapenta fishery is one of the four major sub categories of fisheries in Zimbabwe and others include artificial, recreational and inshore fishery (1). The creation of the previously white dominated offshore fishery happened during the colonial era driven by the idea to maximise fisheries output (2). The target species mainly caught are *Limnothrissa miodon* locally known as kapenta. *L. miodon* an exotic planktivorous pelagic fish species (3–6) that were introduced into Lake Kariba after the riverine species failed to effectively occupy the new created offshore niche that was vacant after the creation of Lake Kariba (2). Details on the construction of the lake as well as the introduction of kapenta are well documented by (2). The kapenta fishery is an international resource shared by Zimbabwe and Zambia (1). The majority of the water that sustain the fisheries in Lake Kariba drains from a 663, 848 km$^2$ drainage basin that stretches from Angola, Zambia, Namibia, Botswana and Zimbabwe (2).

The lake is fed by tropical rivers with fish stocks and sizes fluctuating in response to river flows and water levels which mainly influences the water cycle (7). *L. miodon* is endemic in Lake Tanganyika (8–11), they are pelagic planktivorous species meaning that they feed on both zooplankton and phytoplankton (12, 13) and they have high fecundity rates (14).

Fish production within the lake is mainly influenced by climate which affects water levels, the stratification cycle and nutrient fluxes and there are other factors such as predation and fishing effort (13,15). Details on feed and other ecological factors that influence kapenta catch, breeding and diet are well documented (12, 16).

Due to its high and constant demand *L. miodon* is a target species in Lake Kariba, and this implies that the industry has a multiple of related services of economic significance at both local, national and international scales (1, 17, 18). These services include engineering of fishing rigs, extraction, retailing and wholesaling of kapenta as well as trade of fishing equipment like rig engines and parts, lighting, diesel, salt and fishing nets (1), creating employment to vast populations within Zimbabwe and abroad . Details on economic significance of kapenta are well documented (1). To sum up *L. miodon* plays a significant ecological role as a dominant prey of *Hydrocynus vittatus* and major a part of the pelagic zooplanktivorous community (19).

Methods used to control the fishery are mainly traditional approaches to fisheries management (7, 20–24). They include licencing of permits for kapenta fishing and trade, gear restrictions, the fishing calendar and the delineation of restricted breeding sites and protected areas. Littoral areas are prohibited kapenta fishing as they are breeding sites (waters of 20 m deep and below) (21, 25).

Fisheries management decisions and policies mainly rely on problematic and doubted biological and bio-economic researches (7). Currently the issue of declining kapenta catches in Lake Kariba has gained a lot of attention (9,26). Reports from electronic media and newspapers spread the news that the kapenta fishing industry has collapsed. To add onto that stakeholder in the kapenta fishing industry reported that kapenta catch has fallen to an alarming level (P.Nzvenga). Some of the major industries ceased their operations while others have diversified into other business ventures and others have leased out their kapenta fishing permits after they failed to secure money to pay their permit quarterly fees (P.Nzvenga). This study was aimed at assessing stakeholders’ knowledge and perceptions about the trends and performance of the kapenta fishing industry and use secondary data at LKFRI to determine historical trends of the kapenta fishing industry.
2. OBJECTIVES

1. To assess the trends and performance of the kapenta fishing industry in Lake Kariba, Zimbabwe using local stakeholders' knowledge and perceptions.

2. To determine the historical trends of the kapenta fishing industry at LKFRI based on secondary data.

3. MATERIALS AND METHODS

3.1. Study Area

The study was conducted in three out of five hydrological basins in Lake Kariba, Zimbabwe that is, Sanyati basin [5] because it was the only basin (Lake Kariba Fisheries Research Institute) LKFRI law enforcement rangers managed to conduct night time patrols, Chalala basin [4] and Sengwa basin [3] were surveyed as they were frequently patrolled during strategic and extended patrols.

The study was conducted in the aforementioned basins of Lake Kariba, Zimbabwe (side only) in Kariba district in Mashonaland West province North of Zimbabwe. The climate conditions are tropical and semi-arid (27) and it has four distinct seasons with an annual temperature range of 24.4 to 24.7°C. The annual rainfall for the lake catchment is 1000mm (9, 28, 29). Lake Kariba is located at 16°31′S 28°48′E (see figure 1.1) and the lake serves a lot of purposes from recreational, commercial and domestic water supplies, waste (sewage disposal), irrigation, aquaculture and fisheries.

Figure 1.1: Location of study areas, (B5, B4 and B3 in Lake Kariba Zimbabwe).

Source: (23)
3.2. Data collection

Both primary and secondary data was collected. Primary data on knowledge and perceptions of kapenta law enforcement staff at LKFRI and kapenta fishing staff with regards to the trends of the kapenta fishing industry and its performance in lake Kariba Zimbabwe was collected using semi-structured questionnaires that were administered through interviews. The interviews were conducted between January to October 2016 and it took about 20 to 30 minutes to complete a single interview. Seven out of 7 kapenta Zimbabwe Parks and Wildlife Management Authority (ZPWMA) fishery patrol rangers at LKFRI and 93 out of 308 kapenta fishing staff (nearly 30% of kapenta fishing permit owners) participated in the interviews.

Respondents who represented kapenta fishing companies were randomly chosen from a hat with numbers representing kapenta permit owners register at LKFRI following (30). Due to limited time and resources sample size was 30% of the total size and the questionnaires were guided by the general objectives. Based on the fact that rangers at LKFRI are responsible for patrolling and enforcing the law and regulating kapenta fishing and kapenta fishing companies. Two sets of different semi-structured questionnaires were developed (see table 1.1 and 1.2), the other was administered to the 93 respondents who owned (either rented or owned) kapenta fishing permits while the other was administered to all 7 ZPWMA rangers at LKFRI who were familiar with conducting patrols in the kapenta offshore fishery especially within the aforementioned basins.

LKFRI is the responsible authority managing the kapenta fishery. Other primary data sources included current kapenta catches and kapenta fishing effort statistics, patrol effort data related to kapenta fishery. Secondary data collected included kapenta catch and kapenta fishing effort statistics from 1974 to 2015 (note; complete kapenta catch and fishing data of some of the years was missing), patrol effort data from 2013 to 2015 as data on patrol effort for the years before 2013 was not available at LKFRI.

Patrol effort data that was collected include arrests statistics, targeted and achieved patrols (related to the kapenta fishery only). The semi-structured questionnaires included both open ended questions and closed questions. Questionnaires to be administered were pre-tested in hydrological basin 5 of Lake Kariba only, while for the rangers (LKFRI) only a few members were interviewed. Final adjustments were made to both questionnaires and dates for the final interviews were made public to both the rangers (LKFRI) and kapenta fishing permit owners. LKFRI rangers also assisted on interviewing kapenta fishing permit owners. About 100 respondents that included the rangers (LKFRI) as well as kapenta fishing permit owners participated in the interviews. The questionnaire set for the rangers was administered to all 7 rangers at the responsible authority for managing the kapenta fishery at LKFRI who actively participated in offshore fishery patrols and the second set of questionnaires was administered to kapenta fishing permit owners in Sanyati, Chalala and Sengwa (hydrological basin 5,4 and 3). These sites were chosen as they were the main strategic and extended patrol area limits.

Other basins were inaccessible due to resource shortages as they were too far. The first author conducted observations with the assistance of the rangers (LKFRI) during various offshore fishery patrols that were conducted during the period of study. The observations included how the patrols were executed, ways in which the law was enforced during these patrols and how arrests were made. Secondary data was collected at LKFRI database.

3.3. Data analysis

Descriptive statistics was used to summarise questionnaire responses and multiple responses was categorised as a percentage of the respondents giving the total sum to 100%.

A Kruskal-Wallis test was performed on kapenta fishing companies’ questionnaire data. This was after the data met the following assumptions [1] dependant variables (stakeholders perceptions and knowledge) were ordinal, [2] independent variables (kapenta fishing companies) were differentiated according to hydrological
basins in Lake Kariba and [3] the participants appeared once in their geographical location. Linear regression analysis was performed after the data met the following assumptions [1] there was a linear relationship between time in years and kapenta CPUE, [2] there were no significant outliers, [3] there was independence of observations and this was checked using Durbin Watson statistic. The tests were run using Statistical Packaging for the Social Science (SPSS). Linear regression was used to analyse CPUE data from 1974 to 2016.

### TABLE 1.1: SAMPLE OF SEMI STRUCTURED QUESTIONNAIRE TO LKFRI RANGERS

<table>
<thead>
<tr>
<th>1. Gender?</th>
<th>Male/Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Age of respondent?</td>
<td>18-24/25-34/35-44/45-54/55-64/65-74/ &gt;75 years</td>
</tr>
<tr>
<td>3. Working experience at LKFRI?</td>
<td>&lt; 1 year/2-5/6-10/11-20/&gt;20 years</td>
</tr>
<tr>
<td>4. Are you aware of standards required for patrols and law enforcement in the kapenta fishing industry?</td>
<td>Very aware/aware/not aware</td>
</tr>
<tr>
<td>5. How do you rate the current law enforcement and patrol standards comparing to the standard required for the kapenta fishing industry?</td>
<td>Above/standard/slightly below/below standard</td>
</tr>
<tr>
<td>6. What is the current kapenta catch trend?</td>
<td>Increasing/Decreasing kapenta catches</td>
</tr>
<tr>
<td>7. Basin with most illegal activities related to the kapenta fishing industry?</td>
<td>Basin 5/4/3/2/1</td>
</tr>
<tr>
<td>8. Most arrested individuals are from?</td>
<td>Local/foreign/don’t know</td>
</tr>
<tr>
<td>9. Reason for your answers in 7 and 8?</td>
<td>(open)</td>
</tr>
<tr>
<td>10. What are the main threats you face in the kapenta fishing industry?</td>
<td>(open)</td>
</tr>
<tr>
<td>11. What are the main challenges you face in kapenta fishing industry?</td>
<td>(open)</td>
</tr>
<tr>
<td>12. What is your main suggestion to management for improved management of the fishery?</td>
<td>(open)</td>
</tr>
</tbody>
</table>
TABLE 1.2: SAMPLE SEMI STRUCTURED QUESTIONNAIRE TO KAPENTA FISHING STAFF IN ZIMBABWE

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Gender?</td>
<td>Male/Female/Cooperative</td>
</tr>
<tr>
<td>3. Status of kapenta fishing permit ownership?</td>
<td>own/rent/do both</td>
</tr>
<tr>
<td>4. Working experience in kapenta fishing?</td>
<td>&lt;1 year/2-5/6-10/11-20/&gt;20 years</td>
</tr>
<tr>
<td>5. Kapenta catch trend?</td>
<td>Increasing/Decreasing</td>
</tr>
<tr>
<td>6. Rate of kapenta catch as compared to the year 2000 and before?</td>
<td>very high/high/no change/low/very low/no idea</td>
</tr>
<tr>
<td>7. Reasons for 5 and 6?</td>
<td>(open)</td>
</tr>
<tr>
<td>8 Numbers of kapenta fishing rigs as compared to the year 2000 and before?</td>
<td>much too many/slightly many/no change/slightly few/too few</td>
</tr>
<tr>
<td>9. Ways used to gain entrance into kapenta fishing business?</td>
<td>buy new kapenta fishing permit//rent/do both/no idea</td>
</tr>
<tr>
<td>10. What is the impact of the full moon closure?</td>
<td>Favourable/not favourable</td>
</tr>
<tr>
<td>11. What are the major threats faced in the kapenta fishing industry?</td>
<td>(open)</td>
</tr>
<tr>
<td>12. What are the major challenges faced in the kapenta fishing industry?</td>
<td>(open)</td>
</tr>
<tr>
<td>13. What is your suggestion to management for improved fishery performance</td>
<td>(open)</td>
</tr>
</tbody>
</table>

4. RESULTS

4.1. Local stakeholder knowledge and perceptions

All the interviewed participants reported a declining kapenta catch trend 100% (n=100). Comparing their current kapenta catch to periods before the kapenta fishing permit redistribution exercise that happened in the year 2000, kapenta fishing permit owners reported that currently kapenta catches are very low 41.9% (n=39). 44.1% (n=41) of the respondents reported that the current kapenta catch is low. 8.6% (n=8), 2.2% (n=2) reported that there is no change in the kapenta catch levels and 3.2% (n=3) reported that currently kapenta catches are higher than those of the year 2000 and earlier on years and all the reports above were not statistically significant.

To add onto that the interviewed kapenta-fishing permit owners reported that the current kapenta fishing rigs are slightly many than the kapenta fishing rigs that were in the year 2000 and previous years. 52.7% (n=49) while 30.1% (n=28) reported that the current kapenta fishing rigs were much too many, 9.7% (n=9) slightly
too few, 5.4% (n=5) too few and 2.1% (n=2) reported that there was no change in the number of kapenta fishing rigs. These findings were not statistically significant.

It was also reported that the main methods of entrance into the kapenta fishing business was renting kapenta fishing permits 68.8% (n=64), both renting kapenta fishing permit whilst owning one 10.8% (n=10) and buying new permits 8.6% (n=8). 11.8% of the respondents (kapenta fishing permit owners) did not have an idea on the main entrance methods. To sum up the recently introduced kapenta fishing calendar breaks (full moon closure) was favoured by 66.7% (n=62) of the respondents while 33.3% (n=31) of the kapenta fishing permit owners who participated in the survey did not favour its implementation. There were various threats and challenges encountered in the kapenta fishing industry and some respondents reported that these challenges and threats negatively affect the full moon closure. It was reported that the decline in kapenta catch is due to too much kapenta fishing effort in lake Kariba 45.2% (n=42), climate change 20.4% (n=19), decline of kapenta stocks 12.9% (n=12), overfishing within of the kapenta fishery 7.5% (n=7) and corruption 3.2% (n=3) and these reports were not statistically significant.

Although 10.8% (n=10) of the respondents had no knowledge on the causes of declined kapenta catch, there was a significant difference in the stakeholders responses on the perceived reasons causing low kapenta catches across hydrological basins 5,4 and 3 of lake Kariba Zimbabwe ($\chi^2 = 6.37; \text{df}=2; p=0.04$). There was a significant difference in the threats (see table 1.3) affecting the performance of the kapenta fishing industry across hydrological basis 5, 4 and 3 of lake Kariba Zimbabwe ($\chi^2=60.63; \text{df} =2; p=0.01$).

### TABLE 1.3: THE MAJOR THREATS FACED BY KAPENTA FISHING STAFF IN ZIMBABWE

<table>
<thead>
<tr>
<th>Main threats in the kapenta fishing industry</th>
<th>Number of people</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kapenta poaching and illegal kapenta fishing</td>
<td>44</td>
<td>47 %</td>
</tr>
<tr>
<td>Declining kapenta catches</td>
<td>13</td>
<td>14 %</td>
</tr>
<tr>
<td>Kapenta fishing in breeding sites</td>
<td>12</td>
<td>13 %</td>
</tr>
<tr>
<td>Corruption</td>
<td>8</td>
<td>9 %</td>
</tr>
<tr>
<td>Uncertainty on the Zimbabwean kapenta fishing boundary with Zambia</td>
<td>6</td>
<td>6 %</td>
</tr>
<tr>
<td>High kapenta fishing permit rental fees</td>
<td>5</td>
<td>5 %</td>
</tr>
<tr>
<td>No idea</td>
<td>5</td>
<td>5 %</td>
</tr>
</tbody>
</table>

The ZPWMA rangers at LKFRI reported that the main threats in the kapenta fishing industry were politics 42.9% (n=3), poor kapenta catch 28.6% (n=2), illegal kapenta fishing and trade 14, 3% (n=1) and kapenta fishing permit owners refusing to pay kapenta fishing quarterly fees 14, 3% (n=1). The main offenders arrested were from Sanyati basin and mainly locals 100% (n=7) and this was because other basins were too far 100% (n=7). The main challenges encountered by ZPWMA rangers at LKFRI were workforce shortage and resource shortage 71.4% (n=5) and resistance whilst trying to enforce the law 28.6% (n=2). These findings were not statistically significant. Main challenges affecting kapenta fishing industry performance that were faced by kapenta fishing permit owners were high kapenta fishing rental fees 34.4% (n=32), uncertainty on the kapenta fishing boundary separating Zimbabwe and Zambia 18.3% (n=17), high ZPWMA kapenta fishing quarterly fee and penalty fee 17.2% (n=16), foreign kapenta supply outcompeting local kapenta supply 12.9% (n=12), illegal kapenta fishing and trade in Zimbabwe 10.8% (n=10), declining kapenta catches 3.2% (n=3) and 3.2% no idea (see figure 1.2).

There was a significant difference in the challenges encountered within the kapenta fishing industry across hydrological basins 5, 4 and 3 of lake Kariba Zimbabwe ($\chi^2=12.91; \text{df} =2; p=0.02$).

The following were major suggestions to fisheries management so as to improve the kapenta fishing industry; stopping kapenta poachers coming from Zambian side 22.6% (n=21), reducing kapenta rental and quarterly
fees 21.5% (n=20), conducting rig survey enforcing the law 19.4% (n=18) and conducting as well as explaining to all stakeholders the researches on the kapenta fishing industry 14% (n=13). There was a significant difference in the suggestions made by kapenta fishing staff across hydrological basins 3,4 and 5 of lake Kariba Zimbabwe (KW$\chi^2$=50.7; df=2; p=0.02). The ZPWMA rangers at LKFRI also suggested that some of the equipment used in enforcing the law in the kapenta fishery is primitive therefore there is need of a technological update as well as increasing manpower and remuneration 71.43% (n=5). The following figure (figure1.2) gives us an illustrations of challenges that are affecting the performance of the kapenta fishing industry.

![Challenges in the kapenta industry](chart.png)

**Figure 1.2:** Challenges that are affecting the performance of the kapenta fishing industry.

**4.2. Kapenta CPUE**

There was a significant negative relationship between catch per unit effort CPUE and time (years), ($r (37) = -0.85, p = 0.01 (y=-0.02x+32.1)$). A correlation of time period (years) and CPUE was summarized (see figure 1.3).
There was a decrease of CPUE from 0.86 in 1974 to 0.08 in 2016. The decline was not continuous as some years recorded higher CPUE than their previous years for example year 2000 CPUE increased to 0.6 from 0.3 in 1999.

4.3. Patrol Effort.

Targeted patrols declined from 284 in 2013 to 219 in 2015, achieved patrols increased from 80 in 2013 to 157 in 2015 and there was a decrease in the number of arrests made from 2013 to 2015 (see table 1.3) summarising patrol effort related to the offshore kapenta fishery at LKFRI.

Table 1.3: Patrol Effort for kapenta fishery in hydrological basins 5,4 and 3 (Zimbabwe) at LKFRI 2016. (Note; no secondary data on patrol effort for 2012 and before)

<table>
<thead>
<tr>
<th>Year</th>
<th>Targeted Patrols</th>
<th>Achieved Patrols</th>
<th>Arrests</th>
<th>Ranger staffing</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>284</td>
<td>80</td>
<td>102</td>
<td>15</td>
</tr>
<tr>
<td>2014</td>
<td>226</td>
<td>119</td>
<td>55</td>
<td>17</td>
</tr>
<tr>
<td>2015</td>
<td>219</td>
<td>157</td>
<td>42</td>
<td>17</td>
</tr>
<tr>
<td>2016 (January-August)</td>
<td>219</td>
<td>8</td>
<td>26</td>
<td>16</td>
</tr>
</tbody>
</table>
Patrol data of the year 2016 was not complete as it covered a period of 10 months (from January to October). More so lake patrols targeting the kapenta offshore fishery just cover Sanyati basin only as other basins are too far to conduct offshore fishery lake patrols but strategic and extended patrols covered Sanyati, Chalala and Sengwa.

5. DISCUSSION

Results suggests that the trends and performance of the kapenta fishing industry is not sustainable as almost all respondents who participated in the interviews reported that kapenta catches had declined. More so this was supported by secondary data for kapenta catch trend from 1974 to 2016 and patrol effort data at the responsible authority (LKFRI).

From our main findings, we can also note that the trends and performance of the kapenta fishing industry is characterized by low kapenta catches, illegal kapenta fishing and poaching and high operational fees especially to those who rent kapenta fishing permits. Incorporating local ecological knowledge as well as allowing stakeholder participation in fishery management issues can help the management to achieve maximized and sustainable fisheries output.

Although not significant law enforcement agents’ perceptions, knowledge and suggestions are important because they represent a crucial component in protected area management. These results are consistent with the findings of (31) who used local resource user perceptions to assess conservation projects and found that respondents had a generally positive perceptions and knowledge towards equity and efficiency outcomes, and a mixed outlook on sustainability outcomes in the Sagay Marine Reserve in Philippines for the period 1992–2002.

This study findings differ with those of (31) as this study noted a difference in stakeholders’ perceptions and knowledge towards the performance and the trend of the kapenta fishing industry. This is due to the fact that perceptions and knowledge is mainly influenced by how resource users view and utilise their environment of which ways in which resource users view their environment may differ because of many factors (32). Differences in geographical locations may lead the resource users’ view their environments differently. Their actions are based on experience, perception and knowledge (31–35).

Major challenges recorded in this study included (a) high kapenta permit rental fees, (b) uncertainty on kapenta fishing boundaries between Zimbabwe and Zambia as they share the same kapenta fishery, (c) High authority quarterly fees (d) foreign kapenta supplies from Zambia and Mozambique and (e) lowering kapenta catches. The main threats included (a) poaching both from Zimbabwe and Zambian side, (b) falling catches of kapenta, (c) fishing kapenta in breeding sites, (d) corruption and (e) high costs of renting a kapenta fishing permit. The findings of this study concur with the main findings (36,37) who claimed that the main threat to sustainable fisheries are over exploitation. This may be due to the issue of kapenta permit rental issues that forces the fishery to become almost open access given the issue of manpower shortage.

More so in order to maximise total kapenta catch in a fishery with already declining per unit catch, fishing in breeding sites, poaching and illegal fishing becomes inevitable. (17).
6. CONCLUSION AND RECOMMENDATIONS

6.1. Conclusion

Basing on the objectives of the study, we can conclude that the performance and the trend of the kapenta fishing industry in Zimbabwe was not sustainable this was based on local stakeholders knowledge and negative perceptions this was also supported by secondary data at the responsible authority.

6.2. Recommendations

It is recommended that there is the need to allow stakeholder involvement and participation in fisheries management through incorporating their local ecological knowledge to management. Active participation of local resource users in sustainable management promotes sustainable development (15,28) through utilisation of local ecological knowledge as well as stakeholders involvement in decision making, implementation and participation. To sum up stakeholder involvement also helps in building and gaining competitive advantage within the industry.

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AN ASSESSMENT OF DIVERSITY AND PLAGUE BACTERIA (YERSINIA PESTIS) PREVALENCE AMONG RODENTS IN NKAYI AND UMZINGWANE DISTRICTS, ZIMBABWE

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ABSTRACT
An assessment of rodent diversity and prevalence of plague bacterium (Yersinia pestis) among captured rodents in villages at Umzingwane and Nkayi districts, Zimbabwe was conducted in April 2018. The objectives of the study were to determine and compare the diversity of rodent species in the two districts. Further on the study determined and compared the presence of plague bacteria in rodents captured in selected villages in Nkayi and Umzingwane districts. A total of 44 rodents were captured for three consecutive days in the study sites using removal trapping method. They were then euthanized and blood was withdrawn from them. Blood smears were made in the field prior to carrying the slides to the laboratory. Rodent species were identified in the field as well and it was shown that at Nkayi district gerbils (Tatera leucogaster) were the most common rodent species while in Umzingwane district it was multimammate mice (Mastomys natalensis). Rodents’ diversity was calculated using Shannon-weiner index, results revealed higher diversity at Nkayi, while in Umzingwane district it was lower. No significant difference was shown between the two calculated Shannon-weiner values. In the laboratory Giemsa stain was used to detect plague bacteria. Blood samples were negative for plague bacteria in entire specimen at Nkayi, while in Umzingwane district only one multimammate species tested positive. The findings are significant based on diversity calculations, currently at Nkayi people may relax, since the high rodent diversity index means the disease is being diluted thereby not going to be problematic. In Umzingwane district there was a prevalence calculation done, although lowly but the district should be on emergence alert. However, although the bacilli was lowly detected, it is rather ideal to keep an active surveillance in place in both districts as this study showed abundance of plague; reservoirs (M. natalensis) and amplifiers (T. leucogaster).

Keywords: plague bacteria, prevalence, semi-arid, tropical ecosystem
1 INTRODUCTION

Plague, a disease caused by the bacilli bacterium, *Yersinia pestis*, primarily affects rodents, mainly transmitted from one host to another through bites of infective fleas (1). However, there are other alternative transmission routes like ingestion and direct contact which do not normally play a role in the maintenance of plague bacterium in the animal reservoirs (2). Fleas are generalist in their feeding behaviour, thus in the absence of rodents they seek alternative host like wild and domestic animals, as well as people (3). Thus some flea species, for instance, *Xenopsylla brasiliensis* are implicated as effective plague transmitters (4). Alternatively, plague can be acquired by humans by handling infected rodents or by droplet infection, although humans do not play a role in the long-term survival of the plague bacterium (2). In most cases plague outbreak causes great population decrease in rodents of some species within its local and established ranges (Barnes, 1993 in 5). However some rodents’ hosts act as reservoirs of the disease in the enzootic environment allowing low levels of the pathogen circulation (3).

Among humans if the bacteria is inoculated in the body it multiplies and spread via three ways, namely: - the lymphatic system to the lymph nodes (bubonic plague); blood system (septicemic plague) and the respiratory system (pneumonic plague) (2). It can therefore be seen that rodents-fleas-humans interact this way thereby exchanging zoonotic diseases.

The first cases of human plague in Zimbabwe were recorded in 1954 since then up to 1985 there were 89 cases noted, of which 23 deaths occurred (6). Again plague human cases in the country were recorded in 1994 and 1997, where the highest cases of plague were noted with about 400 cases and 30 deaths confirmed at Nkayi and Lupane districts, Matabeleland North (6). Two districts in Zimbabwe, namely Nkayi and Lupane were identified to be the major plague foci in Zimbabwe (7). Lupane, Nkayi and Umzingwane districts all occur in natural region IV (8) that is, in the plague endemic region. At the moment plague has been dormant in the country for over 20 years, however, unavailability of an active plague surveillance could have adverse repercussions, as an epidemic can occur undetected like what happened in Madagascar, discontinuation of plague surveillance since 2006 has contributed to its resurgence in the capitals suburbs six years after the last reported case (9).

Although in Umzingwane district there have never been incidence of plague cases, however, the districts gold panning activities will provoke its occurrence. Gold panners’ deforestation the land and cause unnecessary bush fires because the gold detectors they use require clear places, these activities have been mentioned as perpetrators of plague event (10). Absence of human plague does not imply its nonexistence in the vertebrate fauna. Only time will tell when conditions become favourable for its transmission, for instance at Nkayi, the 1990s incidence was caused by a massive rainfall, which forced rodents to seek shelter among humans in large numbers (Sibanda, J, 2017, personal communication). A similar event has been reported in Zambia, plague incidence were high during the rainy season when rodents leave flooded burrows to human dwellings (11). Since plague foci were speculated to be dynamic and keep on emerging and reemerging (12).

Plague bacterium can be housed in quite a number of rodents and some small mammals. It was detected in Natal multimammate mouse (*M. natalensis*) and *Gerbilliscus* spp.in Tanzania (13). Furthermore, small mammals like rabbits (*Sylvilagus floridanus*), marmots (*Marmota*) and chipmunks (*Sciurus* species) were shown to maintain plague in the wilderness (3). Surveying diseases among free ranging wild animals population may provide an early warning system for the presence of a disease. Moreover, wild animals have a greater intimacy with the environment than humans and that intimacy may provide superior sensitivity to
environmental changes that can be important indices for disease emergence (14). Thus, a greater focus on monitoring wildlife diseases maybe highly priceless for protecting human health in natural areas with expanded human presence and for shielding fiscal welfare associated with the domestic animal industry. There is less active plague surveillance in Zimbabwe (4). The possible reasons could be financial constraints to for systematic and constant surveillance. However, of late there have been quite a few publications on rodents and fleas in Zimbabwe. The researches were largely focusing on rodent-flea species diversity and abundance in different habitats (15, 16).

This study was conducted to determine and compare the diversity of rodent species in Nkayi and Umzingwane districts. The study as well determined and compared the presence of plague bacterium in rodents’ blood captured in the two districts.

2 MATERIALS AND METHODS

2.1 Study area

The study was conducted in north-western Zimbabwe in Umzingwane and Nkayi districts, respectively (Figure 1). Both districts occur in natural region IV with minimum and maximum temperature ranges of 11-20°C and 19-26°C, respectively (8). The rainfall annual range of the area is 600-450mm. The soil groups are three (3) (vertisols group), four (4) (siallitic group) and five (5) (fersialitic group) (17). Nkayi district has deep Kalahari sands occupying 60% of the area whereas Umzingwane districts soils are derived from granite rocks being coarse, sandy and low in fertility (18). The most common type of vegetation at Nkayi is broad leafed woodlands, *Baikiaea plurijuga* (teak) and *Brachystegia* spp. (19). Umzingwane district on the other hand has three types of vegetation which are bushveld, mainly covered with acacia ranging between 1-5m high; wooded grassland and woodland covered by *Terminalia* and *Combretum* genus trees with at most 5m height. The grasslands are the main source of grazing land (18).

At Nkayi native people there are engaged in extensive livestock production and cultivation of some drought tolerant crops such as sorghum (*Sorghum vulgare*) and millet rapoko (*Eleucine coracana*). However, farmers do sometimes grow some short season maize (*Zea mays*) varieties. Nkayi’s population was reported to be 109,135 while Umzingwane district had 62 990 in 2012 (20, 21). There are high rates of female-headed households in Nkayi (40%) reflecting the migration of men who seek economic opportunities in cities and neighbouring countries (20). On the other hand Umzingwane district is dominated by artisanal small scale gold mining (22).

2.2 Data collection

In each study district, two villages were chosen, based on human flowing in due to local activities and history of plague occurrence, thus purposive sampling. In Umzingwane district, Nhlekiyane and Crocodile communal areas were selected. In Nkayi, the two villages selected were Mathoba and Monki (Figure 1). Villages especially in Nkayi district were chosen based on Environmental Health Technicians (EHT) consultation, while in Umzingwane district, main factors considered were accessibility (convenience sampling) and influx of illegal gold panners.
2.3 Trapping and processing rodents

Prior to setting traps security of the traps, rodents activity, which can be seen by eaten maize combs and clear constructed tracks and warrens were considered. Sylvatic rodents were captured in the surrounding bushes near fields using fifteen Sherman live traps placed about 10 metres apart in transects so as to have variable rodent niches (23). There were three transects in each study village, these were placed in uncultivated places near fields. On the first day traps were set in late afternoon and then inspected in the morning between 6am and 7am, thus before it is too hot, so that captured rodents are not stressed. Traps were left open for three consecutive days that is forty five traps inclusive, on which productive traps were replaced in the morning following Kimaro et al (2014). Traps with captures were taken to a central processing point to euthanize rodents using chloroform, identify rodents, withdraw blood and then bury cadavers thereafter.

2.4 Identification of rodents and blood processing

Rodents were identified according to the illustrations and descriptions by Smithers et al, 1975. Identifications were confirmed with the Natural History Museum, Zimbabwe.

Blood samples were firstly processed by conducting blood smears. These blood smears were conducted by injecting blood from the syringe onto a clean slide and then evenly spreading the blood horizontally by moving another slide attached to the blood on the slide. The blood smears were left to dry prior to being taken to Chinhoyi University of Technology laboratory, Chinhoyi, Zimbabwe, subsequently there were then fixed by submerging in methanol (25). This was done to prevent cells from bursting when they are placed in staining solution. The slides were flooded with Giemsa stain and left like that for twenty minutes (6), thereafter rinsed with water. Using a light microscope, processed slides were viewed searching for bipolar coccobacilli or a safety pin shaped bacilli (26).

Figure 1 Location of Nkayi and Umzingwane districts in Zimbabwe. Notes: 3, 17, 15, 27 represent wards where Nhlekiyane, Crocodile, Mathoba and Monki are located, respectively.
2.5 Data analysis

2.5.1 Rodents Diversity index

H′ is the Shannon-Wiener Index of diversity
Pi is the proportion of the ith species (27).

\[ H' = - \sum_{i=1}^{R} p_i \ln p_i \]

The diversity indices significance difference was determined using the diversity t test in the PAST software (28).

2.5.2 Prevalence of Y. pestis

The prevalence (%) of Y. pestis in rodents’ blood samples was calculated as the number of Y. pestis positive rodents divided by the total number of rodents caught in the respective districts multiplied by a hundred (100). Due to fewer positive rodents, significance difference calculations were not computed.

2.5.3 Day to day capture

Mann Whitney test was used to determine significance difference between day capture in the different districts that is, day 1 in between districts.
3 RESULTS

3.1 Rodents’ composition and diversity

A total of 44 rodents belonging to four species were captured. There were 21 rodents captured in Umzingwane district villages while 23 in Nkayi district villages. At Umzingwane district there were three rodents species captured, namely *Mastomys natalensis* the most abundant rodent species, *Tatera brantsi* and *Saccostomys campestris*. At Nkayi district also there were three rodent species recorded, namely bushveld gerbil (*T. leucogaster*) the most common rodent species, *T. brantsi* and *S. campestris* (Table 1).

The Shannon weiner diversity index was high for Nkayi district (H′=0.887) whereas it was lower for Umzingwane district (H′=0.619). The diversity t test was *t*=-1.144, df= 39.18 and *p* = 0.260. There was no significant difference noted between the diversity indices.

**TABLE 5 RODENT SPECIES IN RESPECTIVE VILLAGES**

<table>
<thead>
<tr>
<th>Districts</th>
<th>V</th>
<th>Rodent species</th>
<th>No.</th>
<th>Total rodents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Umzingwane</td>
<td>C</td>
<td><em>M. natalensis</em></td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>T. brantsi</em></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N</td>
<td><em>M. natalensis</em></td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>S. campestris</em></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Nkayi</td>
<td>M</td>
<td><em>T. leucogaster</em></td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Ma</td>
<td><em>S. campestris</em></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M</td>
<td><em>T. leucogaster</em></td>
<td>7</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>T. brantsi</em></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>S. campestris</em></td>
<td>2</td>
<td>13</td>
</tr>
</tbody>
</table>

‡V-villages, C-Crocodile, N-Nhlekiyane, Ma-Mathoba, M-Monki

3.2 Prevalence of *Y. pestis* among captured rodent species

Plague bacteria was detected in one *M. natalensis* species in Umzingwane district (Prevalence= 4.76 %) whereas in Nkayi district all small mammals were negative.

3.3 Day to day rodent capture

In Umzingwane district the highest rodents capture was on day 2, while the lowest capture was on day 3 (Table 2). Contrary in Nkayi district the highest capture was on day 3, whilst the lowest was on both day 1 and day 2. There were no significant differences in the days captures between the districts:- day 1, U=1.5, Z=0, *p*=1; day 2, U=0, Z=-1.16, *p*=0.25; day 3, U=0, Z=-1.16, *p*=0.25.
### TABLE 2 DISTRICTS AND SUBSEQUENT VILLAGES RODENTS’ DAY CAPTURES

<table>
<thead>
<tr>
<th>Districts</th>
<th>Villages</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Umzingwane</td>
<td>C</td>
<td>4</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>2</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>6</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td>Nkayi</td>
<td>Ma</td>
<td>3</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>2</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>5</td>
<td>5</td>
<td>13</td>
</tr>
</tbody>
</table>

‡C-Crocodile, N-Nhlekiyane, Ma-Mathoba, M-Monki, *t* test *p*<0.05

### 4 DISCUSSION

Rodent diversity was high at Nkayi district (plague endemic) compared to Umzingwane district although no significant difference was noted. This is in agreement with some researchers at West Nile of Uganda who noted no difference in host diversity between the plague endemic and non-endemic foci (29). The observed high diversity of rodents at Nkayi could be advantageous to the district; this may imply that plague is being diluted among rodent species thereby not having a greater impact (30). The reduced rodent species diversity in Matabeleland South may be due to intensified habitat destruction by gold panning activities and limited agricultural activities (31). This extensive land clearing favours maize loving rodent species like multimammate mice (32). Unlike at Nkayi there is still a huge unexplored area, this thereby favouring greater rodent diversity.

Plague bacteria was detected in one multimammate mouse captured at Crocodile village in Umzingwane district. Since time immemorial *M. natalensis* was observed not to easily succumb to plague bacteria, thus termed an enzootic host (13, 33 & 34). Thus some of the caught species may not be ideal host for *Y. pestis*, for instance *T. leucogaster* was observed to easily succumb to *Y. pestis* closely related bacilli *Y. pestis* tuberculosis subsp. pestis (33).

Since there were no die offs observed during the sampling time it implies that an inter-epizootic period could have been in existence during which *Y. pestis* cannot be recovered from fleas, rodents, or any other host (1). Instead it was speculated in Iran and Madagascar that maybe the bacteria endure in soil. However, one study recommended that the transmission route by exposure of susceptible mice to *Y. pestis* contaminated soil seems doubtful under natural conditions because the infectious period was short lived and the transmission efficiency low (35). Thus, during plague quiescent times it is likely that detecting *Y. pestis* is by mere chance.

Plague was difficult to detect in rodents and fleas associated with prairie dog rodents colonies (*Cynomys*) at Thunder Basin National Grassland in Wyoming, United States of America, unless samples were collected immediately after a prairie dog die off (5). Thus in line with this research which as well did not observe any rodent die offs, therefore less positive *Y. pestis* rodent species. The possible reasons for the observed research outcome could be either there can be other uncaught enzootic hosts involved in inter-specific transmission which could be the key in maintaining plague within a community or there are small mammals that are resistant to plague that play as a short term reservoir which were not encountered during the research.

In northern Tanzania, 517 wild, peri-domestic and commensal small mammal, inclusive of rodents and wild carnivores were captured but only three of these mammals were positive for *Y. pestis*, this therefore is an...
indication for the needed large sample though its unnecessary maiming of small mammals (13). There can be possibilities that *Y. pestis* is concentrated on certain organs in the rodent body as was found out in a study in Mongolia, instead, *Y. pestis* were detected in spleen samples, while liver samples from rodents tested negative using Polymerase Chain Reaction (PCR) (36).

5 CONCLUSION
Nkayi district villages recorded greater rodent diversity compared to Umzingwane, although the calculated diversity indices were not significant different. *Y. pestis* was detected in one *M. natalensis* captured at Nhlekiyane village in Umzingwane district while, at Nkayi no rodent species was found positive with *Y. pestis*.

6 RECOMMENDATIONS
Based on the results Nkayi should be on a temporary relaxing mode due to the higher rodent diversity. There arises the need to be on the alert for plague outbreak especially in Umzingwane district villages due to the detected *Y. pestis* in *M. natalensis*. Overall there is need for rigorous plague surveillance system to be put in place in both Matabeleland provinces. A robust test for *Y. pestis* in the field is required, thus it could be favorable if a test meter could be innovated to be used in field researches.

ETHICAL CONSIDERATIONS
Ethical clearance was granted by Chinhoyi University of Technology Ethics Committee.

ACKNOWLEDGEMENTS
We are indebted to Nkayi Principal Environmental health technician, Mr J. Sibanda and the Health technicians Mr(s) G. Mabhena and N. Ncube. Our sincere gratitude also goes to village heads, Mr(s) R. Ncube and R Tshuma (Umzingwane district) and Mr(s) A Mlotshwa and J. M Gwayi (Nkayi district). Comments and suggestions from anonymous reviewers are highly appreciated.
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GROWTH AND YIELD RESPONSE OF SORGHUM (SORGHUM BICOLOR L.) TRANSPLANTS TO IN-FIELD WATER HARVESTING FROM CONSERVATION AND CONVENTIONAL SOIL PREPARATION METHODS
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Abstract
A study to evaluate the growth and yield response of sorghum transplants to in-field water harvesting from six different conservation and conventional soil preparation methods was conducted at Save Valley experiment station. Sorghum transplants were raised in a nursery two weeks before first expected effective rains. Seedlings were planted into permanent treatments on the 27th of December 2017 using the first effective rains. The experiment was laid as a single factor design under Randomised Complete Block Design (RCBD) replicated three times. The objective of the research trial was to determine growth and yield response of sorghum transplants to in-field water harvesting methods. Results showed significant yield difference (p<0.05) with sorghum from deep planting basins having the highest yield (2834 kg ha⁻¹). It was concluded that sorghum transplants shorten the growing season of sorghum in the field. Farmers can adopt potholing/deep planting basins to increase sorghum production.

Keywords: sorghum, water-harvesting, drought, rain-fed, dry spells, runoff, tillage, moisture, conservation
1. INTRODUCTION

Sorghum is a genus with many species and subspecies, types include grain & grass sorghums (for pasture and hay) and sweet sorghums (for syrups). Sorghum is a staple food crop for millions of the poorest and most insecure people in the semi-arid tropics of Africa, Asia and Central America. The crop is genetically suited to hot and dry agro-ecologies where it is difficult to grow other food crops. It is drought tolerant, survives soil toxicity and extreme temperatures. In Asia and Africa sorghum production is traditional, subsistence and small-scale, and sorghum is mainly used for food. Sorghum can also be used in brewing alcoholic beverages. In small scale communal systems sorghum is mainly grown for family consumption purposes.

Sorghum is ranked fifth important cereal crop in Zimbabwe after maize, rice and barley. It does well in areas of very limited resources in terms of fertilizers and rainfall. Grain production of sorghum has since increased significantly in the past years in Zimbabwe due to a number of factors amongst them are nutritional value acceptance and its tolerance to drought and extreme temperatures. The crop is of great importance to small scale farmers for their household food security. Due to climate change sorghum production is proving to be a failure crop even in the areas used to be sorghum productive. The need for drought mitigatory measures is therefore an issue of major concern.

Climate change has resulted in increased vulnerability of smallholder farmers in marginal areas of Zimbabwe where there is limited capacity to changing climate. In-field water harvesting approaches have been used to improve crop yields in the semi-arid regions of Zimbabwe (1).

Decreasing rainfall in the semi-arid regions of Zimbabwe worsens food shortages if the current farming practices do not improve. Decreasing rainfall is a challenge as most of the agricultural systems are predominantly rainfed as irrigation systems are not well developed (2). In addition, most of the rainfall received in semi-arid regions is lost as runoff, and very little water is harvested for plant growth. In Zimbabwe losses >50% of received rainfall have been reported (1). In some semi-arid smallholder farming regions, the rainfall patterns and distribution have changed and there has been an increase in the average duration of intra-seasonal dry spells (3).

1.2: Problem Statement

The need to provide a safety net against drought is a major expected contribution to be addressed by this research work. The main challenge for smallholder farmers to be addressed by this research are poor food security, yield instability and risk of crop failure associated with erratic and unreliable rainfall-the biggest physical constrain to crop production in the semi-arid region.

2. OBJECTIVES

The main objective was to determine the growth and yield response of sorghum transplants to in-field water harvesting from conservation and conventional soil preparation methods.

3. METHODOLOGY

3.1: Experimental Site

The research was carried out at Save Valley Experiment Station (SVES) in the Lowveld of Zimbabwe. The station is 444m.a.s.l and is at latitude 20E 21’ S and longitude 32E 20’ E. The climate of the area is semi-arid with low and erratic rainfall. The rainfall averages 500 mm per annum and yearly totals ranging from 300 mm to 1000 mm. The maximum temperatures throughout the summer months exceed 30°C with
extremes of greater than 40\(^\circ\)C common in the summer months. Minimum temperatures in winter are around 20\(^\circ\)C with rare occasions of frost (4). The station is surrounded by communal areas where mainly drought tolerant crops such as sorghum and pearl millet are grown under rainfed conditions and under irrigation. The area is very flat, with slight slopes of 0.8 % down to the west. The vegetation consists mainly of open woodland of tall Mucha trees with some acacia species, occasional *Adansonia digitata* and some *Euphorbia* species (5). The soil is classified in the US Taxonomy as an Entic Eutrochrept and in the FAO system as a Chromic Cambisol and as Save 4C.2 using the Zimbabwean system (6). The soil is 100 to 150 cm deep and is a medium-grained sandy loam.

### 3.2 Experimental Design

The experiment was a Single factor design under Randomised Complete Block Design (RCBD) replicated three times. Macia variety was used as the testing variety. A net plot size of 3 m x 0.9 m x 2 rows was used. Sorghum nursery bed was prepared and planting in the nursery was done on 12 December 2017 before the expected rains. The nursery was closely monitored and transplanting into permanent prepared planting methods (open end-planting on ridges, open end-planting in furrows, closed end-planting on ridges, closed end –planting in furrows, deep planting basins (Potholes) and flat area/bed) was done on the 29\(^{th}\) of December 2017 with the first effective rains.

### 3.3 Treatments used

Six Treatments were used and these were as follows:

1. Flatbed (Standard conventional tillage) (Flatbed)
2. Deep planting basins (Potholes)
3. Open end tied ridges, planting on ridges (Ridges)
4. Open end tied ridges, planting in furrows (Furrows)
5. Closed end tied ridges, planting on ridges (ClPltrig)
6. Closed end tied ridges, planting in furrows (ClPlows)

### 3.4 Land Preparation

Land preparation was done a month before the onset of the rain season. Tied ridges and potholing was done using hoes (see Fig 3.4.1 and 3.4.2)
3.5 Plant Nutrition Employed

Compound D (7:14:7) at an application rate of 200kg/ha was applied as basal fertilizer at planting and top dressing of Ammonium Nitrate at a rate of 100kg/ha N was used.

3.6 Parameters recorded

Data was collected from the middle two rows with the exception of destructive root length and root girth which was taken from two exterior rows.

3.6.1 Plant height

Plant height was measured from the soil surface to the height of the flag. Initial plant height measurements were made at transplanting. Plant height measurements were made on fortnightly basis and were taken on the same day with other crop growth parameters. A metre rule was used to measure plant heights.

3.6.2 Root length

Plant roots measurements are not often done because such studies are hampered by the time-consuming separation of the living roots from the soil materials and the debris. Root length was measured using a destructive sampling technique whereby a root auger was used at maximum depth of 150 cm after every two weeks. The two exterior rows were the ones used for the roots measurements from each plot. On measuring root length a threading tape was used and this was done after every two week interval.
3.6.3 Root girth

Root girth was measured as the total root circumference using a tape. This measurement reveals to what extent can the roots from different treatments can go in search of plant requirements. This also reveals the toughness and easiness of different treatments to sorghum growth. Root girth was measured on a fortnightly basis.

3.6.4 Stem thickness

A digital vernier caliper was used to measure stem thickness and this was done on fortnightly basis.

3.6.5 Flowering

Days to 50% flowering was recorded as the time from sowing to anther dehiscence in 50% of the plants in the net plot. Flowering was recorded when each plot reached 50% flowering, that is when half of the plot has flowered. Days to flowering was then recorded as the number of days from transplanting to flowering plus the number of days in the nursery.

3.6.6 Panicle length

Panicle length was measured at harvesting using a 30 cm ruler. Only single measurement was done. The measurement was done from the first tip of the panicle to the last tip.

3.6.7 Grains per panicle

The number of grains per panicle is determined mainly by variety. However different nutrient status can also determine the number of grains per panicle. On this parameter, physical count of grains per panicle was done. Ten panicles were sampled and grains per each panicle counted and then divided by ten so as to have the mean number of grains per panicle for each treatment.

3.6.8: One thousand grain weight

A sample of 1000 grains were taken and weighed using a digital scale.

3.6.9: Grain yield

The final yield of a crop is determined by the interaction of environment and crop factors. The crop factors affecting yield include number of plants per unit area, tillering capacity, panicle length, number of grains per panicle and seed weight. These parameters were measured so that the final grain yield differences from the different treatments can be explained. Grain weight was weighed and grain yield in terms of kg/ha was determined and recorded.

3.7.1: Determination of Gross margin analysis associated with the different conservation and conventional soil preparations methods

After the experiment was conducted, the Gross Margin analysis was done to determine the potential revenue associated with the use of different in-situ water harvesting techniques with accordance to Kelly (7). The gross margin analysis was calculated by subtracting the total variable costs (TVC) from total gross income. Gross margin as explained by (8) is the net sales of produced goods, less the production cost of the goods sold. (8) further explained that Gross Margin is frequently expressed as a percentage,
called the Gross Margin Percentage and is calculated using the following formula where estimated figures will be used:

Formula for Gross Margin according to (Anonymous, 2016)

\[
\text{Gross Margin (GM)} = \frac{\text{Gross income (GI)} - \text{Total Variable Cost (TVC)}}{\text{Gross income (GI)}}
\]

Where:

\[
\begin{align*}
\text{GM} & = \text{Gross Margin} \\
\text{GI} & = \text{Gross Income} \\
\text{VC} & = \text{Variable Cost of inputs (i.e. Production Input Cost + fertilizer Cost + labour)}
\end{align*}
\]

3.7.2: Data Analysis

One way Analysis of Variance (ANOVA) for Generalized Linear Models was used to analyse variance or absence of variance of means of response parameters for sorghum to treatments listed above in 7.8, was achieved using SAS Version 9.4 at 95% confidence level (i.e. \(P \leq 0.05\) significance test level). Means of sorghum parameters were separated using various methods including LSD and Tukey's Multiple Comparison Test (also known as Honestly Significant Difference/HSD Test) to compare the mean separation value with those obtained from LSD and Tukey's Multiple Comparison Test.

4. RESULTS

Table 4.1: Analysis of variance (ANOVA) for the effects of different in-field water harvesting methods on different yield and shoot parameters.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Yield (kg/ha)</th>
<th>1000 SWT (g)</th>
<th>Panicle length (cm)</th>
<th>Stem thickness (mm)</th>
<th>Plant height (cm)</th>
<th>Flowering (days)</th>
<th>Maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2834.0 A</td>
<td>51.667A</td>
<td>29.4967A</td>
<td>12.333A</td>
<td>181.833A</td>
<td>63.000A</td>
<td>93.667A</td>
</tr>
<tr>
<td>Potholes</td>
<td>1846.0A</td>
<td>31.667B</td>
<td>22.4567B</td>
<td>8.5667B</td>
<td>157.867A</td>
<td>65.333A</td>
<td>94.667A</td>
</tr>
<tr>
<td>ClPlows</td>
<td>1830.3A B</td>
<td>35.000B</td>
<td>20.6433B</td>
<td>6.9000B</td>
<td>157.867A</td>
<td>65.667A</td>
<td>94.333A</td>
</tr>
<tr>
<td>ClPtrig</td>
<td>1824.7A B</td>
<td>35.000B</td>
<td>21.1000B</td>
<td>7.8667B</td>
<td>157.867A</td>
<td>66.667A</td>
<td>94.333A</td>
</tr>
<tr>
<td>Ridges</td>
<td>1458.0B B</td>
<td>29.4967A</td>
<td>21.3333B</td>
<td>8.3667B</td>
<td>157.867A</td>
<td>63.333A</td>
<td>94.333A</td>
</tr>
<tr>
<td>Furrows</td>
<td>1107.3B B</td>
<td>31.667B</td>
<td>19.4533C</td>
<td>8.5667B</td>
<td>156.467A</td>
<td>66.000A</td>
<td>94.333A</td>
</tr>
<tr>
<td>Flatbed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Significance 0.004 0.0016 0.0001 0.0001 0.0769 0.0674 0.475
CV            12.48 11.84 39.26 8.58 6.28 6.37 0.61
Table 4.2: Analysis of variance (ANOVA) for the effects of different in-field water harvesting methods on different root parameters.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Root length (cm)</th>
<th>Root girth (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potholes</td>
<td>24.147A</td>
<td>29.833A</td>
</tr>
<tr>
<td>CIPlows</td>
<td>26.367A</td>
<td>23.707</td>
</tr>
<tr>
<td>CIPtrig</td>
<td>28.233A</td>
<td>26.373</td>
</tr>
<tr>
<td>Ridges</td>
<td>29.773A</td>
<td>28.073A</td>
</tr>
<tr>
<td>Furrows</td>
<td>25.767A</td>
<td>27.220A</td>
</tr>
<tr>
<td>Flatbed</td>
<td>23.947A</td>
<td>24.953A</td>
</tr>
</tbody>
</table>

Significance | 0.2753 | 0.8001 |
CV           | 12.48  | 21.04  |

4.1: Effects of different in-field water harvesting methods Sorghum yield

Fig 4.1: Sorghum yield as influenced by different water harvesting methods
There was a significant difference (p<0.05) on sorghum yield as influenced by different in-field water harvesting from different conservation and conventional soil preparations methods. The highest yield of $(2834 \text{kg ha}^{-1})$ and the lowest yield of $(1107.3 \text{kg ha}^{-1})$ were obtained in treatments with potholes and flatbed respectively. This means that there was a difference in the growth of sorghum transplants grown under conservation ridge tillage system as compared to the conventional flatbed.

4.2: Effects of different in-field water harvesting methods One thousand grain weight

**Fig 4.2:** One thousand grain weight as influenced by different water harvesting methods.

A significant difference (p<0.05) was also shown on the effect of different in-field water harvesting on 1 000 grain weight with potholing exhibiting the highest seed weight of 51.667g and the least (31.667g) being attained in closed end tied ridges, planting in furrows.

4.3: Effects of different in-field water harvesting methods Panicle length

**Fig 4.3:** Effects of different in-field water harvesting methods on panicle length.

A highly significant difference (p<0.05) was observed on panicle length with the longest panicle (29.4967 cm) and shortest (19.4533 cm) attained in potholing and flatbed respectively.
4.4: Effects of different in-field water harvesting methods stem thickness

![Bar chart showing stem thickness comparison across different water harvesting methods.]

**Fig 4.4: Effects of different in-field water harvesting methods on stem thickness.**

Effects of different in-field water harvesting on stem thickness had a significant difference (p<0.05) with the greatest thickness being attained in potholing treatment and the lowest thickness being exhibited in closed end tied ridges, planting on ridges (Ridges).

4.5: Effects of different in-field water harvesting on root girth

There was no significant difference (p>0.05) on root girth as influenced by different in-field water harvesting method.

4.6: Effects of different in-field water harvesting on root length

There was no significant difference (p<0.05) shown on the effect of in-field water harvesting on sorghum root length. All the treatments showed statistically the same lengths.

4.7: Effects of different in-field water harvesting on plant height

Sorghum plant height showed no significance (p>0.05) as influenced by different in-field water harvesting techniques. All the treatments exhibited statistically same heights.

4.8: Effects of different in-field water harvesting on the number of days to 50 % flowering.

There was no significant difference (p>0.05) on 50% flowering on sorghum transplants respond to different in-field water harvesting from conservation and conventional soil preparations methods.
4.9: Effects of different in-field water harvesting on the number of days to 50 % physiological maturity.

No significant difference (p>0.05) was shown on the effect of sorghum transplants on 50 % physiological maturity as influenced by different water harvesting methods.

4.10: Gross margin comparisons among yields of sorghum transplants grown under different in-field water harvesting methods

Gross margin is defined by (8 as net sales of produced goods, less the production cost of goods sold. (11) explained that Gross Margin is frequently expressed as a percentage, called the Gross Margin Percentage and is calculated using the following formula where estimated figures will be used:

\[
\text{Gross Margin Percentage} = \frac{\text{Estimated Net Sales of Sorghum} - \text{Estimated Input Costs of Sorghum}}{\text{Estimated Net Sales of Sorghum}} \times 100
\]

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Seed</th>
<th>Compound D</th>
<th>AN</th>
<th>Labour days</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Flatbed (flatbed)</td>
<td>10kg@$30</td>
<td>4 bags@$25 each</td>
<td>2 bags@$30 each</td>
<td>Planting -5 labour days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1st weeding-10 labour days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2nd weeding -10 labour days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Harvesting -5 labour days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(30 labour days @$7.50)</td>
</tr>
<tr>
<td>2. Deep Planting Basins (Potholes)</td>
<td>10kg@$30</td>
<td>4 bags@$25 each</td>
<td>2 bags@$30 each</td>
<td>Planting -10 labour days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1st weeding-10 labour days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2nd weeding -10 labour days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Harvesting -5 labour days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(35 labour days @$7.50)</td>
</tr>
<tr>
<td>3. Open End Tied Ridges, Planting on ridges (Ridges)</td>
<td>10kg@$30</td>
<td>4 bags@$25 each</td>
<td>2 bags@$30 each</td>
<td>Planting- 8 labour days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1st weeding-10 labour days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2nd weeding -10 labour days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Harvesting- 5 labour days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(33 labour days @$7.50)</td>
</tr>
<tr>
<td>4. Open end tied ridges, planting in furrows (Furrows)</td>
<td>10kg@$30</td>
<td>4 bags@$25 each</td>
<td>2 bags@$30 each</td>
<td>Planting -8 labour days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1st weeding-10 labour days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2nd weeding -10 labour days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Harvesting- 5 labour days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(33 labour days @$7.50)</td>
</tr>
<tr>
<td>5. Closed end tied ridges, planting on ridges (ClPltrig)</td>
<td>10kg@$30</td>
<td>4 bags@$25 each</td>
<td>2 bags@$30 each</td>
<td>Planting- 8 labour days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1st weeding-10 labour days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2nd weeding -10 labour days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Harvesting- 5 labour days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(33 labour days @$7.50)</td>
</tr>
</tbody>
</table>
Table 4.11.2: Estimated input costs for the treatments

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Estimated Input Cost/ha (i.e labour, seed, fertiliser)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flatbed (flatbed)</td>
<td>385-00</td>
</tr>
<tr>
<td>Deep Planting Basins (Potholes)</td>
<td>460-00</td>
</tr>
<tr>
<td>Open End Tied Ridges, Planting on ridges (Ridges)</td>
<td>445-00</td>
</tr>
<tr>
<td>Open End Tied Ridges, Planting in Furrows (Furrows)</td>
<td>445-00</td>
</tr>
<tr>
<td>Closed End tied ridges, Planting on ridges</td>
<td>445-00</td>
</tr>
<tr>
<td>Closed End Tied Ridges, Planting in Furrows</td>
<td>445-00</td>
</tr>
</tbody>
</table>

Estimated Grain Marketing Board Price (GMB) for sorghum is currently pegged at $390.00. The gross margin percentages for the different treatments are therefore as tabulated below on Table 4.11.3

Table 4.11.3: Gross Margin Percentage for the treatments

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield(tons/kg)</th>
<th>Selling price/ton</th>
<th>Sorghum net sales</th>
<th>Estimated Input cost(USD $)</th>
<th>Gross Margin Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Flatbed</td>
<td>1.1073</td>
<td>390</td>
<td>431.84</td>
<td>385</td>
<td>10.8</td>
</tr>
<tr>
<td>2. Potholes</td>
<td>2.834</td>
<td>390</td>
<td>1105.26</td>
<td>460</td>
<td>58.3</td>
</tr>
<tr>
<td>3. Ridges</td>
<td>1.8247</td>
<td>390</td>
<td>711.63</td>
<td>445</td>
<td>37.4</td>
</tr>
<tr>
<td>5. CIPltrig</td>
<td>1.8303</td>
<td>390</td>
<td>713.81</td>
<td>445</td>
<td>37.6</td>
</tr>
<tr>
<td>6. CIPlows</td>
<td>1.846</td>
<td>390</td>
<td>719.94</td>
<td>445</td>
<td>38.1</td>
</tr>
</tbody>
</table>

From the table above, gross margin percentages for all the conservation tillage practices are far much greater than the gross margin of the conventional tillage. The highest gross margin percentage of 58.3 % was attained on potholing and the lowest (10.8 %) being attained on flatbed.
5. DISCUSSION

5.1 Yield response of sorghum transplants grown with water harvested from conservation ridge tillage systems as compared to flat bed

There was a significant difference (p<0.05) on sorghum yield as influenced by different in-field water harvesting from different conservation and conventional soil preparations methods. According to (12) and (13a and 13b), water harvesting can improve soil moisture storage, prolong the period of moisture availability and enhance the growth of crops. The result on yield is in agreement with (14). Yield results from this study confirmed the effectiveness of deep planting basins and other water harvesting methods in improving soil water availability and food production as reported by (15). Superiority of the tested water-harvesting methods in conserving moisture and promoting infiltration accounts for the differences in yield results and also coincides with research done by (16).

Grain yield in sorghum is a product of several yield components and these components are equally the product of sequential developmental processes. Any reductions in these yield components (panicle length, seed weight, seeds per panicle, tillers per plant and panicle per plant) directly reduces grain yield. Yield is a product of both physiological and metabolic processes that take place during plant’s growth. Of major important aspect of these processes is water. Potholing technique harnesses water directly to the plant use unlike other water harvesting techniques and thus resulting in highest yields. Sorghum grain yield is a function of grain mass and head weight (17). Partitioning of yield into direct and indirect effects revealed that seed weight and panicle length had the highest direct effect on sorghum grain yield. This is in line with findings by (18). There was a direct link between panicle length, seed weight and grain yield. This justifies the need to clarify the nature of relationships between yield and yield components using path analysis (19 and 16). Conservation ridge tillage systems have been reported by (20) in 2006 to increase sorghum grain yield by more than 40 % and soil water by more than 25 % compared to the traditional method of planting on flat beds. (21) in 2013, reported higher sorghum yields of 2806 kg/ ha being produced in tied ridging treatments compared to flat beds.

5.2: Yield response of sorghum transplants grown with water harvested from deep planting basins (potholing) as compared to flat bed

Potholing and other open end and closed end tied ridges are part of climate smart practice capable of contributing to climate change adaptation through increased plant available water, buffering during dry spells, increased yields and better rainwater productivity enabling food production (22). High yields obtained in potholing agrees with findings by (23) where sorghum and maize in Masvingo and Manicaland provinces had a positive yield increase. However, the issue of labour in making the deep planting holes remained unresolved. The practice of making deep planting basins through several researches provided the crop with constant supply of available water for crop use throughout the entire season – thereby overcoming the issue of dry spells which is a common phenomenon in the semi-arid regions of Zimbabwe (1).

5.3: Sorghum one thousand grain weight

There was a significant difference on 1 000 grain weight, the highest being attained in potholing and tied ridges and the least being obtained in the control (flatbed). Differences in 1 000 grain weight could be attributed to differences in moisture retention amongst different in-field water harvesting methods. Water availability determines the size and weight of seed to be formed. The sink-source relationship is also affected by moisture availability. A significant proportion of the little rainfall received in the dry area...
such as Save Valley Experiment Station comes in short and intense form and runoff can be as great as 30%. Two ways to harvest water are the use of tied ridges and potholing, which concentrate water into the planting furrows. Potholing and use of tied ridges have been reported by Ibrahim et al (2008) to improve infiltration of rainwater into the soil, prolong the duration of soil moisture availability in the soil and store surface and subsurface runoff for later use. There was a significant difference in 1 000 seed weight compared to the control (flatbed). Water harvesting enhance the growth of crops and this coincides with findings by (14) and (16). This coincides with findings by (24) where ridge furrow system gave significant superior grain weights compared to flat system.

5.3: Sorghum root length and root girth

The reason for having no significant difference on both root length and root girth could be attributed to genetic makeup of the testing variety since one variety (macia) was used across all the treatments. These findings however do not concur with research done by (25) who found out that sorghum root structure and distribution is affected by soil moisture. However, in extreme water stressed environments sorghum root growth, structure and distribution can be severely affected by soil moisture. Conservation (closed end tied ridges and open end tied ridges) management practices can result in diminished stimulation of rooting by rising atmospheric carbon dioxide (26) and therefore resulting in statistically the same root development pattern with the sorghum from flat bed. Research by (27) and (28) however, revealed that in conservation tillage, carbon dioxide enrichment increases sorghum seasonal root production by 58 % and results in numerous, longer, thicker and faster growing. Root development and growth is a vital system of plants for absorbing soil moisture and nutrients and it influences the drought tolerance (29).

5.4: Sorghum stem thickness

A significant difference in stem thickness may be explained by the soil moisture content of the soil profile (60 cm) that existed as a result of in-field water harvesting methods. Stem thickness of 12.3 cm was significantly greater to the stem thickness of 8.3 cm attained in the conventional method of sorghum planting. The availability of water to the root zone of any plant makes it easy for the uptake of essential mineral elements needed for crop ‘food’ and for other biochemical processes to take place. (30) reported that ridge-and-furrow sowing was significantly superior to conventional flat sowing in elongating plant height, stem thickness, number of seeds per siliqua, 1 000 grain weight and seed yield of Brassica juncea. This is as a result of optimum moisture retention, improved soil fertility and better root growth which in turn stem thickness. Stem girth, root girth and plant height of maize and sorghum planted in deep planting basins have been reported by (1) to be greater as compared to the farmers’ practice of planting on flatbed. The results agrees with (23) in that deep planting basins produced significantly thicker stems. Deep planting basins concentrates water and nutrients to the intended plant and it makes the application of fertilizer direct to the crop. Higher water harvesting and retaining capacity of the conservation methods resulted in the optimum supply of water throughout the growing period is obviously responsible for the differences.

5.5: Sorghum Plant Height

No significant difference on sorghum plant height was exhibited as influenced by different in-situ water harvesting methods. All the treatment had the same heights as they grew. This result coincides with findings by (22) who found no significant differences in sorghum parameters (plant height, stem thickness and flowering. Crop growth conditions may further be hampered by a number of climatic factors such as low humidity levels, and high temperatures during the growing season (31). Different moisture regimes in different treatments only affected final yield, root stem thickens, panicle length and 1000 seed height. The results agrees with findings by (32) and (24) who reported no significant differences in plant height of sorghum from different water harvesting methods. This could be as a result of same proper drainage
optimum moisture availability received across all the treatments since the season received average and fairly distributed rainfall.

5.6: Sorghum panicle length

There a significant differences observed on sorghum panicle length as influenced by the different water harvesting methods. This contrasts with findings by (26) which showed non-significant difference on panicle length of sorghum from the tested in-field water harvesting methods (ridge–furrow tillages). From his research however, panicle length ranging from 21.67 to 25.27 were observed. The results from this research showed panicle length ranging from 19.45 cm to 29.49 cm. Deep planting basins concentrates water to the intended crop and thus resulting in greater panicle length. Panicle length determines the number of grains to be formed. The greater the panicle length the higher the grain yield expected. Optimum water availability promotes elongation of root girth, panicle length, plant height as evidence by (1). It is the water availability collected in deep planting basins that serve the sorghum plant with adequate plant water throughout the sorghum growing period that made the panicle length in deep planting basins to be significantly longer.

5.7: Sorghum days to 50 % flowering

Flowering doesn’t show any significant difference. This could be due to the fact that same variety (macia) was used. Macia variety is a purebred and has the potential to flower at the same time since it had no impurities and off types. This implies that no kind of water harvesting technique can alter flowering days of sorghum.

5.8: Sorghum days to 50 % physiological maturity

There was no significant difference on physiological maturity. This could be explained by the fact that the variety used was one variety across all the treatments and it was genetically bred the same in as far as its maturity is concerned. No field manipulation can take place in reducing the number of days to physiological maturity. The work coincides with research by (32) who reported no significant effect on sorghum crop growth characters except only in plant height and number of leaves. All the sorghum matured at 94 days.

5.9: Sorghum gross margin percentage

The higher gross margin percentage for the conservation soil preparation methods can be justified by the high yields attained in the treatments compared to the fellow conventional (flatbed) method. High yields results in high profitability. Gross margin is defined by (8) as net sales of produced goods, less the production cost of goods sold. Gross Margin is frequently expressed as a percentage, called the Gross Margin Percentage. Potholing though associated with labour intensive but the net sales from its produce is far much above net sales from other conservation (closed end and open end tied ridge systems) and even far much higher than the conventional method of planting sorghum on flat beds.
6. CONCLUSIONS

The study revealed the potential advantage of in-field water harvesting for semi-arid subsistence sorghum production. This work agrees with previous work done by (22) that revealed the following:

(a) In-field water harvesting improved soil moisture retention within the root zone compared to the conventional method
(b) In-field water harvesting conserve a good infiltration rate
(c) Tied ridges with different planting confirmations can do well but the distance between furrows, furrows height and ridge width as well as the distance between the ties should be intensively studied
(d) In-field water harvesting from different soil preparation methods increase yield and yield components
(e) Use of sorghum transplants reduces the duration in which the crop will be in the field and thus reducing the time lag between last year’s harvest and current crop harvest.

Stem thickness, panicle length and 1 000 grain weight are directly related to sorghum yield. It can be concluded that sorghum transplants shortens the growing season of sorghum in the field and can be used to shorten the period between last year’s harvest and current harvest, thereby a better technique in fighting drought. There is superiority of water-harvesting methods in sorghum production. The use of sorghum transplants in association with in-field water harvesting methods guarantees food production especially in the semi-arid regions of Zimbabwe where there is erratic and unfair distribution of rainfall.

7. RECOMMENDATIONS

Subsistence farmers especially in the low rainfall areas can use sorghum transplants coupled with in-field water harvesting methods (though associated with extra labour) in fighting hunger. This can be a useful package in combatting climate change. However, the package can be labour intensive especially in good seasons.

Farmers can adopt potholing/deep planting basins to increase sorghum production in the semi-arid regions. However, the practice depends with the type of the soil.

REFERENCES


ESTABLISHING THE FIRST NATIONAL FARM ANIMAL GENETIC RESOURCE BANK FOR ZIMBABWE

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ABSTRACT

Farm animal genetic resources (FAnGR) need to be conserved to take advantage of adaptation, disease tolerance and other valuable traits in some livestock breeds, among other reasons. In Zimbabwe, FAnGR management is focused on in situ conservation of small populations of a few animal breeds, without complementary ex situ conservation strategies. In this paper, we present the recent establishment of the Chinhoyi University of Technology Semen Station and Cryobank (CUT Bank), whose objective is to conserve, produce and distribute quality genetics to livestock farmers of Zimbabwe. CUT Bank will focus on conserving genetic material from cattle, goats, sheep and chickens. Currently, 5,000 semen doses collected from nine cattle breeds and other genetic material is banked. Sustainability of the bank hinges on collecting from multiple sites, securing the material in the collection, reducing costs, strengthening institutional linkages, investing in research and development, and building infrastructure for wide-scale distribution of quality genetics to farmers.

Keywords: farm animal genetic resources, conservation, cryobank, livestock, animal resource bank
INTRODUCTION

Zimbabwe is home to a number of diverse breeds of livestock (sheep, goats, cattle, chickens and pigs), fish and other domesticated species. The country’s animal genetic resources comprise both exotic and native breeds dispersed across a number of production systems and agro-ecological zones in urban, peri-urban and rural areas [1]. These resources are valuable in the provision of food, feed and fibre for a bigger future world population and for coping with future changes to production conditions and market demands. Exotic breeds are dominant in the market oriented commercial sector, while native breeds predominate resource-limited, multi-enterprise smallholder production systems where they perform a number of functions.

Livestock resources helps to meet the needs of mankind through direct and indirect contribution to food production, livelihoods and economic development, meeting the social and cultural obligations of livestock keepers, and provision of a number of ecological services [2]. Directly, livestock produce food for consumption or sale in the form of meat, milk and eggs. They also provide products and services that can be sold for cash, which can then be used to buy food for the household. Indirectly, livestock contribute to food crop production through the provision of draught power and transport services on the farm, and manure for soil fertility management. Seventy per cent of food consumed globally is produced on small farms, the majority of which are powered by livestock. Livestock also provide savings and insurance services for farmers to fall back on in hard times, especially where conventional banking and insurance services are non-existent, inaccessible or unreliable [3]. In the case of crop failure due to disease and pest outbreaks, drought or climate variability, farmers sell livestock to meet household needs. Consequently, livestock ownership contributes to climate resilience [4, 5]. Alternatively, farmers can invest any excess resources that they have in livestock. Thus livestock are critical to agriculture based livelihoods and the national economy.

Although livestock contribute to resilience and meeting the needs of humankind, they are faced with a number of challenges. Livestock have to cope with greater climate variability, disease epidemics, parasite outbreaks, and changes to dietary habits and market demands. This makes native livestock breeds important because of their possession of adaptive traits [6, 7], superior reproductive performance [8, 9], ability to meet multiple needs of their owners, and preference by farmers [1]. Most indigenous livestock breeds (such as Mashona, Tuli, and Nguni cattle, Sabi sheep, and Mashona goats) are at risk of disappearance as a result of introgression, dilution and replacement by exotic genotypes. Increasing reliance on a few international trans-boundary breeds across diverse production environments and systems threatens maintenance of native livestock diversity. Permanent loss of the valuable genetic diversity, adaptation and disease resistance traits that these native breeds possess requires that they be conserved [7]. Conservation will enable the livestock industry to cope with future changes in environmental conditions, production systems, dietary habits and market demands.

Two major approaches to conservation are used: in situ conservation which entails maintaining live populations of animals in their dynamic state; and preservation of gametes and embryos, also termed ex-situ conservation. Currently, small populations of Mashona, Tuli and Nguni cattle; Boer goats; and Dorper sheep, are under in situ conservation in Zimbabwe. With in situ conservation, breeds are kept in their dynamic state, and can adapt to changing environmental conditions over time, and simultaneous commercial utilisation of the same animals is possible [10]. However, it is costly in terms of the infrastructure and management required. To maintain adequate levels of genetic diversity, conservation herds must be sufficiently large and breed at random. Zimbabwe’s conservation herds are small, numbering only a few hundred animals per site, making the conservation approach insufficient. Thus, both medium and long term conservation of livestock...
genetic diversity will greatly benefit from a complementary ex situ conservation strategy [11]. Ex situ conservation involves collection and ultra-low temperature storage (cryopreservation) of semen, ova, and embryos for future breeding.

Ex situ conservation projects (also called cryobanks) are designed to preserve genetic diversity and integrity for the benefit of current and future generations [12]. McClintock, Groeneveld [13] noted that animal genetic resources banks are required urgently, particularly in sub-Saharan Africa and parts of Asia, where much of the world’s dwindling genetic variation currently resides. The government of Zimbabwe recently established the first Semen Station and Cryobank (CUT Bank) for Zimbabwe.

MATERIALS AND METHODS

2.1 Creation of CUT Bank

In 2016 Chinhoyi University of Technology (CUT) was awarded a grant from the Research, Development and Commercialization of Innovation Fund (RDCIF) of the Ministry of Higher Education Science and Technology Development, Zimbabwe. The grant was intended to help meet costs towards the establishment of a cattle genetic resource bank and supply of commercial animal reproduction services by purchasing breeding cattle and laboratory equipment. The necessary farm structures, facilities, laboratories, and initial running costs were financed by a further grant from the Projects Fund of the University. The purpose of CUT Bank is 1) to preserve animal genetic resources, and 2) to develop, produce and distribute improved cattle genetics through commercial reproductive technology services. Animal reproduction services offered include production and sale of quality semen doses from proven, local, disease-free bulls; and fixed time artificial insemination (FTAI) on farmers’ doorstep. Complementary services include farmer training, screening and diagnosis of reproductive diseases, parentage verification and genetic diagnostic services in livestock.

2.2 Location

The primary site of CUT Bank is the Germplasm and Reproductive Technology Laboratory (GRTL) located at the main campus of the University in Chinhoyi. At the GRTL, semen is processed and frozen until required for use. Blood and DNA samples are kept in ultra-low temperature freezers (-80°C) and hair bulbs are kept at room temperature. In line with international best practice, plans are currently underway to safeguard against risk of loss by backing up the material at two other sites [11]. Screening of bulls and cows for reproductive diseases is done to ensure ejaculatory sanity of the semen and as a service to farmers. The semen donors are housed at the University’s Hunyani Farm, about 5 km from the main campus.

2.3 Animals and material

CUT Bank was initiated primarily for the ex-situ conservation of local cattle and dairy breeds farmed in Zimbabwe and those perceived to be of conservation interest, and in the future, it will expand to include other livestock species as well. Locally bred pedigree bulls and heifers for each of two Sanga breeds (Mashona, Tuli), two Zebu breeds (Brahman, Boran), one European dual purpose taurine breed (Simmental), four composite breeds (Beefmaster, Charbray, Bonsmara, Simbra), and three specialist dairy breeds (Red Dane, Aryshire and Holstein) were acquired for the project. In addition, 5-10 heifers per breed were also acquired as base populations for the project. The Sanga and Zebu breeds are the ones most preferred by smallholder farmers, who have 90% of the cattle holding of the country. The Simmental and dairy breeds are widely used in commercial beef and dairy systems, for which they were included in the collection. Inclusion of composite breeds was based on the fact that most of them are derivatives of those breeds preferred (Brahman or Sanga) or they possess objective traits that
farmers highlighted [1, 3]. During the first phase of the project a combination of blood, hair and semen samples were collected for cryo-banking. Pedigree information on each donor and historical information on movement of animals across herds was also collected.

Cost analysis

A number of fixed and valuable cost items were estimated for the CUT Bank. Fixed costs included costs related to establishment and depreciation of buildings, facilities, fencing, animals, and equipment. Variable costs included labour, liquid nitrogen, genetic material collection and processing, and laboratory expenses. Laboratory expenses include extenders, chemical reagents, consumables and straws. Costs of animal management (feed, veterinary drugs, vaccines, etc.), and semen distribution to the wider cattle population on farms was excluded from the analysis. These costs are not normally ascribed to cryo-banking of genetic material.

Results and discussion

One cattle shed with a capacity of 48 bulls and 120 heifers, a Taltek® animal handling system and spray race were constructed on the farm. A laboratory was also constructed and equipped for semen processing and evaluation, disease screening, molecular genetics and semen cryo-banking. The animal genetic stocks banked within the CUT Bank project are of two types: those banked for future use (including semen, hair and blood samples), and resources (mostly semen) banked for routine or commercial use. All those resources were collected from the breeding farm of the University. That sampling strategy suits the commercial side of CUT Bank, but does not ensure wide diversity of stock kept for conservation purposes. In future, semen collection from privately owned bulls and from the epididymis of slaughtered males may be considered in order to widen diversity and reduce overall cryo-banking costs. Close to 400 FTAI with semen from locally bred pedigree bulls have been done. This work was done to provide access to better genetics and preferred breeds by smallholder farmers. The FTAI success rate has been ranging from 60 to 70%.

The creation of the GRTL, and in particular the Cryobiology and Animal Genetics Laboratories within it, has created significant opportunities for undergraduate and post graduate research in animal reproduction, molecular biology, genetics, pathology, development of vaccines and conservation. Future focus will be on studies related to sperm membrane dynamics, sperm cryobiology, breed prioritisation for conservation, and identification of genetic markers linked to important production traits in livestock.

The argument against ex situ conservation is that the approach is too costly or that it requires greater technical expertise than is commonly available in most developing countries. Cost is usually cited as a limiting factor for establishment of FAnGR cryobanks, yet published reports on animal gene bank costs are scarce [13], or only based on simulations [14]. The capital and infrastructure investments planned and incurred so far in the establishment of CUT Bank provide a good indication of the overall cost of building and running a cryo-conservation and semen station in Zimbabwe. Generally, CUT Bank costs were higher than those reported elsewhere for similar projects (Table 1). Compared to Italian, Netherlands and USA cryobanks, CUT Bank had the highest annual costs per semen donor. The probable reason for this situation is that CUT Bank is entirely dependent on sample collection from its own bull herd. The Netherlands cryobanks studied by McClintock, Groeneveld [13], for instance, use privately held bulls and epididymal semen collection from abattoir animals, without costs of cattle facilities that are incurred in the CUT Bank project. CUT Bank project costs are also higher due to its other functions of breeding and provision of commercial reproduction services to farmers.

From the analyses, it was observed that ex situ conservation is not as expensive as is generally perceived. In a review of animal genetic resource banking, Blackburn [15] suggested that cryo-conservation projects should have a multi-functional character to reduce overall costs. Indeed, this
case study corroborated the fact that initial investment costs of a cryo-conservation program are high in the short term. It is envisaged that inclusion of other species such as sheep and goats in the collection, use of both in-house and outsourced semen donors, collection of epididymal semen from slaughtered animals, and enlarging the size of the collection offer significant opportunities for reducing costs per unit. Wide scale sale of semen doses and reproduction services can generate revenue which can offset these costs at full scale and help to distribute genetic gains widely. However, the low annual costs for storage make cryo-banking attractive relative to other conservation options. The most important component of the annual running cost of a cryobank is liquid nitrogen which is generally available or can be made on site using a small-scale plant. Because of the limited budget available, the work developed so far in the creation of CUT Bank has to be considered as an initial phase.

Table 6 Estimate of annual costs at CUT Bank and other animal cryo-banks elsewhere

<table>
<thead>
<tr>
<th>Costs in US$</th>
<th>Per straw</th>
<th>Per donor</th>
</tr>
</thead>
<tbody>
<tr>
<td>CUT Bank</td>
<td>100,000</td>
<td>20 bulls</td>
</tr>
<tr>
<td>Establishment</td>
<td>1.06</td>
<td>3,132.00</td>
</tr>
<tr>
<td>Running costs</td>
<td>0.05</td>
<td>132.00</td>
</tr>
<tr>
<td>Total CUT Bank</td>
<td>1.11</td>
<td>3,264.00</td>
</tr>
<tr>
<td>LA Bank Italy</td>
<td>2.61</td>
<td>924.73</td>
</tr>
<tr>
<td>USA cryobanks</td>
<td>1.09</td>
<td>163.37</td>
</tr>
<tr>
<td>Netherlands cryobanks</td>
<td>0.40</td>
<td>40.13</td>
</tr>
</tbody>
</table>

*References: LA Bank Italy [16], USA and Netherlands cryobanks [13], CUT Bank (this paper)*

Future developments for the project will have to focus on duplicating the material at one or more secondary sites to protect against risk of loss due to catastrophic events [11]. In Europe, it was observed that the close involvement of breeders, farmer organizations and artificial insemination centres is important in linking the cryopreservation schemes with farmers on the ground [10]. Presently the CUT Bank project still needs to strengthen institutional linkages with breeders, breeding organisations and farmers in order to create demand for its products and services. The Zimbabwe Herd Book and specific breed associations need to be involved because of their big stake in the maintenance of breeds in the long-term. The *ex situ* conservation program of CUT Bank must also be seen to compliment the *in situ* conservation efforts of the government research stations. Greater emphasis need to be put on genetic resource banking versus *in situ* conservation strategies owing to lower costs, increased security, and the ability to conserve a wide array of animal genetic resources [12]. *In situ* and *ex situ* populations can be combined via an associated database such that there would be gene flow between the two populations.

Recently, there are regional efforts to formulate joint interventions for the conservation and sustainable utilization of AnGR in Southern Africa. With joint funding from the European Union, The African Union Inter-African Bureau for Animal Resources (AU-IBAR) plans to establish a Regional Genetic Bank for AnGR in Botswana [17]. This is a step in the right direction for conservation of AnGR within the Southern African region. Although CUT Bank was formed as a sole initiative of the university, it will need to learn from, and collaborate with, other stakeholders in the region to be relevant and sustainable in the long term.
Safety will be improved by equipping storage rooms with oxygen saturation alarm systems and semen tanks with liquid nitrogen monitoring probes. Workers will need formal training in safety and handling of liquid nitrogen. In addition, there is need to build a liquid nitrogen plant onsite to ensure uninterrupted supply of the cryogen.

CONCLUSIONS
Establishment of CUT Bank is a big milestone towards conservation of local livestock genetic diversity and provision of commercial reproduction services in Zimbabwe. In spite of so much work still to be done, the project is achieving its objectives so far. Sustainability of the bank hinges on collecting genetic material from multiple sites, securing the material in the collection, reducing overall costs, growing demand for commercial animal reproduction services offered, strengthening institutional linkages, investing in research and development, and building infrastructure for wide-scale distribution of quality genetics to farmers.
RELATIVE GROWTH PERFORMANCE AND SUSCEPTIBILITY TO SCOURS OF PRE-WEANED PIGLETS ON CREEP DIETS PARTIALLY SUBSTITUTED WITH MORINGA OLEIFERA

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ABSTRACT

The effect of \textit{Moringa oleifera} leaf meal as a scour prophylaxis and on growth parameters of piglets was evaluated. A total of 168 piglets from 15 litters were used. The piglets were cross fostered and randomly assigned to three dietary treatments; 0\% \textit{Moringa oleifera} leaf meal (MOLM) as the control diet, 4.5\% MOLM and 8\% MOLM inclusion test diets. Each treatment was replicated five times. The feed conversion ratio (FCR), average daily gain (ADG), weaning mass (WM) and average daily feed intake (ADFI) and faecal viscosity (FV) were measured and recorded. The effect of MOLM inclusion level on ADFI, ADG, FCR and WM was analysed using PROC GLM of SAS. Dietary inclusion of 4.5\% MOLM significantly reduced the ADFI of piglets (p<0.05) when compared to 0\% MOLM, however 8\% MOLM had higher ADFI than either 0\% or 4.5\% MOLM inclusion. There was no effect of MOLM dietary inclusion on ADG (p>0.05); however 8\% MOLM dietary inclusion had a higher FCR when compared to 0\% or 4.5 \% MOLM. Piglets in control treatment (0\% MOLM) had more incidence of scours than 8\% MOLM diet (p<0.05) and did not differ to 4.5\% MOLM (p>0.05). There was no effect in faecal viscosity between 4.5 \% and 8\% MOLM diets (p>0.05). MOLM dietary inclusion significantly reduced the cost per kilogram weight gain. Therefore in can be concluded that dietary inclusion of MOLM in creep diet up to 4.5\% improved piglets FCR and resistance to scours.
INTRODUCTION
The cost of feed remains the major operating cost in livestock enterprises directly determining viability and growth. As the society becomes more urbanized the demand for edible animal products usually rises. It is projected that by 2050 the demand for pork and other animal products would have arisen by over 70% (1) at the backdrop of shrinking land sizes availed for agricultural activities. There is therefore need for increase in the efficiency and sustainability of feed production, processing and utilization. Climatic change, and the envisaged rise in competition between human beings and animals for grains and oil seeds will further constrain pig meat production (2). This makes pig meat enterprises uneconomic and unsustainable, especially to the resource constrained smallholder farmer. Here lies the drive to look into and explore possible feed ingredients that have at least comparable nutritive value to the ones already in use but more economical to use and resilient to effects of climate change.

*Moringa oleifera* is one among other plants that has the potential to be used as a pig feed ingredient because of its high nutrient content (3). *Moringa oleifera* leaf meal has a crude protein value that is more than 30% and a crude fiber value of around 11% (4) and is known to contain all essential amino acids (including lysine and methionine) (7). This makes *Moringa oleifera* leaf meal a potential protein supplement. It is also easy to cultivate, gives good results even in poor marginal lands, is drought resistant and requires little or no fertilization (8), which makes its production costs to be considerably lower than that of soya beans (22). The increase in the genetic potential of the pigs to produce more piglets per year has led the industry to demand high level of management especially in terms of dam’s nutrition, piglets’ disease control and hygiene (9). Piglet health management among other factors is very critical. Poor performance that is frequently associated with hygiene related ailments like scours can cause huge losses and derail the advances in genetic merit. Piglet scours can lead to either increased pre-weaning mortality or reduced growth. They are responsible for an average of 10.8% pre-weaning mortality and decrease in potential lean growth by 8 to 14 grams of weaned piglets (10). To avoid losses associated with bacterial related ailments, the pig production industry has traditionally resorted to the utilization of injectable, water soluble and in-feed antibiotics such as colistin (13).

The use of antibiotics in pig production has been of great help in improving production performance (10). However, misuse and abuse of antibiotics has induced anti-microbial resistance or insensitivity to antibiotics (12) posing a serious risk to human life since these resistant characteristics are transferrable between swine bacteria and zoonotic or human bacteria through plasma exchange; or antibiotic residues can be left in meat (13). Because of this there has been rapid decline in the use of these in-feed antibiotics in the developed world, with the likes of the European Union reaching the point of instituting a ban on their use in livestock production (13). There is an increased interest in finding natural solutions to replace the in-feed antibiotics. The pre-weaned piglets are the most vulnerable when it comes to bacterial infections mainly due to immature immune and digestive systems (14). A plausible solution would be natural alternatives that not only treat the animal but that act as both remedies and modulators by helping to boost or facilitate early maturity of the animal immune system (13).

*Moringa oleifera*, garlic and *Aloe vera* extracts are some of the natural herbal plants that have been used by human beings in treating various diseases such as asthma, diarrhea, epilepsy and skin diseases (15,16). *Moringa oleifera* has been shown to have immune-modulatory properties and also act as natural remedy to bacterial infections (17,18). A few studies have been conducted in the control of piglet scours using *M. oleifera* and its use as a protein supplement in creep diets. The study seeks to address the problem of piglet scours from birth up to weaning as well as reduce feed costs. The aim of this
study was to evaluate the nutritional and medicinal effect of creep diets with graded levels of *Moringa oleifera* leaf meal (MOLM) fed to pre-weaned piglets.

2.0 OBJECTIVES

2.1. Main Objectives

To evaluate the nutritional and medicinal properties of creep diets with graded levels of *Moringa oleifera* leaf meal fed to pre-weaned piglets.

2.2. Specific objectives

To determine:


2. The Cost Benefit of different inclusion levels of MOLM in creep diet.

3.0 METHODOLOGY

3.1 Study Site

The study was carried out at the Pig Industry Board of Zimbabwe farm in Arcturus. The farm is located 25.5 km from Harare, along the Harare-Mutoko road. The farm is located at 17°44’24.30″S and 31°15’26.76″E at an altitude off 1333m above sea level (Figure 1).

![Figure 1: Study site: Pig Industry Board Arcturus Farm, Zimbabwe](image)

3.2 Experimental animals’ welfare and management

One hundred and sixty eight piglets from 15 sows of Large White, Landrace, Dalland breeds and their crosses, from the commercial unit at the farm, were used in the experiment. The piglets were fed the experimental diets from 7 days of age until weaning at 35±3 days. Piglets from three randomly selected sows were cross fostered after ear notching to neutralise any parental breed effects on the traits under investigation. Each cross-fostered litter then served as an experimental unit.
The five freedoms as enshrined in the Animal Welfare Code of Practise were observed during the experiment. Each sow and its litter were housed in thoroughly cleaned and disinfected 6.2 m² farrowing pen which became the experimental unit. The sows were caged in 2.4m x 0.9m farrowing crates to allow for ease of feeding piglets the experimental diets. The crate area was enough to allow the sow to move and rest freely during the lactation period. Feed and water was provided to piglets ad lib. The numbers of piglets in each experimental pen were determined by the number of piglets farrowed by the random three sows cross fostered.

Sows were provided with water ad lib and the farrowing house had the recommended gradient that allowed free movement of water and urine into the water drainage trench. Piglets were ear notched, navel clipped and tooth trimmed within 24 hours of life. Piglets were given stress mix after every stressful operation such as weighing. The farrowing house creep area was heated with an infrared lamp to warm the piglets.

3.3 Experimental diets
Diet formulation was preceded by sending 200g of MOLM to the laboratory for nutritional evaluation. Eventually, three creep meal diets of 22% CP where formulated (Table 1).

Table 7: Formulated Creep meal dietary treatments of 22% Crude Protein

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>0% MOLM (%)</th>
<th>0% MOLM (kg)</th>
<th>4.5% MOLM (%)</th>
<th>4.5% MOLM (kg)</th>
<th>8% MOLM (%)</th>
<th>8% MOLM (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>53.30</td>
<td>26.6</td>
<td>52.80</td>
<td>26.40</td>
<td>52.30</td>
<td>26.20</td>
</tr>
<tr>
<td>Wheat bran</td>
<td>4.90</td>
<td>2.50</td>
<td>4.90</td>
<td>2.40</td>
<td>4.80</td>
<td>2.40</td>
</tr>
<tr>
<td>MOLM</td>
<td>0.00</td>
<td>0.00</td>
<td>1.30</td>
<td>0.70</td>
<td>2.40</td>
<td>1.20</td>
</tr>
<tr>
<td>Soya bean meal</td>
<td>39.00</td>
<td>19.50</td>
<td>38.30</td>
<td>19.10</td>
<td>37.60</td>
<td>18.80</td>
</tr>
<tr>
<td>Vit-Min premix</td>
<td>2.80</td>
<td>1.40</td>
<td>2.80</td>
<td>1.40</td>
<td>2.80</td>
<td>1.40</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>50.0</td>
<td>100.0</td>
<td>50.0</td>
<td>100.0</td>
<td>50.0</td>
</tr>
</tbody>
</table>

The experimental units were randomly allocated the treatment diets. The control diet contained soya bean meal as the only protein supplement. Each treatment was replicated five times, each cross fostered litter acting as a block with three sows farrowing. All sick experimental piglets fed control treatment were given an antibiotic (Coliflox WS) as the normal practise at the farm. Piglets in treatments containing *M. oleifera* were not exposed to use of antibiotics. In the situations where there
were incidences of scours, piglets in MOLM treatments and control diet were given vitamin mix and glucose as electrolyte replacements.

3.4 Data collection

3.4.1 Feed Utilization and Growth parameters

Piglets were weighed at birth, at day 7 (experimental initial weight) and at weaning using a Salter hanging scale with an accuracy of 100g to compute body weight gain (BWG). Individual piglets were measured and their live-weights recorded. Average Daily Gain (ADG), Feed Intake (FI) and Feed Conversion Ratio (FCR) were computed for each litter as follows:

\[ BWG = \text{week five body weight} - \text{initial body weight} \]

To get the average daily gain of the piglets, it was calculated as:

\[ ADG = \frac{BWG (kg)}{\text{number of days between weighing}} \]

Feed intake was recorded in order to calculate the feed utilization efficiency for the different treatments. To this end, each experimental litter was allocated known amounts of feed. The remaining or residual feed was also recorded and subtracted from the original recorded allocation. This gave the amount of feed that was consumed.

\[ DFI = \text{amount of feed offered (kg)} - \text{amount of feed refusals (kg)} \]

Feed conversion ratio (FCR) was defined and adopted as the amount of feed required to attain one unit of live weight gain. This was calculated as:

\[ FCR = \frac{DFI}{ADG} \]

The experiment was carried out for 4 weeks and the last measurement was recorded at day 28 when the piglets were 5 weeks old and due for weaning.

3.4.2 Data on scours

The parameter employed to measure the effectiveness of MOLM in reducing piglet scours was faecal viscosity. This qualitative data for scours viscosity was taken using the modified Bristol Stool Chart (Figure 2). Three levels or scores were set at 1, 2 and 3; with the highest score of 3 indicating severe scours and the lowest score 1 representing absence of scours while the median represented moderate level of scours. Using the Bristol Stool Chart, Type 1 to type 3 was regarded as normal faecal matter (score 1), Type 3 to 5 was regarded as moderate (score 2) and Type 6 and 7 represented severe scours (score 3).
3.5 Experimental Design and Statistical Analysis
The study was a one factor experiment laid out in a Randomised Complete Block Design. There were five blocks, corresponding to the five different farrowing periods. Each farrowing period had a random three sow litters with piglets cross fostered to randomise effects of breed and other unknown nuisance variables. The three sow litters in a block where randomly allocated to the three dietary treatments and the randomisation was repeated over all the five blocks. An average of 12 cross fostered piglets in a litter constituted an experimental unit. Data on growth and feed intake were analysed using the PROC General Linear Model (GLM) of Statistical Analysis Software (2018). The least significant difference (LSD) method was used to separate the means at p < 0.05.

The following model was used:

$$Y_{ij} = \mu + D_i + B_j + BW + e_{ij}$$

Where:
- $$Y_{ij}$$ = dependent variable
- $$\mu$$ = general mean
- $$D_i$$ = effect due to treatment i
$B_j = \text{effect due to block } j$

$BW = \text{effect of birth weight as a covariate}$

$e_{ij} = \text{residual error}$

Data on faecal viscosity was analysed using the PROCGLM of SAS.

4. RESULTS
4.1 Proximate Analyses of *M. oleifera*
The proximate analysis results showed that *M. oleifera* leaf meal (MOLM) employed in this study had 90% dry matter content comprised of 32.6% crude protein, 39.02% carbohydrates, 11% crude fiber and 13.3% mineral content (Table 2). *Moringa oleifera* leaf meal had high content of major minerals such as calcium (2%) and phosphorus (1.08%).

**Table 8**: Nutritional composition of *M. oleifera* dried leaf per 100g edible portion

<table>
<thead>
<tr>
<th>Component</th>
<th>Average (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter</td>
<td>90.00</td>
</tr>
<tr>
<td>Crude fibre</td>
<td>11.00</td>
</tr>
<tr>
<td>Crude protein</td>
<td>32.60</td>
</tr>
<tr>
<td>Nitrogen free extract</td>
<td>39.02</td>
</tr>
<tr>
<td>Ether extract</td>
<td>4.08</td>
</tr>
<tr>
<td><strong>Ash</strong></td>
<td>13.30</td>
</tr>
<tr>
<td>Calcium</td>
<td>2.00</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>1.08</td>
</tr>
<tr>
<td>Sodium Chloride</td>
<td>&lt;0.10</td>
</tr>
</tbody>
</table>

4.2 Blocking Effect
Blocking against breed effect did not significantly affect ADG and FCR of pre weaned piglets ($p>0.05$). Hence the data was then analysed without blocking.

4.3 Cost Benefit Analysis
MOLM dietary inclusion affected cost of production as shown in Table 4. 4.5% MOLM inclusion level gave the lowest feed costs per kg of gained.
Table 9: Cost Benefit analysis for different MOLM dietary inclusion levels

<table>
<thead>
<tr>
<th>Dietary Inclusion Rate</th>
<th>0% MOLM</th>
<th>4.5% MOLM</th>
<th>8% MOLM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost per kg of feed ($/kg)</td>
<td>0.405</td>
<td>0.403</td>
<td>0.401</td>
</tr>
<tr>
<td>Total Feed intake (kg)</td>
<td>35.9</td>
<td>31.9</td>
<td>35.6</td>
</tr>
<tr>
<td>Total Feed Cost ($/kg)</td>
<td>14.54</td>
<td>12.86</td>
<td>14.27</td>
</tr>
<tr>
<td>Weight gain (Kg)</td>
<td>183.2</td>
<td>196.5</td>
<td>208.2</td>
</tr>
<tr>
<td>Cost per kg of gain ($/kg)</td>
<td>0.079</td>
<td>0.065</td>
<td>0.069</td>
</tr>
</tbody>
</table>

4.4 Effect of Diet on ADFI, ADG and FCR
Diet had no significant effect (p>0.05) on ADG, but significantly affected (p<0.05) both ADFI and FCR as presented in Table 4

Table 10: Effect of dietary inclusion level of MOLM on FCR and ADFI in pre-weaned piglets

<table>
<thead>
<tr>
<th>Dietary Treatments</th>
<th>LS Means ± SE</th>
<th>ADG (kg/day)</th>
<th>FCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>0% MOLM</td>
<td>0.026± ± 0.001</td>
<td>0.22± ± 0.016</td>
<td>0.13± ± 0.007</td>
</tr>
<tr>
<td>4.5% MOLM</td>
<td>0.022± ± 0.001</td>
<td>0.23± ± 0.016</td>
<td>0.13±± ± 0.007</td>
</tr>
<tr>
<td>8% MOLM</td>
<td>0.030± ± 0.001</td>
<td>0.19± ± 0.016</td>
<td>0.16± ± 0.007</td>
</tr>
</tbody>
</table>

abcxyz Means in the same column with different superscripts are significantly different

The highest ADFI and FCR were noted in the highest MOLM inclusion level of 8%, of which ADG was not significantly affected by diet. The lowest feed intake was noted for the 4.5% MOLM inclusion level. FCR of the control diet and the 4.5% MOLM diet were not significantly different.

4.5 Effect of Diet on faecal viscosity
The results presented in Table 5 show that there was a notable decline in scours with increase in MOLM proportion in the creep diet.
Table 5: Effect of diet on faecal viscosity

<table>
<thead>
<tr>
<th>Dietary treatments</th>
<th>LS Means ± SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0% MOLM</td>
<td>41.50± 16.77</td>
</tr>
<tr>
<td>4.5% MOLM</td>
<td>30.85± 16.77</td>
</tr>
<tr>
<td>8% MOLM</td>
<td>28.22± 16.77</td>
</tr>
</tbody>
</table>

abc Means in the same column with different superscripts are significantly different

4.0 DISCUSSION

4.1 Effect of Diet on ADFI, ADG and FCR

Piglets on the 8% MOLM diet had the highest ADFI followed by those on the control diet. Piglets on 4.5% MOLM diet had the least ADFI. This is in close agreement with the findings of Mukumbo et al (19) who noted a significant increase in the average daily feed intake in 7.5% MOLM dietary inclusion level compared to 5% and below. Annor & Bonsu (20) also observed that there was no significant difference in ADFI between 0%, 1%, 2.5% up to 5 % MOLM partial substitution in weaner pigs.

The findings seem to suggest that MOLM inclusion rates of up to 5% where you are getting this from when we did not have 5% inclusion of MOLM either depress feed intake or has no effect on feed intake relative to a control diet without MOLM. However, beyond 5% MOLM inclusion rate feed intake increased with increase in MOLM inclusion rate. The subsequent increase in ADFI with increase in MOLM dietary inclusion may be due to the increase in the level of tannins (anti-nutritional factors) in the diet which translates to low protein digestibility thereby leading to compensatory feed intake by the animal as supported by Mukumbo et al (19).

The findings of this study showed that there was no significant difference in the average daily gain of the piglets on the three diets. In close agreement with these finding, Mukumbo et al (19) also reported no significant difference in the ADG of finisher pigs fed with 0%, 2.5%, 5% and 7.5% MOLM partially substituted diets. Acda (22) also reported no diet effect on average daily gain (ADG) of pigs fed diets that had been partially substituted with up to 10% MOLM. These results therefore revealed that Moringa oleifera can be successfully utilized as a protein supplement in pig production without adversely affecting average daily gain in piglets.

Findings on the average daily feed intake (ADFI) of the piglets showed that piglets that were in the 8% MOLM dietary inclusion treatment had the highest average daily feed intake of all the diets under investigation. Since ADG showed no significant change it implies that high MOLM inclusion rates were associated with decline in feed utilization efficiency. These results agree with the findings of Nduku (21) who observed an increase in daily intake of piglets which were allocated 7.5% MOLM dietary inclusion treatment than other treatment diets whilst their ADG were the same.

At 4.5% MOLM inclusion rate FCR was not significantly different to that of the control diet, but was significantly lower than for the 8% MOLM inclusion rate. This revealed that piglets that were assigned in 8% MOLM treatment were less efficient in converting feed nutrients into body mass. These finding were in support of the study that was carried out by Mukumbo et al (19) who reported that partial substitution of the weaner diet with 7.5% MOLM was less efficient in feed utilization (FCR). However, Acda (22) observed that MOLM partial inclusion in finisher diet was efficient up to 10%. Considering age difference between experimental animals of these three studies, Acda’s (22) discoveries cannot be completely rejected since the digestive tract of finisher pigs is more mature and can utilize a wide range of feeds more efficiently than younger pigs (23). The difference could be due to anti-nutritional factors which are present in Moringa
Moringa oleifera such as tannins (32g/kg) that binds proteins and therefore decreasing the nutrient availability to the animal (4). Serem et al (24) also reported low feed conversion ratio in treatment diets that had 3% MOLM inclusion and 6% MOLM inclusion; however, observed poor performance at 12% MOLM dietary inclusion. This strongly supports the possible effect of anti-nutritional factors (tannins) over the age factor since FCR is worsening beyond 6% MOLM dietary inclusion in pre-weaned, weaned and grower pigs.

4.2 Effect of Diet on Scours in piglets
MOLM diets recorded significantly reduced scours compared to the control diet with no MOLM. This was in close agreement with the findings of (25) who observed the immune-modulatory effect of M. oleifera in hastening the development of immature piglet immune and digestive systems. This showed that MOLM had some pharmacological effects that either aided in preventing the growth of pathogenic diarrhoea in the piglet’s gut or early maturity of the piglet’s immune system.

4.3 Cost Benefit Analysis
The Cost Benefit Analysis revealed that MOLM diets significantly reduced feed costs as compared to the control diet. The least costs of production were reported for the 4.5% MOLM inclusion rate. This was supported by observations made by (7) who reported 4% MOLM diet as the most efficient in broiler production.

5.0 CONCLUSION AND RECOMMENDATION
MOLM is a potential substitute of Soya Bean meal as a protein source in piglet creep diets, though at moderate inclusion rates of below 5%. Such diets significantly reduce production costs without altering growth rate in piglets. MOLM diets also appear to promote normal digestion process and seem to stimulate early development of the immune system of piglet thereby reducing the incidence of piglet scours. MOLM fed piglets had the lowest faecal viscosity, reflecting that there were healthier than piglets on the control diet. It can be concluded that MOLM can be successfully used in creep diets without detrimental effects, reducing the producer’s costs of production through lowering feed and drug costs whilst subsequently lowering the mortality rates and increasing the weaning masses.

Further studies are recommended to determine the most appropriate methods to bind tannins so as to improve on MOLM digestibility and to assess whether these benefits of MOLM will persist to the weaner, grower and finisher stages.

REFERENCES


MULTISTOREY AUTOMATED CAR PARKING SYSTEM (MACPS): TOWARDS SMART CITY PARKING
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Abstract.

The increase in urban traffic results in a need for more car parking facilities yet the surface area does not increase. City authorities respond by creating new parking space which results in blocking some roads. A Multistorey Automated Car Parking System (MACPS) offers a better solution to optimize the use of available ground leaving more ground space which can be used for roads and other facilities. In this paper, the design and prototyping of such a system is presented. The MACPS is based on the elevator principle to park and retrieve cars. It utilizes three-dimensional movements piloted by a microcontroller to control three DC stepper motors used for parking. A miniaturized system was developed and tested using small toy cars and 5-watt stepper motors for demonstration of concept. The developed prototype could automatically park and retrieve the toy cars after the user had selected the relevant parking slot. The work demonstrates the feasibility of implementing multistory automated parking system.

Keywords: Multistorey parking, Automation, Prototype, elevator principle, three dimensional motion.

1. INTRODUCTION

In today’s world vehicle parking space is becoming a big problem. As population is increasing, the number of vehicles is also increasing but the area to park the vehicles is not increasing \[1\]. This creates a big problem to vehicles like cars and mini vans for parking. This results in people parking cars on undesignated points which may result in traffic jam(s), accidents and also municipalities lose a lot of money. A report by Zimbabwe Situation showed that the Harare City Council was losing a lot of money such that instead of collecting $1.3 million per month, the local authority was getting a paltry $400 000 from parking payments \[2\]. In order to make sure the council gets more money, parking garages may solve the problem of unaccounted parking fees as parking garages usually have a single entrance and single exit so it is easier to control traffic and collect parking fees.

Multilevel car parking is becoming popular as it enables the conservation of space. The conventional multilevel parking garages makes use of ramps and driveways which consumes space \[1\] that could be used for accommodating more cars if the garage was to be automated. Automated garages are proposed to work for seven days a week and this will increase the safety of parked vehicles at any given time of the day and also increases convenience for motorists \[3\]. The Newsday reported on an incident when a motorist parked her vehicle on a street parking bay and there were no parking marshals to serve her so when she returned she found that her car was clamped \[4\].
However, using automated parking brings its own challenges such as the need of using lift mechanism for moving the vehicle from one floor to the other, the safety of the vehicles as they are being transported and the specifications of the vehicles to be parked.

The idea of multilevel automated parking systems removes the inefficiency of current methods of parking enforcement (several people continuously roaming around checking parking spots). The objective of such technologies is the reduction of burden on the driver, improvement of traffic capacity, and provision of reliable and secure car parking facilities.

I. DEVELOPMENTS TOWARDS MULTISTOREY PARKING

Multistorey buildings require expert architectural designs for the space [5] and so does the implementation of multilevel parking systems. It follows that the development of such a system is a multi-discipline endeavor. A multilevel parking can be defined as a parking system utilizing volumes of floors for temporarily parking vehicles [6]. There are different designs of parking garages of this type with the very common ones making use of ramps to move from one level to the other and driveways to access the parking bays [7]. Less common are parking garages that use lifts to go from one level to another [8].

An automated car parking system (APS) is a mechanical system designed to park and retrieve cars without having a human operator and it then minimizes the area or volume required for parking cars. In multilevel parking garages, an APS provides parking for cars on multiple levels stacked vertically.

Automated parking systems first appeared in Europe as early as the 1900’s [9] and in the North America in the 1920’s at Hotel La Salle in Chicago [10]. According to The Mechanical Parking Guide 2011 by Leon Hamelink [11], the earliest reference to something akin to an automated parking system was the Garage Rue de Ponthieu in 1905. The system consisted of a lift in the center of the structure to move cars up one or two floors where attendants on the floors would park the cars. While this can technically be considered a semi-automatic system, the Garage Rue de Ponthieu [12] contained many elements found in modern automated car parking systems.

The next sections present the different technologies used in multilevel automated parking systems as explained in [13].

2.1 Automated Guided Vehicle (AGV)

AGV technology is being used in automated parking where vehicles are parked on pallets in the parking modules. They are collected from parking modules by the AGV’s driving beneath the vehicle pallet, lifting it, and then moving it out of the parking module into the system. Unlike mono-path “rack and rail” systems, which are limited to one lane of lateral movement along a steel rail, the robotic valet uses robots that roll freely in any direction across solid concrete slabs (including underneath parked cars) enabling faster retrievals and the ability to work around obstacles [14].

2.2 Rail Guided Cart (RGC)

Nowadays Rail Guided Cart (RGC) technology is being used in automated parking where the RGC operates in a similar way to AGV except that the RGCs are less complex and more robust than AGVs. The RGCs are therefore more cost effective and more reliable. Vehicle elevators are used within the system to move the vehicle pallets with or without an RGC.

2.3 Crane System

Crane parking systems are single mechanisms to simultaneously perform the horizontal and vertical movements of the vehicle to be parked or retrieved in the parking system. The crane mechanism moves horizontally on rails, typically located on the floor and ceiling of the parking system, and has
a vertical elevator platform fitted where vehicles to be parked and retrieved are placed. This means
that a floor to ceiling opening in the center of the system is required for the crane to operate.

2.4 Tower System
Tower system typically consist of a vehicle elevator with a parking space either side of the elevator
shaft. This configuration is repeated over several levels to complete the parking tower. Typically,
there is a parking module located on the ground floor, where the vehicle is turned, and the vehicle
elevator raises to one of the parking levels of the tower and deposits the vehicle sideways into a
parking space. This process is reversed to retrieve a vehicle

2.5 Silo system
Silo systems are cylindrical systems with a single, centrally positioned mechanism used to park and
retrieve vehicles. The central mechanism moves vertically and rotates simultaneously allowing the
vehicle platform to move to and from one parking slot to another very quickly. Silo systems are
installed underground, and are most suitable where soil conditions are particularly unfavorable, but
can also be installed above ground. Single or multiple parking modules are possible with silo systems
but only one vehicle can be parked or retrieved at a time.

2.6 Shuttle System
Shuttle systems utilize autonomous shuttles and elevators to park and retrieve vehicles. The number
of shuttles in the system is flexible and is based around the client’s throughput and budgetary
requirements. The shuttles move horizontally in a shuttle lane, which is either a recess in a solid floor
or a set of rails in a steel or concrete structure, to a designated location. A robot, or pallet exchanger,
or conveyor belts, located on the shuttle then parks or retrieves a vehicle at the designated location by
moving the vehicle from or to the shuttle and the parking space.

2. SYSTEM DESIGN
The development of the prototype included hardware and software development. The development
of these components is outlined in this section.

3.1. Hardware implementation
The hardware consists of Arduino microcontroller board, matrix keypad, liquid crystal display (LCD),
5-Watt bipolar stepper motors, H-bridge motor controller, light emitting diodes, and parking structure.
The parking structure model was designed using Fusion 360 software and it composes of parking
shelves, three movements in the x-plane, y-plane, and the z-plane movements. The three movements
were driven by stepper motors and belts. On one end of each movement the belt was connected to an
idle pulley. Figure 3 below shows a parking model designed using Fusion 360 software.

The bipolar stepper is a two phase four wire motor. Each phase has two wires and one terminal should
be high at any given time to energize it. In order to change the direction of rotation, the phases should
reverse the polarity and this is achieved by using an H-bridge which allows the current to flow in an
opposite direction in relation to the previous direction.
Figure 3 Parking structure model

Figure 4 below shows a stepper motor inputs with fly-back diodes.

Figure 4 Stepper motor with fly-back diodes

Figure 5 shows the H-bridge to motor connection. The motor drive makes use of the L298N chip which has four inputs and four outputs. In every step of sequence, two wires are always set to opposite polarities. Because of this, it is possible to control a stepper motor with only two wires instead of four. By using an NPN transistor on each pair of wires, you can turn one off while the other goes high. The transistor’s base is connected to the first pin via a resistor and to the output pin of the microcontroller. The second pin is connected to the +5V through a pull-up resistor, and the transistor’s emitter goes to ground.

When the transistor is fully biased then it can allow current to flow across the collector and emitter. This stage is called saturation region and when the base current is removed the transistor becomes fully off, and this stage is called as the cut-off region.

\[
R_b = \frac{V_{be}}{I_b}
\]

1

\[
R_b = \frac{5V}{5mA}
\]

2
3.2. Software implementation

The software part of the project was done in two parts which are an embedded C program to control the three stepper motors and C# program for windows form application for database management. The program to control the stepper motor was written in Arduino software and then uploaded into the Arduino microcontroller board via a USB cable.

The database was designed using the Azure SQL Server in Microsoft Visual studio 2017. The database has three tables, the vehicles table which stores parked vehicles information, user sign up which captures the information of all users (parking attendant), and parking charges table for billing purposes. The image in Figure 6 below shows a typical table in the database, the Vehicles table with six columns.
For database management, Windows form applications were designed that will be used to save the data into the database. The Windows form applications were created using C# and Microsoft Visual Studio 2017. An example of a Windows form application used for adding vehicles into the vehicles table is shown in Figure 7 below.

![Figure 6 Vehicle table](image)

### 4 RESULTS AND DISCUSSION

The MACPS was designed, integrated and tested. The results are shown in two categories that are simulations (using Proteus software) and practically.

The electrical circuits were tested using Proteus software before building practical circuits and soldered onto the vero-board. The model designed using Fusion 360 was simulated before building the final model using wood.

The diagram in Figure 8 below shows a keypad and LCD connected to an Arduino. The keypad allows entry of commands to the Arduino and the LCD provides a Human Machine Interface.
Figure 9 below shows the practical results of the parking display with LCD display, keypad entry, and LEDs that show the statuses of the parking lots. The parking comes with instructions on how to park or retrieve your vehicle.

![Figure 8 Liquid crystal display and keypad](image1.png)

![Figure 9 Parking display](image2.png)

The parking system prototype is shown in Figure 10. From the diagram the parking mechanism is at its resting position with the car waiting at the picking/dropping point. The picking/dropping point is where the driver leaves his/her vehicle before the system takes over the car for parking and when the driver comes to collect the vehicle the system will bring the vehicle at this same point so that the driver can take control of the vehicle. The size of the vehicle to use this parking facility is limited to light motor vehicles with net mass less two thousand three hundred kilograms. The height of the vehicles is limited to 2.5m maximum.
The application was tested and the parking attendant was able to log in successfully into the system. For this design the vehicle information and payment details were being entered manually due to limited resources. For real world use of the system the designer will recommend the use of cameras to capture the vehicle information by taking vehicle registration number.

Figure 9 above shows the different vehicle information that were captured before the vehicle can enter into a parking bay and the search option to search for any parked vehicle.

After testing the prototype, it was time to look at possible challenges that can be faced in implementing a project of this nature in Zimbabwe. Due to the economic situation currently affecting all businesses in the country the major problem in doing a project of this nature is funding. The other point to highlight is that the system will need uninterrupted power supply so rather than depending on the power supply from the national grid we can consider using solar energy but again it has problems of high initial cost.
5 CONCLUSION

The prototype of the Multi-storey Automated Car Parking System was designed, implemented, and tested. During testing of the prototype, the system was able to move the cars into the parking bays and also retrieving of cars was done. As for the application the user was able to log into the application, the vehicle’s details and payment details were manually captured. Both the practical results and the simulated results proved that the system can be used to solve real-world problems. The goal of the project was to show that automatic storage and retrieval principle can be used in parking vehicles. The most important safety feature is that all vehicles are to be parked with no occupants inside.

Projects of this nature need to engage different stakeholders and find out more what people think of the proposed idea(s). This will also help in finding more ideas that will help to design a system(s) in the interest of the users. The system can help municipalities and privately owned businesses such as hotels for example.

RECOMENTATIONS

Several improvements can be done to the system to increase efficiency:

- The use of IP cameras in capturing the vehicle information will eliminate the use of manually entering vehicle information.
- For the payment of parking the system can be designed only to use all other payment methods except cash.
- Project of this nature needs different professionals so that a project of higher quality is produced.

6 REFERENCES

NEEM LEAF EXTRACT FOR THE CONTROL OF THE SWEET POTATO WEEVIL (CYLAS FORMICARIUS ELEGANTULUS (SUMMERS) IN SEMI-ARID REGIONS OF ZIMBABWE
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ABSTRACT

The trial on assessing neem leaf extracts for the control of the sweet potato weevil was carried out at Chiredzi Research Station during the 2016 winter season. The objective of the trial of this study was to evaluate neem leaf extracts for pesticidal activity against the sweet potato weevil, Cylas spp. Treatments combinations used are dipping vine cuttings in carbaryl at 65g/10l of water at planting followed by sprays of the same insecticide at the same rate at three week intervals, dipping vine cuttings in 100ml neem extract/10L of water at planting followed by sprays of the same rate at three week intervals, dipping vine cuttings in 75ml neem extract/10L of water at planting followed by sprays of the same rate at three week intervals, dipping vine cuttings in 50ml neem extract/10L of water at planting followed by sprays of the same rate at three week intervals, dipping vine cuttings in 25ml neem extract/10L of water at planting followed by sprays of the same rate at three week intervals and an untreated check with vine cuttings dipped in distilled water at time of planting. After the data was subjected to one-way analysis of variance, and means separated at α=0.05 by least squared differences (LSD), with sweet potato weevil count transformed using arc-sine transformation after adding 0.5 to each value, preliminary findings have concluded that neem leaf extracts can reduce sweet potato weevil activity among treatments.

Key words Neem extracts, bio-active ingredients, sweet potato weevil, control, yield
1.0 INTRODUCTION AND JUSTIFICATION

Sweet potato, *Ipomoea batatas*, is an important carbohydrate source in the world, particularly for Asian and African populations. It is a versatile crop; the young leaves and the shoot are sometimes eaten as greens (1). The potential of this crop as a major raw material for industrial purposes (2, 3) has increased its significance. In the culinary industry for example in Ghana and Uganda, sweet potato is used in the preparation of custard, baby foods (Cerevita and Cerelac), pastries, composite flour, yoghurt and French fries. It produces more edible energy, protein and dry matter per hectare than any other crop (4). Also, sweet potato has early maturity period compared with yam and cassava. These attributes have placed sweet potato in the famine mitigation bracket. Sweet potato has varied pharmaceutical significance. The crop has been reported to contain pro-vitamin A or beta-carotene and has the potential to reduce vitamin A deficiency (5). It is also used for the treatment of diabetes (6). The consumption of sweet potato has been recommended for low blood glucose levels (7). In spite of the numerous benefits of the crop, its production in Zimbabwe is at the subsistence level where farmers rarely cultivate more than one acre of land.

Pests’ infestation is a major biotic constraint to production. Nematodes for instance, represent a significant problem in sweet potato production causing reduction in yield and quality of storage roots (8). *Meloidogyne* spp., *Rotylenchulus reniformis*, *Pratylenchus* spp. and *Ditylenchus* spp. are the major sweet potato pests. However, the sweet potato weevils, *Cylas* spp. constitute a major threat to the production of the crop (9, 10). *Cylas puncticollis* and *C. brunneus* are among the most devastating species.

The adult female lays eggs singly in cavities excavated in vines or in storage roots, preferring the latter. The egg cavity is sealed with a protective, gray fecal plug. The developing larvae tunnel in the vine or storage root. Pupation takes place within the larval tunnels. A few days after eclosion, the adult emerges from the vine or storage root. Because the female weevil cannot dig, she finds storage roots in which to lay her eggs by entering through soil cracks. Alternate hosts of sweet potato weevils are *Ipomoea* spp. weeds. Adults of all species may be conveniently sexed by the shape of the distal antennal segment, which is filiform (thread-like, cylindrical) in males and club-like in females. The males have larger eye facets than the females. At optimal temperatures of 27–30°C, *C. formicarius* completes development (from egg to egg) in about 33 days.
Adult longevity is 2 1/2 to 3 1/2 months and females lay between 100 and 250 eggs in this period. At suboptimal temperatures, development takes longer.

Damage symptoms are similar for all three species. Adult sweet potato weevils feed on the epidermis of vines and leaves. Adults also feed on the external surfaces of storage roots, causing round feeding punctures, which can be distinguished from oviposition sites by their greater depth and the absence of a fecal plug. The developing larvae of the weevil tunnel in the vines and storage roots, causing significant damage. Frass is deposited in the tunnels. In response to damage, storage roots produce toxic terpenes, which render storage roots inedible even at low concentrations and low levels of physical damage. Feeding inside the vines causes malformation, thickening, and cracking of the affected vine (11).

Losses of marketable yield as high as 60-97% has been reported (12, 13). Low levels of infestation can reduce root quality and marketable yield because the plants produce unpalatable terpenoids in response to weevil feeding (14). The application of inorganic pesticides such as neem leaf extracts for the management of *Cylas spp.* though effective has been criticized on grounds of high cost of production and environmental pollution.

The neem (*Azadirachta indica*) contains more than 100 bio-active ingredients and it is rich in protein. Its bitter taste is due to an array of complex compounds called "limonoids". The most important bio-active principal is azadirachtin (repellent); other compounds are gedunin (anti-malarial), nimbin (anti-inflammatory, anti-pyretic), nimbidin (antibacterial), nimbidol (anti-malarial, anti-pyretic), quercentin (anti-malarial), salannun (repellent), and sodium nimbinate (spermicide). Young neem leaves contain 60% water, 23% carbohydrates, 7% proteins, more than 3% minerals, and 1% fat (15). Its derivates neutralise nearly 500 pests worldwide, including insects, mites, ticks, and nematodes, by affecting their behaviour and physiology. Neem does not normally kill pests right away; rather it repels them and affects their growth. As neem products are cheap and non-toxic to higher animals and most beneficial insects, it is well-suited for pest control in rural areas. (16)

The most commonly used products in pest control are extracts from seeds or leaves. The seeds have about twice the potency of the leaves, but they are only available for 3-4 months each year. Leaves have to be dried in the shade, because the sunlight will break down some active ingredients. The powder obtained from crushed leaves can be used directly for dusting crops or as powder in stored foods. It can also be mixed with water on sprayed on crops. If the kernels are used they should be soaked in water overnight. The extract can be filtered and applied by a hand-pump sprayer. As the active compounds of neem decompose rapidly, drops under attack have to be treated weekly. The development of cost effective and environmentally friendly sweet potato weevil management options should therefore engage the attention
of researchers. Thus, the objective of this study is to evaluate neem leaf extracts for pesticidal activity against the sweet potato weevil, *Cylas spp*

**1.2 MATERIALS AND METHODS**

1.2.1 Study Site

The study will be carried out at Chiredzi Research Station located in the south-eastern lowveld (agro-ecological region 5) of Zimbabwe. The station is at an altitude of 429m above sea level and it experiences temperatures of above 29 degrees Celsius and receive rainfall totals of 450-650 year round. Triangle PE1 series such as shallow sandy clay soils dominate (17, 18). The trial was conducted during the (January-May) season and repeated during the (August-December, 2016). The location experiences a low rainfall pattern with a mean annual rainfall of about 450mm. Mean temperatures are relatively uniform throughout
the day and ranges from 33.3°C during the day, dropping to about 21°C at night. Relative humidity ranges between 45-90%.

1.2.2 Experimental Procedure

1.2.2.1 Preparation of the neem extract

- Neem leaves will be crashed and mixed with distilled water.
- The substrate is left over night and sieving will be done to get the substrate.

1.2.2.1 Treatments

- 1. Dipping vine cuttings in carbaryl at 65g/10l of water at planting followed by sprays of the same insecticide @ the same rate at three week intervals.
- 2. Dipping vine cuttings in 100ml neem extract/10L of water at planting followed by sprays of the same rate at three week intervals
- 3. Dipping vine cuttings in 75ml neem extract/10L of water at planting followed by sprays of the same rate at three week intervals
- 4. Dipping vine cuttings in 50ml neem extract/10L of water at planting followed by sprays of the same rate at three week intervals
- 5. Dipping vine cuttings in 25ml neem extract/10L of water at planting followed by sprays of the same rate at three week intervals
- 6. Untreated check. Vine cuttings dipped in distilled water at time of planting.

1.2.2.2 Planting Material

The planting material (vines) was obtained from the oleiriculture section. Apical vines of sweet potato cv. Magutse were cut into 30 cm sections with each vine cutting having 7 nodes. Planting was done on
stools that were spaced at 1m. A complete block design with three replicates and 6 treatments were laid in the nursery site. Each plot/stool was infested with 10 adult weevils four weeks after planting.

1.2.2.3 Data collection and analysis

Parameters which were assessed in the experiment include: mean population of *Cylas formicarius* on sweet potato plants at 3 weekly intervals starting from the 4th week, number of perforations on sweet potato leaves, number of healthy and unhealthy tubers, number of holes on sweet potato tubers at harvest, number of weevil larvae on tubers and yield. Data concerning adult weevil counts or larvae on tubers will be square root transformed, analyzed using Genstat 14 statistical package. Means were separated using Fisher’s Protected Least Significant Difference (LSD)

1.3 Results

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Leaf perforations</th>
<th>Mean adult weevils</th>
<th>Mistable yield</th>
<th>Non-mistable yield</th>
<th>Holes per tube</th>
<th>Tunnel/ tuber</th>
<th>Larvae /tuber</th>
<th>Adult weevils</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cabaryl 65g</td>
<td>1.25a</td>
<td>0.78a</td>
<td>3.55ab</td>
<td>1.22a</td>
<td>0.33a</td>
<td>1.25a</td>
<td>1.03a</td>
<td>1.37a</td>
<td>0.032</td>
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<tr>
<td>100 ml neem</td>
<td>1.57ab</td>
<td>1.04bc</td>
<td>5.2b</td>
<td>1.10a</td>
<td>0.67ab</td>
<td>1.25a</td>
<td>0.92a</td>
<td>0.61a</td>
<td>0.284</td>
</tr>
<tr>
<td>75 ml neem</td>
<td>1.56ab</td>
<td>1.86abc</td>
<td>5.99a</td>
<td>1.73a</td>
<td>0.35a</td>
<td>3.6a</td>
<td>0.61a</td>
<td>0.61a</td>
<td>0.125</td>
</tr>
<tr>
<td>50 ml neem</td>
<td>1.62ab</td>
<td>2.11bc</td>
<td>3.51ab</td>
<td>2.66a</td>
<td>0.33a</td>
<td>8.3a</td>
<td>0.61a</td>
<td>1.21a</td>
<td>0.042</td>
</tr>
<tr>
<td>25 ml neem</td>
<td>1.94ab</td>
<td>2.45c</td>
<td>0.44a</td>
<td>4.94a</td>
<td>1.02a</td>
<td>6.0a</td>
<td>0.52a</td>
<td>0.92a</td>
<td>0.003</td>
</tr>
<tr>
<td>Untreated</td>
<td>2.42c</td>
<td>2.76b</td>
<td>4.58a</td>
<td>4.25a</td>
<td>3.33b</td>
<td>8.3a</td>
<td>1.42a</td>
<td>0.61a</td>
<td>0.174</td>
</tr>
<tr>
<td>Cu %</td>
<td>27.2</td>
<td>37.4</td>
<td>50.2</td>
<td>35.2</td>
<td>48.8</td>
<td>34.4</td>
<td>81.3</td>
<td>54.7</td>
<td>0.000</td>
</tr>
</tbody>
</table>

1.3.1 Effect of neem extracts on leaf perforations

Results show no statistical significant differences among treatments. The untreated check and the 25 ml neem extract recorded the highest number of mean perforations than all other treatments. No differences were noted between the 50, 75, 100ml neem extract and the 65 g cabaryl. This assumed that an average of 75-100 ml can be used to manage weevil feeding behaviour, same as 65 g cabaryl.

1.3.2 Adult weevils

Significant differences at p<0.05 (Fig 1) were recorded among treatments. Plots with 65g cabaryl recorded a significant low mean number of adult weevils of 0.78. The untreated check had a significant higher mean
number of 2.78 of adults weevils per plot. No differences were noted between the 50, 75 and 100 ml neem extracts. This may assume that the quantities can be used to manage weevil populations.

1.3.3 Marketable and non-marketable yield

No significant results were recorded at p>0.05 among treatments. The 25ml neem leaf extract and the untreated check yielded the highest non marketable yield. Respectively, higher number of exit holes were recorded on the 25 ml neem extract and the untreated check. High number of tunnels were recorded on the 50, 25 and the untreated check.

1.4 Discussion of results

During this investigation neem leaf extract tested showed differential toxicity on adult *C. formicarius elegantulus* by reducing the damages they caused to sweet potato leaves during feeding. Neem has anti-appetant effects, and acts as a growth regulator that can affect moulting and larval development of certain arthropods. Moreover, it weakens insects and inhibits their resistance (19). This might have caused the different insignificant mean leaf perforations on various treatments assessed. The contact of neem products with insect larvae reported to be lethal to their various developmental stages, as well as it contributes to their malformation (20). This might have caused the resulting of an insignificant number of tubers being attacked among treatments.

Studies have shown elevated concentration of azadirachtin in neem leaves and seed (21, 22). Olfaction plays an essential role in the life cycle of insects that use a wide range of environmental chemical cues to locate and evaluate food, mates, and egg-laying sites as well as to avoid predators and other dangers (23). Neem leaf extracts present 12 modes of action capable of repelling and killing insect pests (24, 19). It might be the reason why weevil populations among other treatments were not significant. The potato weevil has odour reception and signal transduction which occurs in the dendritic membrane of olfactory sensory neurons in the antennae (25, 26). This might have caused avoidance by the weevil in some treatments. This enables it to flee away from most chemical compounds applied within its vicinity. It causes lethal toxicity during the pupal stage leading to various morphological deformations such as malformed adults, partial ecdysis, and molt blocking that defers and inhibits adult formation (27). However, recently it has been reported that neem oil along with its pest deterrent attributes, also causes malformations in the growth and survival of a non-target predator, *Podisus nigrispinus* which is a zoophytophagous pest commonly used in the biological control of pests. An increasing morphological deformation in the wings, legs, and scutellum along with mortality was observed.
with increasing concentration of neem oil. Thus, it is also imperative to consider, effect of neem based pesticides on, non-target predators (28).

1.5 Conclusions

For all assessed parameters during this investigation, neem leaf extract tested showed differential toxicity on adults *C. formicurius*, thereby reducing the damages they caused to sweet potato leaves, tubers. 100 ml neem leaf extract was the most effective treatment, followed by 75 ml neem extract. Both 75 and 100 ml neem leaf caused a lower mean leaf perforation and adult weevils of 1.5. An average lower non marketable yield of 1.46 tonnes per hectare as well as a lower larvae per tuber of 0.75. Neem has been reported to be more efficient in controlling insects as it has anti-appetant effects, and acts as a growth regulator that can affect moulting and larval development of certain arthropods. Moreover, it weakens insects and inhibits their resistance. The contact of neem products with insect larvae reported to be lethal to their various developmental stages, as well as it contributes to their malformation.

1.6 Recommendations

Neem leaf extracts at 100 ml per 15 litres of water can be used to manage the sweet potato weevil. Neem (*Azadirachta indica*) contains bio-active ingredients and it is rich in protein. The most important bio-active principal is azadirachtin (repellent) with other compounds such as salannun (repellent, anti-appetant), and sodium nimbinate (spermicide). Neem. No recommendations as yet since the trial is on-going.

References


THE EFFECT OF CULTIVAR AND ORGANIC ENRICHED FERTILISERS ON PLUM (*Prunus salicina*) GROWTH AND DEVELOPMENT UNDER HIGH DENSITY MANAGEMENT SYSTEM

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**ABSTRACT**

High density orchard management systems and ideal nutrition positively influence productivity in deciduous fruits. The main objective was to evaluate the effect of cultivar and organic fertilisers on plum (*Prunus salicina*) growth and development under high density management system of 2222 plants per hectare. The experiment was set as a 4*4 factorial in a Randomised Complete Block Design with 4 replications. Cultivars, Rosearli, Sapphire, Santarosa and Souvenir were evaluated in combination with three organic enriched fertilisers; Comp J organic, Comp C organic tobacco fertiliser, 100 % organic soil builder from Nico orgo Pvt Ltd and inorganic Compound J. Data was collected yearly on tree girth (mm), flowering dates at 50% and 100%, number fruits/cluster, mean fruit weight (mm), fruit length (cm) and fruit diameter (mm). Flowering was generally influenced by cultivar. Sapphire came into flower earlier and lastly Rosearli. Girth extension, fruit width and fruit weight differed significantly (P<0.001) with variety. Organic enriched fertilisers can be used in plum production.

**Key words:** *Prunus salicina*, organic fertiliser, pruning, flower, fruit,
INTRODUCTION

The horticultural world market is going organic in most horticultural produce and farmers who resist change will eventually find themselves out of business. The Horticultural Research Institute aspires to remain relevant to the Industry and has started to build experiences in organic fruit production, so that they could advise farmers accordingly.

Plums are principally grown in the Eastern highlands and the northern regions of Zimbabwe in commercial orchards and around home gardens. Plums are stone fruits belong in the same family with nectarines, apricots, peaches and almonds. In the region, Zimbabwean plums have an advantage of coming into season earlier between September and November as compared to South Africa which are ready in December. Locally, the fruits are marketed for fresh consumption as a well as processed.

Research has found a number of factors limiting plum production globally. In Asia (Milošević, Milošević, and Glišić 2013) pointed out that the main limiting factor for intensive plum production is acidic soils with deficiency of organic matter and inadequate major nutrients availability. Nutrient deficiencies result in limited vegetative growth, low productivity and poor fruit quality of plum trees (Milošević and Milošević 2011). Pollination, adequate irrigation and drainage were also cited (Ingels 2000) (Meland 2005) to have an influence on growth and development of deciduous fruits. (Smith 2003) reported that supplying the right and adequate nutrients to the fruits is critical to achieve consistent production and high quality fruits. Organic fertilisers are an important consideration for both health and environmental benefits.

Plums need substantial cold to end their dormancy. Mild winter delays spring growth and delayed flowering. Studies by (Arroyo et al. 2013) relates the point that the different phenological stages of fruit trees and their seasonal timing vary with local climatic conditions which fluctuate from year to year.

A number of plum varieties were evaluated at HRI since 1986, and most of the varieties were performed well under high density management under Marondera and Nyanga conditions. It is from this background that HRI proposed to conduct further evaluations under low input and organic fruit production management.

Objectives

The main objective was to evaluate the effect of cultivar and organic enriched compound fertilisers on plum (Prunus salicina) growth and development under high density management system in Marondera starting in 2012

METHODS

2.1. Study site

The trial was carried out at Horticulture Research Centre (HRC) (18°11'S and 31°28'E), which is in agro-ecological region IIa and has an altitude of 1630m above sea level. The experiment was established during the 2012-2013 season. Plum planting material was raised from mother stock plants at HRC. Soil mineral analyses was carried out in winter of 2012. Soil pH was 5.3 on the calcium chloride scale (medium acid soils). The soil type was medium grained sandy loam (MgSL).
2.2. Experimental design

The trial was set as a 4*4 factorial in a Randomised Complete Block Design. The fertilisers and plum cultivars formed 16 treatment combinations which were replicated four times in the form of blocks. The gross plot was made up of 64 trees. Cultivars were planted out as the main plot at four levels and fertilisers were the sub plot at four levels. The trees were spaced at 3*1.5m (2222 plants/hectare) at a planting depth of 60*60*60 cm.

Table 11: Four different plum cultivars and four different compound fertiliser types

<table>
<thead>
<tr>
<th>Factor 1 Cultivar</th>
<th>Factor 2 Fertiliser type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rosearli (1)</td>
<td>1. Compound J (15:5:20)</td>
</tr>
<tr>
<td>Sapphire (2)</td>
<td>2. Compound J organic enriched (15:5:20) <em>from Nico orgo Pvt</em></td>
</tr>
<tr>
<td>Santarosa (3)</td>
<td>3. Compound C organic enriched tobacco fert (5:15:12) <em>from Nico orgo Pvt</em></td>
</tr>
<tr>
<td>Souvenir (4)</td>
<td>4.100% organic soil builder(2:2:2) <em>from Nico orgo Pvt</em></td>
</tr>
</tbody>
</table>

2.3. Treatment combinations for four plum cultivars and four compound fertilisers

1a Rosearli * 1000g Compound J (15:5:20) - 1kg/ tree
1b Rosearli * Compound J organic enriched (1kg/tree)
1c Rosearli * Compound C organic enriched tobacco fert (5:15:12) - 3kg/tree
1d Rosearli * 100% organic soil builder (2:2:2) - 7.5kg/tree

2a Sapphire * 1000g Compound J (15:5:20) - 1kg/tree
2b Sapphire * Compound J organic enriched (1kg/tree)
2c Sapphire * Compound C organic enriched tobacco fert (5:15:12) - 3kg/tree
2d Sapphire * 100% organic soil builder (2:2:2) - 7.5kg/tree

3a Santarosa * 1000g Compound J (15:5:20) - 1kg/ tree
2.3. Management and data collection

Pruning was done to remove dead and diseased wood and as part of training. The trees were pruned uniformly during the first winter after planting for the formation of framework and scaffold branch selection. The training system was made into an open centre. General management including irrigation, weeding, spraying was done as and when needed. Fertilisation with the four compound fertilisers was done yearly as a split application in spring and at post-harvest. The fertiliser was placed beyond the canopy edge of the tree and worked in with hoes. Weeds in the line of trees was removed 0.5m on each side of the trees. Sprinkler irrigation was used during the whole planting season. In some years we experienced scale infestations which was controlled with Orchex and Dimethoate 40 EC. No hand thinning or chemical thinning was conducted in the experiment the fruits naturally aborted. The plum varieties were evaluated on basis of plant development, yield levels and fruit quality.

2.4 Data collection and analysis

Data were measured on the extension growth (mm) by measuring girth (girth is the distance around the trunk which is perpendicular to the axis of the trunk) after every year using veneer callipers. The same area at initial measure was used which is about 1.3m above the ground. Observations on flowering dates at 50% and 100% were made. The number of fruits per cluster, mean fruit weight of ten fruits, mean fruit diameter (mm) and mean fruit length (mm) were also recorded. Data was analysed using Genstat 14th edition (VSN International 2012).

3.0 RESULTS

Noticeable differences were noted in increase in girth and flowering pattern within the cultivars and fertiliser treatments. All the cultivars showed vigorous growth in canopy development. It was observed that the pattern of flowering was almost the same with cultivar Sapphire flowering first, second Santarosa, third Souvenir and forth Rosearli. The current results showed that flowering in 2015/2016 was earlier than during 2014/2016 season.

The plums flowered heavily during the 2015/2016 season (Figure 1) but experienced fruit abortion due to very high summer temperatures and insufficient watering (Figure 2).

Cultivar showed some significant differences (P<0.05) on the girth extension over the six years on record (Table 2 and Table 3) with Sapphire having the least girth of 20.53 mm. An incremental girth extension trend
was noticeable over the years. There were no significant differences (P>0.05) on girth as affected by fertilizer type.

The type of cultivar significantly influenced (P<0.001) the number of fruits per cluster with Sapphire having the least (two fruits/cluster). During the 2015/2016 the plants were affected by bacterial canker causing them to exude water/gum on some parts on the stem resulting in gradual wilting of the plants until they die. The cultivar Santarosa was very susceptible resulting in the highest number of trees affected. During the third and fourth year the plums succumbed to Zinc deficiency resulting in small pointed leaves, leaf chlorosis and rosette leaves on tip ends (Figure 2). Boron deficiency symptoms were also noticed during the same period. The interaction effect between type compound fertilizer and cultivar was non-significant for all the measured parameters. The compound fertilizers did not influence the known fruit characteristics such as fruit size and colour. Relatively low fruit counts were recorded for all the cultivars. Cultivar differed significantly for mean fruit weight (g), fruit length (cm) and diameter (cm) as shown in (Table 4). Sapphire had the highest mean fruit weight (64.0 g) and Rosearl the least (37.7 g)

### Table 2: The effect of type of compound fertiliser on girth extension (mm), number of fruits per cluster and time of flowering for plums (*Prunus salinica*)

<table>
<thead>
<tr>
<th>Fertiliser type</th>
<th>Girth @ 1 year (mm)</th>
<th>Girth @ 6 years (mm)</th>
<th>Fruits/cluster</th>
<th>50% flowering 2014/15</th>
<th>100% flowering 2014/15</th>
<th>50% flowering 2015/16</th>
<th>100% flowering 2015/16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compound J (15:5:20)</td>
<td>12.81</td>
<td>76.3</td>
<td>4.42</td>
<td>05/09/15</td>
<td>09/09/16</td>
<td>25/08/16</td>
<td>29/08/16</td>
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<tr>
<td>Compound J organic enriched (15:5:20)</td>
<td>12.5</td>
<td>78.9</td>
<td>4.00</td>
<td>05/09/15</td>
<td>09/09/15</td>
<td>25/08/16</td>
<td>31/08/16</td>
</tr>
<tr>
<td>Compound C organic enriched tobacco fert (5:15:12)</td>
<td>13.13</td>
<td>85.1</td>
<td>3.73</td>
<td>08/09/15</td>
<td>11/09/15</td>
<td>25/08/16</td>
<td>29/08/16</td>
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<tr>
<td>100% organic soil builder (2:2:2)</td>
<td>11.77</td>
<td>73.6</td>
<td>3.57</td>
<td>05/09/15</td>
<td>09/09/15</td>
<td>25/08/16</td>
<td>31/08/16</td>
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<tr>
<td><strong>Interaction</strong></td>
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<td>0.905</td>
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<td><strong>LSD</strong></td>
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<td>9.64</td>
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<td>-</td>
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</table>

† Means followed by the same letter are not significantly different according to the Least Significance Difference value; General observations made on 50% and 100% flowering dates
**Table 3:** The effect of cultivar on girth extension (mm), number of fruits per cluster and time of flowering for plums (*Prunus salicina*)

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Girth @ 1 year (mm)</th>
<th>Girth @ 6 years (mm)</th>
<th>Fruits/cluster</th>
<th>50% flowering 2014/15</th>
<th>100% flowering 2014/15</th>
<th>50% flowering 2015/16</th>
<th>100% flowering 2015/16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rosearli</td>
<td>13.36</td>
<td>76.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>05/09/15</td>
<td>09/09/15</td>
<td>01/09/16</td>
<td>07/09/16</td>
</tr>
<tr>
<td>Sapphire</td>
<td>13.36</td>
<td>82.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>05/09/15</td>
<td>09/09/15</td>
<td>17/08/16</td>
<td>22/08/16</td>
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<tr>
<td>Santa Rosa</td>
<td>11.06</td>
<td>68.6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>05/09/15</td>
<td>10/09/15</td>
<td>27/08/16</td>
<td>02/09/16</td>
</tr>
<tr>
<td>Souvenir</td>
<td>12.35</td>
<td>85.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>07/09/15</td>
<td>09/09/15</td>
<td>22/08/16</td>
<td>26/08/16</td>
</tr>
</tbody>
</table>

**p-value**
- 0.062
- 0.05
- <0.001
- -
- 0.94
- 0.573
- 0.905
- -
- 1.92
- 9.65
- 1.38
- -

† Means followed by the same letter are not significantly different according to the Least Significance Difference value; ‡ General observations made on 50% and 100% flowering dates.

**Figure 12:** Plum cultivar Santarosa in full bloom during the month of September 2016

**Figure 13:** Plum cultivar Souvenir with yellowing fruits in the process of abortion
Figure 14: Plum tree showing Zinc deficiency symptoms (leaves are small and pointed occurring in rosettes)

Table 4: The mean fruit weight (g), diameter (mm) and length (cm) of plums as influenced by cultivars

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Fruit weight (g)</th>
<th>Fruit diameter (mm)</th>
<th>Fruit length (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rosearli</td>
<td>45.3&lt;sup&gt;c&lt;/sup&gt;</td>
<td>4.26&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.83&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sapphire</td>
<td>64.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.26&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.17&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Santa Rosa</td>
<td>37.7&lt;sup&gt;d&lt;/sup&gt;</td>
<td>5.34&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.27&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Souvenir</td>
<td>58.9&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.09&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.15&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>p-value</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>0.005</td>
</tr>
<tr>
<td>lsd</td>
<td>1.827</td>
<td>0.2565</td>
<td>0.1796</td>
</tr>
<tr>
<td>± sed</td>
<td>0.747</td>
<td>0.1048</td>
<td>0.734</td>
</tr>
<tr>
<td>% cv</td>
<td>1.8</td>
<td>2.6</td>
<td>1.5</td>
</tr>
</tbody>
</table>

† Means followed by the same letter are not significantly different according to the Least Significance Difference value
4.0 DISCUSSION

There were no apparent significant differences on effects of the organic enriched fertilisers and the control compound fertiliser on the vegetative growth of the different plum cultivars. However, the observed differences in flowering dates of the different varieties could be directly linked to their breeding and genetic background. The varieties maintained their earliness to flowering despite variations in agronomy, management and weather variations. The differences in the earliness to flower can be explained by the variation of the prevailing temperatures (Appendix 1). Vigorous growth and fast canopy development of the cultivars is commendable because it allows for maximum light interception.

The hot summers experienced during some seasons e.g. 2015/16 had a bearing on flower abortion and fruit development because then the country had power shortages resulting in massive load shedding. Due to farm fragmentation and limited farming activities around the farming area our plum trial was highly susceptible to monkey and bird damages affecting total yields not reported here and fruit quality. This rendered most of the fruits unmarketable.

Although the main idea of the experiment was to produce quality plums with as little fertiliser as possible some micronutrient components could not be ignored completely as symptoms showed with time. Boron supplement was recommended as it is an essential trace element required for abundant yield and high quality fruits (Li-Yuehua 2003). Related reports show that Zinc deficiency triggers leaf defoliation resulting in poor bud formation and reduced yields (Dar 2014). Bacterial canker was managed through a number of methods; severely affected trees were removed, dying branches were pruned and removed from orchard, irrigation frequency was increased and weed management improved.

The significant differences observed for fruit characteristics weight, diameter and length influences the potential fruit yield of the different cultivars. Appropriate and well timed fertilisers are key for the expression of yield characteristics in plums as argued by (Dar 2014).

The results of the present study shows that compound fertilisers whether inorganic or organic enriched works best with other micronutrient supplements supporting work by (Thakur and Thakur 2014) who argued the importance of integrated nutrient management on growth and yield of plum cultivar Santa Rosa.

5.0 CONCLUSIONS

Organic enriched compound fertilisers can be used successfully in plum production but with other fertiliser supplements for essential microelements such as zinc and boron to improve on fruit growth, development, flowering and fruiting. Soil and foliar analysis is recommended to apply appropriate management techniques.
ACKNOWLEDGEMENT

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DECLARATION

No part of this work has been published elsewhere.

REFERENCES


APPENDICES

Appendix 1: Mean monthly minimum and maximum temperatures (°C) recorded at Marondera Meteorological Station from 2015 to 2018.
ABSTRACT

Fall armyworm (Spodoptera frugiperda) has been a pest of occasional importance in the agricultural sectors of the south eastern Lowveld since 2016 with sporadic outbreaks often developing rapidly in maize and sorghum, and resulted in severe defoliation. Fall armyworm adult moths were captured in pheromone traps baited with an insecticide strip containing 10% 2.2-dichlorovinyl dimethyl phosphate over a 12 month period at Chiredzi Research Station. Monthly catches collected daily from traps placed in the main irrigated block showed a population rise at the start of the summer season (August-October), a fall in November followed by a sharp rise in the last half of December. Fall armyworm moth distribution during these periods varied significantly, suggesting seasonal population patterns. These results represent an indication that the fall armyworm strain might have a substantially population dynamic in the agricultural vicinity of Chiredzi Research Station. Evidence from data collected suggest that the army worm moth was predominant during the onset of the summer periods. It further indicates that the worm can display a markedly different response to seasonal environmental cues.

Key words

Population dynamic, fall armyworm, damage, pheromone trap, forecast, yield
1.0 INTRODUCTION

The fall armyworm (*Spodoptera frugiperda*) is a species in the order of Lepidoptera. The term "armyworm" can refer to several species, often describing the large-scale invasive behaviour of the species' larval stage. It is regarded as a pest and can damage and destroy a wide variety of crops, which causes large economic damage. Its scientific name derives from *frugiperda*, which is Latin for *lost fruit*, named because of the species' ability to destroy crops (Croxton *et al*., 1968). Because of its propensity for destruction, the fall armyworm's habits and possibilities for crop protection have been studied in depth. It is also a notable case for studying sympatric speciation, as it appears to be diverging into two species currently (Groot *et al*., 2010). Another remarkable trait of the larva is that they practice cannibalism.

The fall armyworm (*FAW*, *Spodoptera frugiperda*), is native to the Americas and arrived in Africa in early 2016. Since its arrival, it has moved quickly and is now in over 25 African countries including Ethiopia, Kenya, Niger, Tanzania and Zimbabwe (3). The pest has the potential to cause significant damage and yield loss to over 80 plant species, including maize, rice, and sorghum. Already, it is estimated that it will cause over $3 billion in damage to maize throughout Africa in regions that are already food insecure (3).

The fall armyworm (*Spodoptera frugiperda* (JE Smith); *Lepidoptera, Noctuidae*) was first reported as present on the African continent in January 2016 (4). Subsequent investigations have revealed the pest in nearly all of sub-Saharan Africa (SSA), where it is causing extensive damage, especially to maize fields and to a lesser degree sorghum and other crops. Currently, over 30 countries have identified the pest within their borders including the island countries of Cape Verde, Madagascar, São Tomé and Príncipe, and the Seychelles. The best evidence to date suggests that the FAW type introduced into Africa is the haplotype originating from south Florida (USA) and the Caribbean (5). The location(s), date(s), mode, and number of introductions are not known at present but anecdotal observation and the response of single-gene genetically modified Bt maize in South and East Africa suggests it has been present for at least several years (6). The generally hospitable agro ecological conditions for FAW in SSA suggest that FAW will establish as an endemic, multigenerational pest in Africa. Though new agricultural pests are periodically introduced into the African agricultural environment and pose some degree of risk, a number of characteristic factors make FAW a more devastating pest than many others:

Moths generally disperse about 500 km (300 miles) before oviposition, which is sufficient to move from seasonally dry habitats to wet habitats (7). They fly downwind, above the boundary layer (the lowest part of the atmosphere, above which the wind direction and strength may be different), so the direction of movement depends largely on prevailing winds. When the wind pattern is right, moths move much larger distances: for example, 1,600 km (8). Clearly, FAW has the potential to spread rapidly across Africa: at least 500 km per generation, with a suitable wind. As yet, the literature review undertaken by CABI has found little evidence regarding what triggers adult dispersal, or indeed whether it is a feature of every generation.

Similarly, no studies have been found on whether part of each generation remains in situ, or whether the entire generation disperses. It seems likely that dispersal is triggered by the level of crowding experienced by the larvae, but this has not been tested. This makes it difficult to make robust forecasts of the likely pest problem in the next cropping cycle. Anecdotal observations from South America indicate that there is poor correlation in FAW populations from one crop season to the next (*Y. Colmanarez, pers comms*). There may also be geographical or strain differences in this behaviour. It has been assumed that FAW
disperse on wind-assisted flights until they are sexually mature and ready to mate (8), but we have not found any definitive studies on this aspect. However, this seems likely and would explain why males disperse alongside females. It is regularly intercepted in intercontinental trade (9, 6). It has now appeared in Africa (Goergen et al., 2016, Cock et al., 2017) and is rapidly spreading throughout tropical and subtropical regions of the continent.

Reports related to the relationship between date and damage by FAW in commercial maize have been published in other countries, (10, 11), and (12, 13). Studies related with the population dynamics of FAW at Chiredzi Research Station, and how environmental factors affect this phenomenon were not previously reported at Chiredzi Research Station. Understanding the factors that influence the distribution and abundance of an insect is a fundamental issue of insect ecology and is a practical concern with insects that cause economic damage (14). Insect population dynamics have fundamentally different characteristics depending on the strength and form of exogenous (density-independent) vs. endogenous (density-dependent) forces.

To date, development and implementation of a coordinated, evidence-based effort to control fall armyworm in at the station has faced a number of challenges. In particular, fall armyworm is a recently introduced pest. Therefore, scouting by farming communities and effective monitoring at the station, ward and district levels are limited. In addition to delaying recognition of the pest’s movement through farming communities, this lack of surveillance, monitoring, and scouting capacity has delayed efforts to determine several key unknowns about fall armyworm populations on the farming communities and the dynamics of the pest’s establishment and spread.

The lessons learned from the invasive pest should be identified quickly because they are important for monitoring and interception of this invasive pest as well as other future invasive pests. Thus the objective of this research work is to develop and come up with a coordinated, evidence based effort in the management of fall armyworm in the South eastern Lowveld of Zimbabwe.

1.2 Materials and Methods

1.2.1 Study location

The study was carried out at Chiredzi Research Station (21°01’S, 31°33’E 429 m above sea level) located in the South-Eastern Lowveld (agro-ecological region 5) of Zimbabwe. Its temperatures ranges from 29 – 39 °C and can reach up to 42°C. The area receives rainfall totals of 450-650 mm year round. The low latitude of 1200-1500 ft a.s.l is an effective safeguard against frost in all but the extreme circumstances. Minimum temperatures tend to run low in winter and frost can occur in low lying areas. Triangle PE1 series such as shallow sandy clay soils dominate (15, 16). Moth collection was done in the irrigated main block from mid-June 2017 to May 2018.

1.2.2 Pheromone Confirmation

Standard tricolour plastic trap (green top, yellow funnel, white bucket) baited with an insecticide strip containing 10% 2,2-dichlorovinyl dimethyl phosphate a commercially available fall armyworm pheromone were placed mid-June 2017 to May 2018 and collections were made on a daily basis. The trap was hung from a suspended pole or branch about 1.5 m above the ground.
The traps were checked on a daily basis by counting the number of fall armyworm moths inside by:

1. Opening the bucket trap by an anti-clockwise twisting of the low transparent bucket at the bottom of the trap while holding firmly the yellow funnel on top
2. Create a clean flat surface and invert the bucket to pour out the moths onto this surface
3. Remove any non-fall armyworm moths and insects that may have been caught in the trap
4. Carefully count the number of fall armyworm moths by putting counted ones to one side
5. If you in doubt as to whether the moth is fall armyworm, then compare a sample provided on a chart for ease of identification.

The pheromone lure was usually replaced every 3–6 weeks to achieve optimum results, depending on temperature, humidity and pheromone components and release characteristics. Unopened pheromone dispensers were stored within an air-tight bag(s), tightly sealed glass containers or foil pouches, preferably inside a refrigerator or freezer to achieve up to two years shelf life. Pheromones degrade rapidly if exposed to bright light or high temperatures. Therefore, dispensers were kept inside their sealed packaging until ready to use. To activate the bucket trap, the lure is placed into the red rubber septum and then put the septum in the green coloured receptacle. The receptacle is then plugged into a hole on top of the green cap, which provides the roof of the bucket trap. The receptacle is then covered by a white lid. During lure replacement, the receptacle cap is simply removed and the rubber septa inserted into it.

1.2.3 Meteorological data collection
Daily temperature records were obtained from a meteorological station found at the station. Other records that were collected include monthly rainfall figures, wind speed as well as humidity.

1.2.4 Data analysis
Regression analyses were performed to determine the relationship between fall armyworm populations with temperature, wind speed, humidity and rainfall (17, 18) by a stepwise approach. For the analyses, the mean of low and high temperatures, humidity, wind speed and mean rainfall during the sampling month, were used. From these data it was possible to estimate the month in which the environmental factors most affected the fall armyworm populations. The Pearson correlation coefficient (19, 20, and 21) was used to quantify the association between variables such that the relationship between an outcome variable (catches) and associating factors or confounding variables (rainfall, temperature, humidity and wind speed) can be tabulated.

Correlation coefficient ‘r’ was calculated using the following formula:

\[
r = \frac{n\sum xy - \sum x \sum y}{\sqrt{(n\sum x^2 - (\sum x)^2)(n\sum y^2 - (\sum y)^2)}}
\]

Where, \( x \) and \( y \) are values of variables, and \( n \) is size of the sample.

The value of correlation coefficient is interpreted in the following manner:

If ‘r’ is equal to 1, then there is perfect positive correlation between two values;

If ‘r’ is equal to -1, then there is perfect negative correlation between two values;

If ‘r’ is equal to zero, then there is no correlation between the two values.
1.3. Results

1.3.1 Population dynamics of the fall armyworm moth in response to the environment over the 2017-18 season

The general trend of the distribution of the fruit fly across seasons indicate a rise in the total mean catches from August to September (Fig 1) coupled by a sudden drop in the months of October and November. This was followed by a sharp rise in the number of catches between November and December. However in January and February, the total number of catches remained low and rose again between May and June of the preceding season. December recorded the highest number of more than 200 catches over the trapping period, while low catches of below 10 moths per day were recorded in July, November and February.

1.3.2 Effect of temperature and humidity on adult fall armyworm moth catches

Due to rises in humidity and temperature, moth populations rose in the months of August and Sept. Moth populations dropped in September and November but temperature and humidity remained constant. A sharp rise of temperature (Fig 2) from 23 to 26 in the months of November and December resulted in a sharp rise in the number of catches from 9 to 232 over the trapping period. Moth populations drastically dropped in December, January and February. Populations rose again in February though temperature was dropping and moth populations remained on a rising mode over the preceding winter months.

1.3.3 Effect of rainfall and wind speed on adult fall armyworm moth catches

Despite low rainfall and wind speed in July, August and September, moth populations rose. A drop in moth population coincided with rainfall increase in September and November. Due to high rainfall (Fig 3) and low wind speed in January, moth populations dropped implying that wind responsible for migration of the fall armyworm moth. High rainfall total in December and January led to drops in the moth populations over the current months. Low rainfall and low wind speed as winter months approached led to increase in moth populations at the station

1.3.5 Correlation of fall armyworm moths to weather elements

A positive relationship (Fig 4) existed in the distribution of the fall armyworm moth between temperture ($r =0.567$) and wind speed ($r = 0.643$). Though weak, a positive relationship was also observed between rainfall ($r =0.326$) and humidity (0.463). This imply that all the weather elements had a positive influence in as far as the distribution of the moth over the season was concerned.
Fig 1: Monthly population dynamics of the adult fall armyworm moth over the 2017-18 season
Fig 2: Effect of humidity and temperature on population dynamics of the fall armyworm over the season.

Fig 3: Effect of rainfall and wind speed on population dynamics of the fall armyworm over the season.
Fig. 4 Correlation of fall armyworm moths to weather elements
1.4 Discussion

There has been an upward and downward surge in the number of fall armyworm adults that were trapped over the season. Fall armyworm populations were maintained at an average of 12 catches during the winter months of July and August (Fig 1). This is in line with the findings of (22) who observed fall armyworm infestations occurring throughout the season due to the intolerance of the species to winter freezes and hot months. This infestation pattern may be explained by overwintering of the moth at Chiredzi Research Station, followed by annual re-invasions of its geographic surroundings through successive long-distance flights during the winter and summer periods. There were periodic down surges of the fall armyworm catches over the season. Populations fell in August, November, January and February. This may signify fecundity of the worm since most females will be laying out eggs, hence reduced flights to look for partners. Temperature affects larval development, food consumption, and adult female longevity and fecundity, and that developmental times are temperature-dependent. (17)

Lack of moisture during pupal stages appears to have little direct effect on survival or development rates. However, indirect effects of moisture are likely more important for fall armyworm population sizes than direct effects. This is because abundance tends to peak during rainy seasons, particularly in drier sites, possibly because of increased host plant growth. On the other hand, infestation rates are highest in maize deprived of irrigation for the longest, likely because plant moisture stress favours insect development (23)

Although the trapping data generated during the one year survey at Chiredzi Research failed to establish any particular site as the “parental source” of fall armyworm migrants entering uninfested areas of the Station, there appears to be no question that favourable wind currents were conducive to the spread of the fall armyworm into and from the area. Meteorological analyses show at least one distinct area in terms of mean wind direction-the south-eastly winds, thus movements can be ascribed to relative beneficial atmospheric transport conditions from the south which depended on the direction of winds in the South eastern Lowveld of Zimbabwe. This is in line with several studies that investigated how synoptic wind patterns affect the frequency, intensity, and displacement of migratory flights of noctuid moths (24, 25). Such studies demonstrated that weather transport systems are the most important climatic factors governing fall armyworm abundance at a migratory destination (26), that the direction of migratory flight is highly correlated with wind headings (28), and that migratory pathways can be modelled using projections of air transport trajectories (28). The meteorological data collected indicated a significant change in wind speed at Chiredzi Research Station as from September, October, November and December 2017. This resulted in a rise in the number of catches as from the month of September to December. There was also a rise in the number of moths between May and June 2018. This is in line with (28) who observed habitation being influenced by atmospheric circulation that provided a less transport potential to enhance movement of migrating fall armyworm moths. Thus with suitable wind pattern, moths can move much larger distances, (8). Fall armyworm thus, has the potential to spread rapidly across Africa: at least 500 km per generation, with a suitable wind." (9)

Studies at Chiredzi Research station have demonstrated integrated effects of temperature and moisture as significant on their vital rates, developmental time and fecundity (28). This is also in line with (29), who observed rainfall, maximum, and minimum relative humidity being positively associated with armyworm moth catches. A rise in catches were observed from August to September, and this period was coupled by a precipitation of 4.3mm. This is also in line with studies on serious outbreak of the 3rd-generation armyworm
larvae which concluded that low temperature and frequent rainfall could have created favourable conditions for the breeding of the 2nd-generation adults and suitable hosts for the 3rd-generation larvae (28). Rainfall may have influenced the microclimate especially the humidity substantially, and the humidity could affect armyworms directly in multiple ways (30). The effects of rainfall and humidity on armyworm individuals and populations at Chiredzi Research Station have been reported in many researches (for example 31, 32, 33, 34, 35, 36). This was also seconded in Jin’s experiments, which observed that fecundity, egg development, hatching rate, larval survival, and larval development were shown to be positively impacted by high relative humidity (31). Low humidity makes the egg shell a more difficult obstacle for larvae to chew their way out. Higher humidity in air or soil directly brings about higher survival rates of the 1st, 2nd, and 4th instar larvae (10). Therefore, humidity might be an important factor affecting the formation of the initial population. Low humidity also reduces vigour of larvae and hence reduces their ability to cause damage. The duration of larval stage is inversely correlated to humidity, so larvae can reach their foraging peak earlier with higher humidity (30)

### 1.5 CONCLUSION

These results present an indication that the fall armyworm strain have a substantially population dynamic in the agricultural vicinity of Chiredzi Research Station starting on the onset of the rain season. Evidence from data collected suggest that the army worm moth was predominant during the onset of the summer periods. It further indicates that the worm can display a markedly different response to seasonal environmental cues such as temperature, wind speed and direction as well as humidity.

### 1.6 RECOMMENDATION

Farmers should implement control measures for the management of the fall armyworm from the onset of the rain season. They must also bear in mind that the worm can tolerate cooler conditions posed by the winter season of which it remains a pest of economic importance in cereal production in the South eastern Lowveld of Zimbabwe.

### ACKNOWLEDGEMENTS

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DISTRIBUTION OF THE POTENTIALLY INVASIVE SPECIES GIANT MILKWEED (*CALOTROPIS PROCERA* L. AITON) IN ZIMBABWE

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ABSTRACT

Alien plant species contribute most to plant invasions, hence the need to monitor their distribution. *Calotropis procera* L. (Aiton) has the potential to become invasive and was first recorded around the 1960s in Zimbabwe. Using Maxent and QGIS, the current distribution of *C. procera* was mapped using known locations from herbarium specimens, citizen science records and field data collected along the major highways of Zimbabwe. Actual distribution data was modelled against independent environmental variables (R< 0.7) to identify the most suitable habitats prone to invasion by *C. procera* and determine the most influencing factors responsible for its invasion in Zimbabwe using Maxent. The model performance was good (AUC>0.89). *C. procera* has not saturated its current potential distribution and poses as a threat in the low-lying semi-arid and arid regions of Zimbabwe. Its distribution and invasion success is somewhat disturbance-dependent. Hence the need to adopt management strategies that minimize the loss of vegetation.

Keywords: *Calotropis procera*, Species Distribution Modelling, Maxent, invasive species
1. INTRODUCTION

Rejmánek and Richardson (2013) indicated that the interest in the spread of non-native trees and shrubs and their impacts on biodiversity and ecosystem functions is increasing, however there is still inadequate information on invasive species from some regions of the world. Accordingly, spatial distribution of the exotic species is an important factor to consider when determining its invasibility (1). Zimbabwe currently has approximately 1449 exotic plant species and, 84 invasive species(based on the potential spread from parent plant) (2), although only 11 have been declared invasive and warrant management (3).

Species distribution models (SDMs) provide great potential as a management tool that can be used by conservation managers to deal with invasive species. They assist in identifying the distribution of invasive species (4) monitor the spread of invasive species (5).Several models have been developed that utilise both presences and absence species data.

Apart from the sporadic records kept at the National Herbarium of Zimbabwe and citizen-science citings, very little is known about the distribution of the potentially invasive plant *Calotropis procera* L. (Aiton) in Zimbabwe. SDM will assist in identifying the most suitable habitats and to determine whether the species has achieved its full potential. Commonly known as the giant milkweed or Sodom apple it belongs to the family Asclepiadaceae and is native to Asia, India and north and eastern Africa (6). It has been declared a noxious weed in the Northern Limpopo Province of South Africa (7) and the western and northern Australia (8). In Zimbabwe, the species is classified as naturalised (9), though invasive behaviour has been suggested (10).

It is a shrub or small tree that can grow up to 6m when mature (Photograph 1a). It has distinctive grey-green waxy leaves; smooth grey-green stem covered with a soft thick corky bark. Leaves are opposite sessile, glaucous, ovate to obovate with prominent veins on the underside and a short, pointed tip. Inflorescence is a dense multi-flowered, umbellate cyme (Photograph 1c). Flowers are white and pink/purple with 5 petals grouped in umbels. The fruits (Photograph 1b) are 8–12 cm long, inflated, obliquely ovoid follicles that split and invert when mature to release 300-500 seeds/fruit that can be dispersed over several hundred metres by a gentle breeze (8) (8, 11, 12). It has a deep tap root and can reproduce vegetatively through stem and root suckers and root cuttings. Each stump gives rise to two half stumps (11).

When cut or broken, the plant exudes a milky sticky sap which contains the chemical calotropin which is toxic and affects the heart, causes blistering and irritation in people (8). *C. procera* has allelopathic properties including germination inhibition, plumule and radicle growth reduction on plant such as barley (*Hordeum vulgare* L.), wheat (*Triticum aestivum* L.), cucumber (*Cucumis sativus* L.), fenugreek (*Trigonella foenum-graecum* L.), alssana (*Senna occidentalis* L.), tomato (*Lycopersicon esculentum* Mill.), and eggplant (*Solanum melongena* L.). It reduces productivity of pastures (11).

*C. procera* is known to have many uses such as the treatment of asthma, syphilis, leprosy, ringworm, piles and is highly used in Indian traditional medicine. It is also a used as an ornamental plant (13). The latex has also been used as arrow poison in Southern and
Photograph 1. Calotropis procera plant in Beitbridge district of Zimbabwe a) mature plant (b) fruit before splitting open c) flowers arranged in umbels d) vegetative regrowth of C. procera showing several sprouts

Mapaura A. (2016)

Calotropis procera plant in Beitbridge district of Zimbabwe a) mature plant (b) fruit before splitting open c) flowers arranged in umbels d) vegetative regrowth of C. procera showing several sprouts

Mapaura A. (2016)

In Zimbabwe, the species is perceived to have been introduced as an ornamental plant around the 1940s; and managed to become naturalised (9). Current recordings by other plant researchers have suggested that the plant is exhibiting invasive behaviour in some localities where it is found (10); . Interestingly, not all introduced species become invasive in the new environments and according to Vander Zanden (15), in Moore (2005) 1 in every 10 new introductions becomes invasive. The purpose of this study therefore is:

a) to ascertain the actual distribution of *C. procera* in Zimbabwe,

b) to identify suitable habitats prone to *C. procera* invasion using SDM and
c) to identify the factors that contribute to the spread of *C. procera* in Zimbabwe.

2. MATERIALS AND METHODS

2.1 Study Area

Zimbabwe is a landlocked country and situated in Southern Africa between the Limpopo (south) and Zambezi (north) rivers lying within the latitude 15° and 23°S and 25° and 34°E. Its total land area is 390,757 km². Zimbabwe is bordered by Mozambique to the east, South Africa to the south, Botswana to the west, and Zambia to the north and northwest (*Figure 15. Map showing location of study area*).

The country has 10 administrative provinces and 62 districts. The central part of the country is known as the high veld and it stretches from the southwest northwards with altitudes between 1,000 and 1,600 m whilst the extreme east is mountainous (Eastern Highlands).

Zimbabwe has a tropical climate with many local variations. The southern areas are known for their heat and aridity, parts of the central plateau receive frost in winter, the Zambezi valley is also known for its extreme heat and the Eastern Highlands usually experience cool temperatures and the highest rainfall in the country (16)

*Figure 15. Map showing location of study area*
Calotropis occurrence data on the locations of C. procera was obtained from specimens collected in the National Herbarium and Botanic Garden in Harare, Zimbabwe and citizen science collections downloaded from Zimbabwe flora website (10). Field data was collected along the major highways of Zimbabwe between April 2016 and December 2017 and all C. procera locations were noted using a geographic positioning system (GPS) unit, Garmin etrex 20x, with an accuracy level of 5m. A total of 124 locations were collated. Duplicate locations and data lacking geographic coordinates was removed for the data sample. The final dataset used in the model had 88 locations (Appendix 1).

2.2 Calotropis occurrence data

Secondary data on the locations of C. procera was obtained from specimens collected in the National Herbarium and Botanic Garden in Harare, Zimbabwe and citizen science collections downloaded from Zimbabwe flora website (10). Field data was collected along the major highways of Zimbabwe between April 2016 and December 2017 and all C. procera locations were noted using a geographic positioning system (GPS) unit, Garmin etrex 20x, with an accuracy level of 5m. A total of 124 locations were collated. Duplicate locations and data lacking geographic coordinates was removed for the dataset.

3 Species distribution mapping

3.2. Bonn, a vector map showing the distribution of C. procera over 40 years was created. The map was then overlayed on a satellite image of Zimbabwe to identify the different land use classes that promote the prefoliation of the species in the country. The potential distribution map generated from Maxent was also over-layed with satellite imagery and habitats highly prone to invasion were also identified.

2.3 Environmental variables

Climate data were downloaded from Worldclim (17) at 1km² resolution. Elevation and land-use data were obtained from the Data-Interpolating Variational Analysis Geographic Information System (DIVA-GIS) database at 30sec resolution (18). All environmental data was downloaded freely. The environmental layers were reclassified to the same resolution and extent using the reclassification tool in (18)Quantum GIS (QGIS).

Variables with the most influence on the distribution of C. procera were selected based on the histogram method (19). This method stipulates that variables with normal distribution and those with highly skewed values have an important influence on the species’ distribution and should therefore be included, whilst those that show no pattern or are truncated are excluded from the model. Regression analysis was used to identify variables that were highly correlated ($R \geq 0.70$) and only one variable was included in the model based on the biology of the species. Six variables were selected for inclusion in the model (Table 12).
Table 12. Variables selected for modelling in Maxent

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bio 3</td>
<td>Isothermality</td>
</tr>
<tr>
<td>Bio 6</td>
<td>Min. temperature of the coldest period</td>
</tr>
<tr>
<td>Bio 8</td>
<td>Mean temperature of wettest Quarter</td>
</tr>
<tr>
<td>Bio15</td>
<td>Precipitation of the wettest period</td>
</tr>
<tr>
<td>Bio18</td>
<td>Precipitation of warmest quarter</td>
</tr>
</tbody>
</table>

The following landcover classes were represented in the model:

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Broadleaved evergreen forest</td>
</tr>
<tr>
<td>2</td>
<td>Broadleaved deciduous forest</td>
</tr>
<tr>
<td>3</td>
<td>Broadleaved deciduous woodland 40% cover</td>
</tr>
<tr>
<td>12</td>
<td>Broadleaved deciduous closed to open thicket</td>
</tr>
<tr>
<td>13</td>
<td>Herbaceous closed to open vegetation</td>
</tr>
<tr>
<td>15</td>
<td>Closed to open shrubland</td>
</tr>
<tr>
<td>16</td>
<td>Cultivated and managed land</td>
</tr>
<tr>
<td>19</td>
<td>Bare area</td>
</tr>
<tr>
<td>20</td>
<td>Water bodies</td>
</tr>
<tr>
<td>22</td>
<td>Settlements</td>
</tr>
</tbody>
</table>

2.4 Model selection

Maxent provides the best model to use for this study compared to other models as it utilises presence-only data, performs well and is fairly stable in both prediction accuracy and the total area predicted especially when dealing with small species occurrence data sets (20). It has been used successfully with high prediction accuracy in modelling the current and potential distribution of terrestrial plants to assist in making conservation decisions (21) (21, (20)20. It has gained much acceptance in fields such as evolutionary ecology, invasion biology (22), biogeography, epidemiology (23)and conservation (24). It is an open source software that can be obtained freely at www.cs.princeton.edu/~schapire/Maxent. Maximum Entropy.
(Maxent) is a modelling technique which uses ‘presence-only’ data to measure the ecological niche of a species. It is a machine-learning program that uses probability to predict the likelihood of a species occurrence against environmental variable data (25). The prediction accuracy and performance of the model, is measured using the Area Under the Curve (AUC). If the AUC ≥ 0.05 and nearer to 1 then the model performance is good, however an AUC ≤ 0.05 shows poor model performance.

2.5 Model building

A total of 89 geo-referenced occurrence records were used in the model split into 70% training and 30% testing data. 10-fold cross-validation, with 1000 iterations using the sub-sampling method. Duplicate records were removed and only 70 were used to run the model. The model was run using the logistic output format. Jack-knife analysis of the variables aided in identifying variables that had the most importance in predicting the model. Variables with a permutation importance of less than 1% or that reduced the predictive performance of the model were removed from the model and a final set of 6 variables was used to predict the distribution of the species (Table 1)

The 10 probability maps generated from the model run were averaged to obtain a mean habitat suitability distribution map for *C. procera*. Response curves for the different variables (x-axis) and the predicted probability of suitable habitat (y-axis) were generated. Upward trends for variables indicate a positive relationship and downward trends represent a negative relationship

2.6 Species distribution mapping

Point location data overlaid on administrative shapefiles of Zimbabwe were used to generate maps showing the current distribution of *C. procera* using QGIS 3.2. Bonn. Outputs from the maxent run were visualized and overlaid with administrative vector shapefiles of Zimbabwe to generate probability and habitat suitability maps (26)

2.7 Model validation

The prediction accuracy and performance of the model, is measured using the Area Under the Curve (AUC). If the AUC ≥ 0.8 then the model performance is good, however an AUC ≤ 0.05 shows poor model performance.

An AUC ≥ 0.8 indicates good model performance. Ground truthing was done in three of the 10 provinces (Manicaland, Mashonaland Central and Matabeleland south) in March and April 2018 to also validated the prediction accuracy of the model. The average Kappa value and True skill statistic (TSS) was calculated using the following equations (27):
\[ \text{CohenKappa} = \frac{\frac{a+b}{n} - \frac{(a+b)(a+c) + (c+d)(d+b)}{n^2}}{1 - \frac{(a+b)(a+c) + (c+d)(d+b)}{n^2}} \]

\[ \text{TrueSkillsStatistic (TSS)} = \frac{ad-bc}{(a+c)(d+d)} \]

Where:
- \( a \) = number of cells for which presence was correctly predicted by the model;
- \( b \) = number of background cells for which the model predicted presence;
- \( c \) = number of cells for which the species was found but the model predicted absence;
- \( d \) = number of background cells for which absence was correctly predicted by the model;
- \( n \) = \( a + b + c + d \)

The kappa statistic ranges from \(-1\) to \(+1\), where \(+1\) indicates perfect agreement and values of zero or less indicate a performance no better than random. The TSS takes into account both omission and commission errors, and success as a result of random guessing, and ranges from \(-1\) to \(+1\), where \(+1\) indicates perfect agreement and values of zero or less indicate a performance no better than random. However, unlike the kappa value, TSS is not affected by prevalence (27).

3. RESULTS

3.1. Calotropis procera distribution in Zimbabwe

\textit{Calotropis procera} was mainly found in the northern and southern low-lying parts of the country. Rushinga and Mount Darwin districts, Mashonaland Central, had the earliest records of \textit{C. procera} recorded in Zimbabwe. Not many records of the species were found for the 1990s, however from the early 2000 to date, \textit{C. procera} became more prominent. In the southern low-lying areas of Zimbabwe, \textit{C. procera} was first recorded around the period 2005-2015. (Error! Reference source not found.)
3.1.1 Distribution of *C. procera* based on Maxent model

*Error! Reference source not found.* shows the probability of occurrence of *C. procera* averaged between the 10 replications. The model predicted a higher probability of finding *C. procera* in the north-eastern part of the country along the border with Mozambique, as well as the southern part bordering with South Africa (warmer colours). The model predicted a zero probability of finding *C. procera* in the central plateau of Zimbabwe.

*C. procera* covered the northern parts of Matebeleland north, Mashonaland south and central and Mashonaland east. In the southern parts of the country the species covers the southern regions of Manicaland. Masvingo and Matebeleland south The model predicted the occurrence of *C. procera* in Guruve, Centenary and Beitbridge districts to be very high (P ≥ 0.9) whilst in most parts of the highveld (central parts of Zimbabwe) the likelihood of finding *C. procera* was very low (P ≤ 0). (Fig 3).

Suitable habitats for *C. procera* covered the northern parts of Matebeleland north, Mashonaland south and central and Mashonaland east. In the southern parts of the country the suitable habitats for *C. procera* covered the southern regions of Manicaland. Masvingo and Matebeleland south (*Error! Reference source not found.*).

3.1.2 Evaluation of model performance

On average the prediction performance of the 10-fold maxent model performance was good (mean AUC=0.8892; s.d.= 0.03361). The Kappa value and TSS were both above zero and towards 1 indicating that the model performed fairly well at the minimum presence threshold for the 10 replications (Table 2). The potential current distribution of *C. procera* covered the northern parts of Matebeleland north, Mashonaland south and central and Mashonaland east. In the southern parts of the country the species covers the southern regions of Manicaland. Masvingo and Matebeleland south (Fig 3).

<table>
<thead>
<tr>
<th>Species</th>
<th>AUC</th>
<th>SD</th>
<th>Accuracy</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Kappa</th>
<th>TSS</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>C. procera</em></td>
<td>0.89.089</td>
<td>0.03</td>
<td>0.35</td>
<td>0.96</td>
<td>0.35</td>
<td>0.22</td>
<td>0.30</td>
</tr>
</tbody>
</table>

17. Potential current distribution of *C. procera* in Zimbabwe

Table 13. Evaluation of Maxent sub-sampling 10-fold cross-validation model for the distribution of *C. procera* in Zimbabwe
3.2 Factors that influence the distribution of C. procera in Zimbabwe

Minimum temperature in the coldest period (bio6), mean temperature in the wettest quarter (bio8) and land cover had more than 10% permutation importance in the final model with minimum temperature in the coldest period contributing 50% to the model (Error! Reference source not found.).

Analysis of the marginal response curves generated by the model, highlights the species response to the different environmental variables A peak on the response curve shows the optimum condition or range that results in the higher probability of occurrence. Figures 5-10 show the average marginal response of the 10 replications (red) and the variance between the models (blue). All the variables showed some variance between the 10 replications.

Presence of C. procera is notable from minimal temperature of 5°C to 9.5°C (7Error! Reference source not found.) Mean temperature in the wettest period of 19-26.5°C provide the optimal temperature conditions for the presence of the species (Fig 8Error! Reference source not found.). The species can survive in areas where average precipitation during the warmest period is as low as 60mm to as high as 220mm. Precipitation greater than 230mm will result in the decline of species occurrence (Fig 5Error! Reference source not found.). Precipitation seasonality (Fig 4Error! Reference source not found.) and isothermality (Fig 6Error! Reference source not found.) had negative responses to the occurrence of C. procera.
regards to land-use, The probability of occurrence of the species was highest in land used for agricultural purposes (P=0.63) followed by areas associated with rivers and other water bodies. (Fig 9) The probability of occurrence in the woodland with 40% cover (cover class 3; P=0.15) was low (Error! Reference source not found.).

4. DISCUSSION

4.1 Current and Potential distribution of C. procera

Invasive plants are alien plants which reproduce consistently and sustain populations over many life cycles without (or in spite of) direct human intervention and can produce reproductive offspring, often in large numbers, close or at considerable distances (approximately 100m:< 50 years for plants that spread by seed and other propagules and 6m: <3 years for taxa that spread by roots, stolon and creeping stems) from the parent plant; and thus have the potential to spread over a considerable area. (28). This definition also includes species that stopped spreading because they occupied the total range of suitable habitat and whose local eradication leads to re-invasion. An invasive plant can also be defined as an alien plant species that becomes established in natural or semi-natural ecosystems or habitat; is an agent of change and threatens biological diversity (29).

Given the distribution pattern revealed by this study and the behavior pattern of Calotropis in other countries, it is evident that the species has become invasive in Zimbabwe and it has not yet exhausted its habitat range. It is therefore important to come up with management practices to control its spread and eradicate it.

C. procera exhibits both sexual and asexual reproductive capabilities and has several means of dispersal. Once established, it can overcome environmental barriers by surviving in extreme environmental conditions (12); it exhibits allelopathic effects on crop plants (11), reduces the value of rangelands (30); is toxic to both humans and animals (8) hence is highly likely to affect agricultural production in the areas in the low-lying areas of Zimbabwe. Studies on the allelopathic behavior of C. procera indicated that it reduces the germination of crops such as soyabean (Glycine max L. Merrill) (31), cucumber (Cucumis sativus), tomato (Lycopersicon esculentum), and eggplant (Solanum melongena) (32). It also reduces the quality of rangelands (8) and can cause livestock deaths (33).

4.2 Factors influencing C. procera distribution in Zimbabwe

Not all introduced species become invasive. It has become widely accepted that only a small proportion of introduced species establish and only a small proportion spread and become invasive. At the same time, not all species known to be invasive elsewhere become invasive in new areas. (15). The response of a species to the environmental and anthropogenic factors in the new environment greatly contribute to the species ability to invade. It is important to understand the factors responsible for the spread of C. procera in Zimbabwe and
to understand how the species responses to different factors as this forms the basis to any management program.

Environmental factors

Precipitation seasonality indicates the measure of rainfall variability within the season. The increase in the probability of occurrence of *C. procera* with increased rainfall variability supports studies on the biology of the species that showed that the species can perform well under conditions of water stress (11, 34) and thus thrive in the arid and semi-arid regions of Zimbabwe.

The lack of occurrence of *C. procera* at temperatures below 4.5˚C support the studies by Hassan et al (2015) that indicate that the species is not frost tolerant and can only survive at minimum temperatures above 5˚C (13). This might explain why occurrence of the species is minimal to non-existent in the central parts of Zimbabwe that experiences very low temperatures during the winter seasons and are highly prone to frost incidence. Climate change predictions indicate an increase in the minimum temperatures, erratic rainfall and increased incidences of drought and floods in Zimbabwe (34). This could have significant implications on the spread of *C. procera* in the Zimbabwe. The current scenario shows that minimum temperature is the environmental barrier restricting colonisation of new areas (Error! Reference source not found.). The suggested 2.6˚C increase in the minimum temperature (34), will result in reduced incidences of frost and likely affect the invasion process of *C. procera*.

4.2.2. Land-use

Research findings on the distribution of *C. procera* carried out in Australia highlighted that *C. procera* usually invades floodout country and other low-lying areas associated with rivers (8), the model also identifies rivers and water bodies as an important factor in the natural dispersal mechanism of the species. Once established, it produces and disperses a large number of viable seeds, which germinate easily and can tolerate extreme environmental conditions (34; 35).

The continual changes in land cover taking place due to opening up of woodland for agricultural purposes, infrastructural development have the potential to facilitate increased rate of invasion of *C. procera* in Zimbabwe as the study indicated that *C. procera* responses well to land disturbances. Menge et al (35), highlighted that *C. procera* invasiveness is disturbance dependent; and that the species seedlings failed to survive were the grass cover was high; therefore suggested management practices that minimised disturbances to grass cover as a means to managing invasion. Annelis responsible for the spread of *C. procera in Zimbabwe* and the implications it might have on the distribution pattern and its management. Agricultural land also provided a preferred habitat for *C. procera*. Anthropogenic activities such as agriculture play an important role in the distribution of *C. procera* as new areas are opened up for colonisation. The high probability of occurrence in cropland identified by the model (fig 6f) and increased citings after 2000 somehow suggests that the fast-track land reform programme might have had a significant contribution to the spread of the species due to the increase in the land cleared for agricultural purposes during the program.

(37). This could have significant implications on the spread of *C. procera* in the country. The current scenario indicates minimum temperature as the limiting factor governing the spread of the species across the
whole country; a 2.6°C increase in the minimum temperature will therefore reduce the incidence of frost thus promote the establishment of the species in new areas. Increased waterflow caused by floods will also provide a dispersal means for the species thus becoming a major threat to agricultural productivity and reducing the quality of pastures as noted by Csurhes (2009). Given that more about 50% of the total land area is suitable for C. procera invasion it is important to understand its impacts on the ecosystem functions, agricultural productivity and human settlements in a bid to develop management strategies to deal with this potentially invasive plant species that is taking over vast stretches of productive land.

5. CONCLUSION

The study showed that the current distribution of C. procera in Zimbabwe coupled with the possible implications indicate that it has become invasive.

Most of the invasion success is dependent on disturbance as highlighted by the study. There is need therefore to develop management practices that reduces the disturbance level such as reforestation programmes, reducing overgrazing and establishing grassland. In areas where populations of C. procera are small, urgent uprooting of the species is recommended and chemical control where mono-specific stands of the species have developed. (11) Success of any control intervention is centred on the public. Awareness and educational initiatives both by government and environmental organisations need to be implemented.

Monitoring of alien species is very important and SDMs can be used as a detection tool to identify areas were management efforts need to be concentrated. The success of modelling species distribution is largely dependent on the availability of species location data. Temporal and spatial gaps in species collections in Zimbabwe limited the exploitation of SDM as a management tool in biodiversity conservation. There is need to increase the awareness on the impact of invasive species, increase herbarium collections of alien plant species, promote the involvement of citizens in conservation through citizen science initiatives.

6. ACKNOWLEDGEMENTS

We would like to acknowledge the Department of Research and Specialist Services for funding our work. Gratitude is also extended to the various reviewers who took time to provide suggestions to this research report.

7. REFERENCES


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PUBLIC-PRIVATE SECTOR PARTNERSHIPS FOR DESTINATION IMAGE RECOVERY AND SUSTAINABLE PERFORMANCE OF THE TOURISM SECTOR IN ZIMBABWE

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Sub-theme: Fostering Public-Private Sector Partnerships for sustainable development

Abstract

This paper investigates the Public-Private Sector Partnership in Zimbabwe’s tourism sector involving the Zimbabwe Tourism Authority (ZTA) and the Tourism Business Council of Zimbabwe (TBCZ) The former represents the government (public sector) while the latter represents the interests of the tourism and hospitality operators (private sector). The two sectors are pivotal in determining destination image restoration and enhancing the economic performance of Zimbabwe’s tourism sector. Zimbabwe’s image as a tourist image is weak and it has led to a decline in the economic performance of the tourism sector. Research data was collected at various tourism centers in the country from three categories of respondents, namely international tourists, service providers and key tourism and hospitality stakeholders. A structured and semi-structured questionnaire as well as a semi-structured interview guide were used respectively. The study, which used a mixed methodology, found out that most of the service providers were of the view that the ZTA had contributed notably during the past year in enhancing the economic performance of their businesses while a substantial number were unsure whether or not TBCZ had protected their interests during the same period. However, the ZTA and TBCZ and other key informants indicated that they were working well as partners to achieve destination image restoration in Zimbabwe. There was however, lack of transparency between ZTA and TBCZ members. This was worrisome and it is suggested that there is a need to continue to foster the Public-Private Sector Partnership in Zimbabwe’s tourism sector. Sound Public-Private Sector Partnerships were vital in achieving image recovery and sustainable economic performance of Zimbabwe’s tourism. ZTA’s efforts in destination promotion and employee training and TBCZ’s efforts in lobbying government to reduce tourism levy, were applauded. The paper recommends that ZTA and TBCZ require increased budget allocation and creating a revolving Fund for TBCZ both of which demand boosting the tourism economy using a host of strategies.

Keywords: Public-Private Sector Partnerships, Destination Image Recovery, Sustainable, Performance, Tourism, Zimbabwe
1 INTRODUCTION

The Travel and tourism industry is one of the fastest growing economic sectors in the world (1). Globally, the sector contributes 1 in 10 jobs and US$1, 6 trillion in exports, which is equivalent to 7 per cent of the world’s exports and 10 per cent of the world’s GDP (2). In 2017, the travel & tourism industry continued to make a real difference to the lives of millions of people by driving growth, creating jobs, reducing poverty and fostering development and tolerance (3). Thus, the travel and tourism industry is a very important industry. It therefore requires urgent attention when things are not right and generally demands to be well looked after. Its importance also demands that governments invest time, money and other resources to ensure that their countries are competitive tourist destinations. In tourism, a strong destination image (DI) tends to be associated with a sound performance of the tourism sector and destination competitiveness (DC) (4). The enjoyment of maximum revenues from the tourism industry by tourist destinations often entails the adoption of the stakeholder approach. This may include the use of public-private sector partnerships (PPPs). PPPs have been used in travel and tourism for building the facilities needed which, unfortunately, most governments do not have sufficient expertise and capital to construct (5). Indeed, research on PPPs in the travel and tourism industry have been biased towards the provision of infrastructure and services (6, 7). Such investment is associated, not only with establishing hotels, restaurants, shopping and entertainment centers, but also transportation-related projects, including the construction and reconstruction of airports, railways, ports and communication lines (5). However, research which focuses on the service providers’ assessment of the performance of the national tourist organization (NTO) (the government agent) and the representative of the private tourism organizations as key parties in the destination image recovery (DIR) process, seems to be uncommon.

The use of PPPs to meet a wide variety of public needs dates back centuries in the United States (8). One of the first examples was the Lancaster Turnpike, a toll road built by the private sector with public sector oversight and rights-of-way. It was opened in 1793, connecting Pennsylvania farmers with the Philadelphia market and drastically reducing the travel times. Research has covered successful implementation of PPPs to local communities-providing water supply services in Sub-Saharan Africa, for example, the case of Ghana and South Africa. The study found out that the areas suffering water scarcity are mostly poor, conflicted areas where climate change and fast population growth create extra pressure to provide basic services like water supply services. There is a dearth of literature on the nexus between PPPs, Destination Image Recovery (DIR) and Sustainable Performance of the Tourism Sector. This study seeks to fill this interstice. Furthermore, as noted elsewhere, few articles have studied destination performance, even though it is a key tool for managing the destination. It is critical that the government and the private sector collaborate to achieve both DIR and sustainable performance of the tourism sector. There is a variety of techniques for the private and public sectors to work together in order to achieve their common goals (11). The major ones where there is significant experience in government and private participation include marketing and promotion, infrastructure development and renewal, product development, attraction development/renewal/diversification, cultural and heritage protection and environmental protection/enhancement (11).

In the field of tourism, different authors have proposed different definitions of sustainability and sustainable development (12, 13), but the most well-known is the definition proposed by the World Trade Organization (WTO) (2001) establishing that sustainable tourism development meets the needs of present tourists and host regions while protecting and enhancing opportunities for the future (Diaz and Rodriguez, 2016). Baker and Mearns (2017) noted that the UNWTO (2015) has reinforced the drive towards sustainable development through initiatives such as the ‘2017 International Year of Sustainable Tourism for Development’; which places intense focus on improving industry performance within five areas, namely social inclusiveness,
employment and poverty reduction; resources efficiency, environmental protection and climate change; cultural values, diversity and heritage; and mutual understanding, peace and security and inclusive and sustainable economic growth. Sustainable tourism portrays an overall positive image for the industry (16). In this study, sustainable performance refers to economic performance. Diaz and Rodriguez (2016) conducted a study to determine the sustainability factors and performance of a tourism destination from the stakeholders’ perspective. The results revealed that the key factors that have a direct and significant relationship with performance are the key resources and supply chain, security, alternative leisure, and governance. The implication is that a sound collaboration between the ZTA and TBCZ in managing these key factors is bound to lead to a long-term performance of Zimbabwe as a destination.

Zimbabwe however, is battling a negative tourist DI which has contributed to the decline of the performance of its tourism sector. Although a number of studies, for example (Ndlovu, 2009; Karamabakuwa, Shonhiwa, Murombo, Mauchi, Gopo, Denhere, Tafirei, Chindarande and Mudavanhu, 2011; Njerekai, 2014) have been conducted to resolve the problem, DI and performance are still a challenge. Zimbabwe’s travel and tourism competitiveness index (ranking) has been declining from 2011 (20; 21). It was 3.3 out of 7 in 2011, 3.3 out of 7 in 2013, 3.1 out 7 in 2015 and 3.1 out of 7 for 2017 (3).

2. OBJECTIVES
The study was guided by the following major and specific research objectives:

2.1 Major research objective
To establish stakeholders’ evaluation of the ZTA and TBCZ partnership for DIR and sustainable performance of the tourism sector in Zimbabwe

2.2 Specific research objectives
The study sought to:

1. Establish the current situation regarding ZTA-TBCZ partnership for destination image recovery and sustainable performance of the tourism sector in Zimbabwe
2. Assess stakeholders’ views regarding ZTA-TBCZ partnership for destination image recovery and sustainable performance of the tourism sector in Zimbabwe
3. Recommend strategies for enhancing ZTA-TBCZ partnership for destination image recovery and sustainable performance of the tourism sector in Zimbabwe

3. METHODOLOGY
This study adopted the Pragmatism research philosophy. This philosophy is a position that contends that the research question is the most important determinant of the research philosophy adopted (23). Thus, pragmatism is preoccupied with addressing the research question. In order to achieve this purpose, pragmatism is not committed to any one system of philosophy and reality (24). (Creswell (2017) asserted that pragmatism applies a practical approach, integrating different perspectives to help collect and interpret data. In view of this, (Creswell, 2017) indicated that it is possible to work within both positivist and interpretivist positions if one is using pragmatism. The study used a mixed methodology and a convergent parallel mixed methods research design. The convergent parallel mixed methods design supported the research requirements. It was the most appropriate research design in that it allows for the collection and analysis of both qualitative
and quantitative data separately (24). The mixed methodology is quite appropriate when assessing the image of a tourist destination (25). The convergent parallel mixed methods design helps to improve the quality of the study especially given that it is well suited to situations in which the researcher needs to rule out the possibility that something about the methods themselves produced the results (27). The research methodology and research design therefore add value in terms of increased confidence in the research findings (26).

A combination of structured and semi-structured response formats was used to reduce interviewer bias, enhance clarity of responses and provide a broader scope for respondents (28). Qualitative data from service providers and key informants was collected concurrently with quantitative data from international tourists. The study was conducted between May 10 and October 8, 2018.

Purposive sampling, specifically judgement sampling was used to select both service providers and key informants. Tourism and hospitality service providers interact intensely with tourists and the tourism authorities and the sampling technique was appropriate for a research such this one which was exploratory in nature (29). Systematic random sampling was used to select international tourists. Systematic random sampling selects every nth unit after a random start (30). It allows for recreating the data collection environment thus it produces credible results while offering flexibility (30).

There were 62 tourism and hospitality service providers, who included managers, supervisors, ordinary employees and entrepreneurs. There were 17 key informants and 237 international tourists giving a total of 316 respondents which corresponded to 90% of the targeted sample size.

Data from service providers was drawn from hotel staff and management, travel agents, tour operators, transport providers, dry cleaners, event organizers, restaurant employees, helicopter and other air service providers (Victoria Falls), bankers, curio and artwork sellers, cruise and game drive firms, houseboat firms and lodges. The key informants who were interviewed were from the Civil Aviation Authority (CAAZ) (4 respondents), the Zimbabwe Tourism Authority (ZTA) (4 respondents), Ministry of Tourism and Hospitality (2 respondents), Zimbabwe Parks and Wildlife Management Authority (2 respondents), Zimbabwe Association of Airlines (1 respondent), Association of Zimbabwe Travel Agents (1 respondent), Zimbabwe Council for Tourism (1 respondent), Air Zimbabwe (1 respondent), Hospitality Association of Zimbabwe (1 respondent).

A semi-structured questionnaire was administered to tourism and hospitality service providers and semi-structured interviews of key informants were conducted. In line with ethical considerations, interviewees were tape-recorded after they were made aware of and had consented to the tape-recording. All interviews were conducted in Harare because head offices of the key tourism stakeholders such as CAAZ, ZTA, Ministry of Tourism and Hospitality, Air Zimbabwe, Zimbabwe Parks and Wildlife Management Authority, Tourism Business Council of Zimbabwe and others, are housed in Harare. Data from service providers and international tourists was obtained from Victoria Falls, Bulawayo, Kariba, Gweru, Masvingo, Chinhoyi, Zvishavane, Chegutu, Kwekwe and Harare. About half of the number of the structured questionnaires for international tourists were distributed at Robert Gabriel Mugabe International Airport in the international departure lounge while the tourists waited to fly out of the country. Potential respondents were asked if they
were non-Zimbabweans to ensure that they were indeed part of the sampling frame. For the avoidance of double counting, potential respondents were also asked if they had completed the questionnaire before, for example, at a hotel or at some tourist attraction or some other place in Zimbabwe. As part of ethical considerations, all respondents were informed about the purpose of the study and that their participation was voluntary and they could withdraw from the research at any stage. Confidentiality of their identities was guaranteed and they were informed that the study was purely academic. The key informants who were keen to know the study results were told that the results would be made available to them.

3.1 Data Analysis
After transcribing, the interviews were sent to key informants who had provided them so they could assess and establish whether or not they had been accurately recorded. All interviewees confirmed that the interview was a true record of what they had said. NVivo version 12 was used to analyze qualitative data while SPSS version 23 (descriptive statistics and factor analysis) was used to analyze quantitative data from service providers but mainly from international tourists.

4. FINDINGS
3.2 Response rate
From the seventy six questionnaires which were distributed to tourism and hospitality service providers, sixty two usable questionnaires were returned giving a response rate of 83% which was very good. Normally, the lower the response rate, the greater the concern that the resulting sample will not adequately represent the population (31). That concern was not relevant in this study. All the targeted seventeen interviews with key informants were conducted giving a 100% response rate. Two hundred and thirty seven usable tourist questionnaires were returned.

3.3 Demographic Data
Service providers and key informants

<table>
<thead>
<tr>
<th>Gender</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>40</td>
<td>50.6</td>
<td>50.6</td>
<td>50.6</td>
</tr>
<tr>
<td>Female</td>
<td>39</td>
<td>49.4</td>
<td>49.4</td>
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</tr>
<tr>
<td>Total</td>
<td>79</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

Table 1
Source: Primary data
The percentages of females and males (service providers and key informants) were almost equal. Labour force participation is low around the world. (Table 1). This suggests absence of bias with regards. However, the World Bank further noted that tourism to the composition of the sample in terms of gender provides better opportunities for women participation. This points to a concerted effort by the researchers to in the workforce, women’s entrepreneurship, and produce credible results. This finding tends to women leadership than other sectors of the economy. contradict

Key informants
ars of Experience

<table>
<thead>
<tr>
<th>Years of Experience</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 5 Years</td>
<td>1</td>
<td>5.9</td>
<td>5.9</td>
<td>5.9</td>
</tr>
<tr>
<td>5-9 Years</td>
<td>2</td>
<td>11.8</td>
<td>11.8</td>
<td>17.6</td>
</tr>
<tr>
<td>10-14 Years</td>
<td>5</td>
<td>29.4</td>
<td>29.4</td>
<td>47.1</td>
</tr>
<tr>
<td>15-19 Years</td>
<td>4</td>
<td>23.5</td>
<td>23.5</td>
<td>70.6</td>
</tr>
<tr>
<td>20 Years and Above</td>
<td>5</td>
<td>29.4</td>
<td>29.4</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

Table 2

Source: Primary data

Eighty two percent of the key informants had more than 10 years’ experience in the tourism and hospitality sector (Table 2). More than 29% of key informants had at least twenty years’ experience. The key informants’ views were therefore highly credible because their experience suggested that they had dealt with ZTA and the TBCZ for a long time. They were therefore aware of the strengths and weaknesses of these organizations. Ninety per cent of service providers had been in the tourism and hospitality sector from a period of between one year to more than 16 years, making their contribution to the study very relevant and dependable (Table 3).
### Service providers

#### Years in Industry (Service providers)

<table>
<thead>
<tr>
<th>Years in Industry</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 1 year</td>
<td>6</td>
<td>9.7</td>
<td>9.7</td>
<td>9.7</td>
</tr>
<tr>
<td>1-5 years</td>
<td>26</td>
<td>41.9</td>
<td>41.9</td>
<td>51.6</td>
</tr>
<tr>
<td>6-10 years</td>
<td>17</td>
<td>27.4</td>
<td>27.4</td>
<td>79.0</td>
</tr>
<tr>
<td>11-15 years</td>
<td>11</td>
<td>17.7</td>
<td>17.7</td>
<td>96.8</td>
</tr>
<tr>
<td>16 years and above</td>
<td>2</td>
<td>3.2</td>
<td>3.2</td>
<td>100.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>62</strong></td>
<td><strong>100.0</strong></td>
<td><strong>100.0</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Table 3**

**Source:** Primary data

### Service providers

#### Job position

<table>
<thead>
<tr>
<th>Job position</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top Management</td>
<td>12</td>
<td>19.4</td>
<td>21.4</td>
<td>21.4</td>
</tr>
<tr>
<td>Middle Management</td>
<td>25</td>
<td>40.3</td>
<td>44.6</td>
<td>66.1</td>
</tr>
<tr>
<td>Supervisory Level</td>
<td>11</td>
<td>17.7</td>
<td>19.6</td>
<td>85.7</td>
</tr>
<tr>
<td>Shop floor Employee</td>
<td>8</td>
<td>12.9</td>
<td>14.3</td>
<td>100.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>56</strong></td>
<td><strong>90.3</strong></td>
<td><strong>100.0</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Missing System</strong></td>
<td><strong>6</strong></td>
<td><strong>9.7</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>62</strong></td>
<td><strong>100.0</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 4**

**Source:** Primary data
The bulk of the service providers were managers with 40.3% being middle managers followed by top managers (19.4%) and then first line managers (17.7%) (Table 4). All key informants occupied managerial positions with 24% holding very senior positions such as managing director, executive director, and chief executive officer and so on. This was significant in the sense that members of management drive strategic arrangements such as public-private partnerships and influence destination appeal and performance. The UNWTO (2015) indicated that PPPs are often vital and important elements in the establishment of tourism based initiatives and the improvement of the market competitiveness of destinations. This made managers appropriate respondents because they had significant input to the research problem at hand. Both service providers and key informants were highly educated. Holders of first and master’s degrees comprised 79% of the total respondents. This positively influenced the response rate. Poorly educated respondents who cannot read and write well may skip open-ended questions to which they are to write out their answers (31). Respondents were well educated hence questions were well attended to.

### Service providers and key informants

#### Highest level of education completed

<table>
<thead>
<tr>
<th>Education Level</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘O’ Level</td>
<td>1</td>
<td>1.6</td>
<td>1.6</td>
<td>1.6</td>
</tr>
<tr>
<td>‘A’ Level</td>
<td>3</td>
<td>4.8</td>
<td>4.9</td>
<td>6.6</td>
</tr>
<tr>
<td>Diploma</td>
<td>8</td>
<td>12.9</td>
<td>13.1</td>
<td>19.7</td>
</tr>
<tr>
<td>First Degree</td>
<td>41</td>
<td>59.7</td>
<td>60.7</td>
<td>80.3</td>
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<tr>
<td>Master’s</td>
<td>25</td>
<td>19.4</td>
<td>19.7</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>61</td>
<td>98.4</td>
<td>98.4</td>
<td>100.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Education Level</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Missing</td>
<td>1</td>
<td>1.6</td>
</tr>
<tr>
<td>Total</td>
<td>62</td>
<td>100.0</td>
</tr>
</tbody>
</table>

**Table 5**

**Source:** Primary data
4.1 Current situation regarding ZTA-TBCZ partnership for destination image recovery and sustainable performance of the tourism sector in Zimbabwe

The roles of the TBCZ which the service providers and the ZTA highlighted, included the provision of platforms (fora) by the TBCZ to interact with its member organizations and ZTA. Service providers were of the view that the provision of these platforms made the ZCT the interface between the tourism and hospitality service providers and the ZTA. The TBCZ was applauded by service providers and appreciated for its efforts in this regard (Table 6). The ZTA on the other hand was acknowledged by the TBCZ and its members for their work in terms of destination marketing, the provision of platforms to interact with tourism and hospitality stakeholders. ZTA’s role in training was not regarded as having been given prominence by the ZTA during the past three years. However, both ZTA and TBCZ lamented the idea that they were operating under a shoe-string budget. This tended to restrain them in terms of their operations, some of which could serve to cement their public-private partnership. Pratap, Kaurav, Baber, Chowdhary and Kapadie, (2015) argued that DMOs such as the ZTA do not have control over the activities of their associates but bring together expertise and resources, integrating them with a degree of independence and objectivity. It therefore follows that DMOs must have a high-level skill of developing and managing partnerships. International tourists’ assessment of the quality and importance of destination attributes corroborated the finding that there was need to seriously foster the public-private sector partnership in Zimbabwe, with the ZTA-TBCZ partnership being one of them.

The statistical means for price competitiveness and shopping facilities were as low as 3.34 and 3.31 respectively while the means for the importance of the same attributes to international tourists were as high as 4.22 and 3.76 respectively. This suggested that although price competitiveness and shopping facilities were important determinants of tourist destination choice and DIR, tourists were largely unhappy about them. This finding resonated with the ranking of Zimbabwe’s business environment by the (WEF, 2017). Zimbabwe’s global ranking in this pillar is a very poor 134 out of 136. Similarly, the statistical means for quality of accessibility of destinations within Zimbabwe and road condition were a low 3.24 and 2.40 respectively. The statistical means for their importance were however as high as 4.22 and 4.06 respectively suggesting that these attributes were crucial for DIR. Assaf and Josiassen, (2012) rated tourism and related infrastructure the number one driver of destination performance. This suggested a need for a strong ZTA-TBCZ partnership in order to achieve DIR and sustainable performance of Zimbabwe’s tourism sector in order to rehabilitate tourism and related infrastructure.
Service providers and key informants comments on TBCZ and the ZTA

Table 6

Source: Primary data
4.2 Assessment of stakeholders’ views on ZTA-TBCZ partnership for destination image recovery and sustainable performance of the tourism sector in Zimbabwe

Contribution of the ZTA towards the performance of tourism and hospitality organizations

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
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<tr>
<td>Yes</td>
<td>26</td>
<td>41.9</td>
<td>41.9</td>
</tr>
<tr>
<td>Unsure</td>
<td>21</td>
<td>33.9</td>
<td>75.8</td>
</tr>
<tr>
<td>No</td>
<td>15</td>
<td>24.2</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>62</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 7

Source: Primary data

While all the 17 key informants who were interviewed indicated that they were working very well with the service providers who included hotels, airline organizations, travel agents, the Zimbabwe Parks and Wildlife Management Authority, Civil Aviation Authority of Zimbabwe (CAAZ) and others, the service providers did not seem to provide a resounding positive response. Service providers were asked the following question:

“Has the Zimbabwe Tourism Authority (ZTA) contributed in any way during the past three years towards enhancing the economic performance of your business?”

A slight majority (42%) responded in the affirmative (Table 7). A notably high figure (34%) indicated that they were unsure. This suggested that a notable percentage of service providers did not feel the ZTA’s impact on the performance of their organizations during the past three years. The Zimbabwe Tourism Act, Chapter 14:20 of 1995 stipulates that the functions of the ZTA include, *inter alia*, to develop marketing skills and initiatives within the tourist industry and to promote high standards in the tourist industry through the establishment of standards, training and human resource development. However, a key informant from ZTA was asked:

What are the major issues affecting the economic performance of your organization? Key informant 15, 18 September, 2018)

They responded: “For us, I think it’s just adequate funding.” So, a lack of resources especially financial resources, was cited as one major factors which incapacitated the ZTA. A key informant from the ZBCT also cited funding as their major limiting factor. They remarked:
“Yes, the issue of funding is a major issue. We have talked about the revolving fund for many years now, we have been talking about setting up a revolving fund since 1994” (Key informant 11, 19 September, 2018).

Literature does not quite highlight the role played by funding in DIR and the enhancement of performance of the tourism sector. Karambakuwa et al., (2011) noted that measures to revamp the tourism sector depended on proper planning and coordination among various stakeholders, as well as the availability of funding for tourism infrastructure and marketing efforts. The ZTA’s training function is one area in which the ZBCT-ZTA relations could be exploited for DI recovery and enhancement of tourism performance. ZTA needed to do more with regards to training. A key informant was of the view that:

“Training has not been high profile for ZTA. Yes it’s a function they have but they have never really… You see, they need to, for the training aspect, they need to go to industry and work with industry, not to determine training needs in their offices.” (Key informant 15, 18 September, 2018).

However, when asked about the contribution of the ZTA to the economic performance of the private firms in tourism and hospitality, one response was: “They do. They have tried a lot” (key informant 15.) It was however, interesting that in response to the claim: There is transparency in the way in which the tourism levy is used, the mean statistic was as low as 2.81 indicating that the service providers refuted the allegation. This pointed to a need to foster a tighter partnership between government and the private sector with regards to image repair and achieving sustainable performance of tourism in Zimbabwe.

The 24% of respondents who said ‘No’ to the question:
Has the Zimbabwe Tourism Authority (ZTA) contributed in any way during the past three years towards enhancing the economic performance of your business is a significant figure?

In fact, those who responded negatively and those who were unsure constitute the majority (67.1%). The Board of Airlines for example lamented the non-payment of fees by government to their members. This position was echoed by service provider number 16 who postulated that:
“Airlines are asking for American dollars which are in short supply in Zimbabwe. Airlines are not paid on time. ZTA should intervene.”

Service providers (airlines) expect ZTA to intervene in the issue of non-payment of fees and yet ordinarily, they should approach their mother body-the ZCT. This tends to suggest a lack of role clarity in the service
provider’s mind between ZTA and ZCT or to the functions of ZTA and ZCT. Literature is rather silent on the role played by stakeholder relations between the public and private sectors with regards to DIR and the achievement of sustainable performance of the tourism sector. Past research (Assaf and Josiassen, 2012; Li, Ali, and Kim, 2015) identified the key factors or determinants that contribute to industry performance. These include tourism and related infrastructure, economic conditions, security, safety and health, tourism price levels, government policies, environmental sustainability, atmosphere of the place, labor skills and training, and natural and cultural resources. Assaf and Josiassen, (2012) and Li et al., (2015) noted that these dimensions actually determined the perception of DI. According to Zidana, (2015), the macroeconomic determinants of tourism performance included the levels of per capita income for tourists’ source countries, the nominal exchange rate, and levels of investment in the tourism sector, political and economic stability of the host country and/or neighboring countries in the sub-region. The contribution of the public-private partnerships to DIR and sustainable performance of the tourism sector is not highlighted.

### Protection of business interests by Zimbabwe Council for Tourism

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid</td>
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<td>17</td>
<td>27.4</td>
<td>27.4</td>
</tr>
<tr>
<td></td>
<td>Unsure</td>
<td>33</td>
<td>53.2</td>
<td>80.6</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>12</td>
<td>19.4</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>62</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

**Table 8 sustainable performance of the tourism sector in Zimbabwe**

**Source:** Primary data

A notable percentage (33%) of the tourism and hospitality service providers were unsure whether or not the TBCZ had protected their business interests. Like in the case of the ZTA, this seems to suggest that there is a need to further strengthen relations between the private tourism and hospitality operators and their representative body. A small percentage (27%) of service providers responded positively to the question: Has the TBCZ protected your business interests in any way during the past three years?
The Zimbabwe National Tourism Sector Strategy (NTSS) spells out that tourism is private sector driven. To that extent, it is important that the interests of the private firms are well catered for by their umbrella body if sustainable tourism development is to be achieved in Zimbabwe. Possibly, the ability to cater to the needs of member organizations should serve as the antecedent to sound public-private sector partnership(s).

4.3 Strategies for enhancing ZTA-TBCZ partnership for destination image recovery and sustainable performance of the tourism sector in Zimbabwe

The study found out that the ZTA-TBCZ partnership was one of the strategies for regaining lost markets and unindustrialized new source markets (Figure 1). The other strategies included improving destination accessibility, price competitiveness, and infrastructural development and so on. There was a need for government to honor its obligation of paying airlines the fees which have accumulated over a long period of time. A key informant remarked that:

“But I can tell you that, maybe, because our billing is done on a weekly basis, what we would get on average for a week is generally less than 30 percent of our requirements. So, we continuously have this backlog of 70% week on week.” (Key informant 10, 18 September, 2018).

The nonpayment of fees to airlines comprises their operations and tends to put a wedge between the public sector (represented by ZTA) and the private sector (epitomized by the TBCZ). Consequently, this compromises DIR and the sustainability of tourism performance. However, in order to achieve this, the national economy should be attractive enough to lure potential investors including those who will invest in tourism. Diaz and Rodriguez (2016) argued that the levels of investment in the tourism sector; and political and economic stability are key drivers of DIR and sustainable performance of the tourism sector.

A sound economy was very likely to result in the government increasing the ZTA budget so it could better perform its statutory functions. The functions identified included providing consultancy and advisory services in relation to tourism, promoting the development of tourist facilities, promoting Zimbabwe as a destination for tourists, promoting the tourist industry in overseas, regional and domestic markets and conducting training and human resource development (35). The
accomplishment of these functions would benefit both ZTA and TBCZ, hence these functions would help to enhance the ZTA-TBCZ partnership. Further to this, there is need for the public sector to be actively involved in setting up a Hospitality and Tourism Fund to assist the industry to be viable while benefitting government too. A Key informant commented that:

“We expect that Fund to be established with funds coming from various quarters including government”. (Key informant 15, 18 September, 2018).

Strategies for acquiring new tourist markets

Figure 1

Source: Primary data
The Fund will be used to guarantee the viability of the tourism and hospitality private sector. This is key for DIR in the sense that the availability of a variety of service providers is bound to add to destination attractiveness. Such an arrangement was also bound to heighten competition and make prices competitive and hence contribute to the sustainability of the performance of the sector. Zimbabwe’s price competitiveness global position is currently 51 out of 136 country destinations (3). It is far worse than Botswana’s price competitiveness position which is 13 out of 136.

In order to enhance the partnership, it was imperative that a value chain analysis be conducted to ease pressure on the tourist arising from prices. Prices were perceived to be uncompetitive. This was also found out by (Zimstat, 2016) which conducted a Visitor Exit Survey in Zimbabwe and established that the main reason for visitor negative perceptions about Zimbabwe as a tourist destination related to high prices. Key informant 15 highlighted that the tourism and hospitality value chain showed that the industry only had the customer below it. It was a price taker which took prices which had been engineered by other stakeholders at the top, including the government, and pushed it down to the customer. There was need for the tourism and hospitality stakeholders to come together and review pricing.

An improvement in economic performance would contribute towards curbing corruption. The study revealed that corruption has been frustrating to both government and the private sector operations. The allegation that ‘the perception of corruption in the country has negatively affected my business’s performance’ had a statistical mean value of 3.73. The high mean statistic suggested that service providers agreed with the claim. Assaf and Josiassen, (2012) ranked a country’s corruption index together as the third most important driver of tourism performance together with security, safety and health.

5. CONCLUSION

That there is a case for DI recovery in Zimbabwe, is beyond question. The question may be what strategies, from the plethora of strategies available for achieving DI repair, were bound to generate the best results. Research findings suggested that the public-private partnership involving representatives of the public and private sectors was a strategy which could play a meaningful role in DI recovery and turning around the performance of the tourism sector in Zimbabwe. It could be a potent tool for achieving the sustainable performance of the tourism sector in Zimbabwe and in similar country destinations. Therefore, the tourism and hospitality entities in the public and the private sectors need an introspection regarding the execution of their obligations for each other. In a public-private partnership, obligations flow from one party to the other and there are mutual benefits. The study contributes to expand empirically, the antecedents of DI regeneration and the sustainable enhancement of performance of the tourism sector. However, the study has certain limitations. It did not include the views of academics, notably those lecturing hospitality,
tourism, travel and leisure disciplines in tertiary institutions including universities. It did not provide a comprehensive revelation of the legalities in relation to the ZTA-TBCZ partnership. However, these limitations provide an opportunity for further research. Further research could explore the legal dimensions relating to the operations of both the ZTA and the TBCZ while incorporating the views of academics.

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AN ASSESSMENT OF WOODY VEGETATION STRUCTURE AND COMPOSITION WITHIN A PERI-URBAN PARK: A CASE-STUDY OF SABLE GAME PARK, CENTRAL ZIMBABWE

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ABSTRACT

Peri-urban biodiversity is under threat due to population growth which has induced a growing demand for energy to cater for human needs and space for development. Wood fuel is the cheapest form of energy utilised by urban settlements in close proximity to urban parks resulting in changes in woody vegetation structure and composition. This study assessed woody vegetation composition and structure in a peri-urban park, Sable Game Park, located in Kwekwe, Zimbabwe. The objectives of the study were (i) to determine the status of woody vegetation composition and structure across the Park and (ii) to establish the impacts of human activity and herbivory on the woody vegetation. Information helps in developing strategies for the conservation of biodiversity in urban parks. Data were collected from 30 plots using stratified random sampling across the park to collect data. Results showed that the park has a high number of woody species with reduced desired stems and species size. Results also showed a significant difference for all the structural and composition attributes (p<0.05) as distance from the park boundary to the core increased. Wood poaching was the greatest driver in woody vegetation structure and composition and it is considered as an ecological and an environmental problem contributing to the degradation of vegetation at Sable Game Park. This study recommends collaboration among local communities, natural resource managers, ecologists and relevant stakeholders involved in urban development for sustainable urban green ecosystem development.

Keywords: Peri-Urban Park; Woody Vegetation; Urbanisation; Fire.
INTRODUCTION

Vegetation structure and composition in savannah communities are mainly influenced by natural processes such as water availability, nutrient availability, and fire and herbivory but the site factors have been changing by the impact of anthropogenic activities (1). Increased urbanisation has been reported to be threatening biodiversity and wildlife habitats through anthropogenic interference which include encroachment in natural environments and poaching of woody vegetation (2). Hence it is essential to conduct studies of floras of peri-urban parks where there is severe threat to natural vegetation due to high accessibility for urban residents.

Woody vegetation in urban ecosystems plays an important role in maintaining the environment and quality of life through offsetting carbon emissions, remove air pollutants, shading and cooling of communities and buildings (3). Peri-urban parks also offer people the opportunity to connect with nature, engage in physical activity and find a haven away from the city noise (4).

Sable Game Park acts as a buffer–zone to the Dutchman’s Pool which supply Kwekwe residents with consumable water. It is a tourist attraction centre with a good aesthetic value hence has become a source of income and employment for the local residents.

Yet little is known on the ecosystem structure and characteristics of woody vegetation in peri-urban areas of the developing world (5). Studies done in developed nations have discussed the loss of peri-urban vegetation cover in Southern Africa (6; 7; 8). There is a general lack of baseline data leading to a dearth of information on woody species composition and structure in peri-urban parks in Zimbabwe that contributes to continued degradation of these ecosystems (9).

This study aims to contribute to the understanding of woody vegetation structure and composition at Sable Game Park in Kwekwe, Zimbabwe. Sable Game Park close location to an urban area, City of Kwekwe, can be perceived as a threat to its long term integrity. This threat is directly linked to anthropogenic factors since the park is also surrounded by a township (Mbizo Township) (9). However, there is no documentation of the composition and structure of woody vegetation in Sable Game Park which is a necessity in the better management of the Park. Hence the research will be conducted in order to assess the woodland structure and composition of Sable Game Park and the dominant woody species. This study will provide important information that will assist in the management of both natural and urban environments.

This study will bring about new knowledge on the pattern of woody vegetation and structure in urban parks facing increasing urbanisation. Proper management of large area of natural vegetation depends to a large extent on the knowledge of vegetation composition and structure (11). Currently there is paucity of information on the structure and composition of woody vegetation at Sable Game Park despite its recognition as one of the few peri – urban parks in Zimbabwe hence the likely increasing pressure on the park. Against this background, assessing the woody structure and composition of Sable Park could guide current management on its woodland management strategies. This will ensure effective management of the natural resources at Sable Game Park.
1. OBJECTIVES
(i) To determine the status of woody vegetation composition and structure across Sable Park.
(ii) To establish the impact of human activity and herbivory on woody vegetation across Sable Park.

METHODOLOGY

3.1 Study Area

This study was conducted at Sable Game Park which is located in Kwekwe district, in the Midlands province of Zimbabwe (Figure 1). The park was established in 1976 as a way of protecting natural resources from encroachment by the township of Mbizo in Kwekwe as its population was growing very fast and this boom was a threat to the beautiful Dutchman pool area and Echo-park. It was officially opened in 1989 by Fritz Meyer the founder member of Wildlife Society of Zimbabwe. Sable Game Park is situated on the south bank of Dutchman’s pool 12 kilometres northeast of Kwekwe town but less than 5 km from Mbizo residential area. The game park covers 300 hectares of land (3km²).

![Figure 1: Location of Sable Park in central Zimbabwe.](image)

Sable Park contains picturesque kopjes and is surrounded for the greater part of its borders by the Sebakwe River. It is also rich in gold and iron-ore. In terms of the agro-ecological regions of Zimbabwe it lies in region IV a semi extensive farming region characterised by poor and sporadic rainfall ranging from 450-560mm. It is also characterised by mean minimum temperatures of 18°C and mean maximum temperatures of 27°C.

3.2 Demographic Profile

The 2012 census done showed that Kwekwe has an estimation of 100 900 people with 93 000 (Kwekwe Municipality Records) people in Mbizo only. Mbizo is situated less than 5km away from the boundary
of Sable Game Park with agricultural practices done just outside the boundary and illegal gold panning done in the Park.

3.3 Flora and Fauna

Animal species found in the park are shown in Table 1. Sable Park used to be a home to a number of plain game that include sable, kudu, eland, impala, bush bucks, zebra, wildebeest and warthogs (10). Due to enormous poaching between the periods of 2006 to 2010 most animals were poached and the fence was removed by poachers resulting in easier access for them into the Park and escape of animals from the Park. Only a few animals that include kudus, impalas, wildebeests and warthogs were left up to date. In terms of flora; Sable Game Park is dominated by *Julbernadia Globiflora, Brachystegia Spiciformis* and *Brachystegia Boehmii*, a typical Miombo woodland.

Table 1 showing species common and scientific names of animals at Sable Game Park

<table>
<thead>
<tr>
<th>Species common name</th>
<th>Scientific name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bush buck</td>
<td><em>Tragelaphus scriptus</em></td>
</tr>
<tr>
<td>Eland</td>
<td><em>Tragelaphus oryx</em></td>
</tr>
<tr>
<td>Impala</td>
<td><em>Aepyceros melampus</em></td>
</tr>
<tr>
<td>Kudu</td>
<td><em>Tragelaphus strepsiceros</em></td>
</tr>
<tr>
<td>Sables</td>
<td><em>Hippotragus niger</em></td>
</tr>
<tr>
<td>Wildebeest</td>
<td><em>Connochaetes taurinus</em></td>
</tr>
<tr>
<td>Warthog</td>
<td><em>Phacochoerus aethiopicus</em></td>
</tr>
<tr>
<td>Zebra</td>
<td><em>Equus quagga</em></td>
</tr>
</tbody>
</table>

3.4 Sampling design and data collection

Stratified random sampling procedure was adopted in this study. Thirty plots were demarcated at random from the park boundary moving to the core using random tables. Stratified Random sampling was used to collect data to observe if there is difference in the composition and vegetation structure of the woody plants as one moves across the park. Global Positioning System device was used to locate plots on the ground. Plot size was determined following Walkers’ method of having at least 15 to 20 trees in a plot. A total of 30 rectangular study plots 20m x 30m (0.06ha) were sampled following (12). Rectangular plots were used because they are considered best owing to its least conformity to plant shape and distribution patterns (13). These were laid out with the aid of marked string. Data collection was done from April to May 2014 a time when species composition is most conspicuous.

3.5 Field technique and variable assessment method

Different vegetation attributes provide essential data to determine structure and composition of vegetation. Data for tree height was collected by placing a graduated 7m pole against the tree. For trees taller than 7m visual estimation was done. Woody plants were considered a tree when it is greater than 3m in height (14). All woody species less than 3m height were regarded as shrubs. Shrub height was
measured with a tape measure. Girth was measured with a tape measure at 1.2m breast height as widely used in Miombo (15). Canopy depth was measured using a 7m graduated pole. Diameter was measured using a tape measure 90 degrees perpendicular to the ground. These were identified using field guides (15; 16) and where unknown species were encountered, samples were taken and later identified with assistance of botanists. Data for human disturbance that is, fire evidence and tree cutting, were recorded as 1 for any signs of human impacts and 0 if there are no signs. Any signs of fire such as fire scars or burn marks and characteristic re-growth from the base of dead stems or charred plant remains were considered as fire-induced. Woody plants were examined for signs of browsing (e.g. broken branches, leaves and trampling) to give insight of browse evidence.

4. Data Analysis

4.1 Vegetation structure

Average tree height, shrub heights and stem number were calculated for each study plot. Density was calculated as the total number of all species occurring in one plot and expressed in trees per hectare. Density was calculated for the total number of trees in a plot, for the total number of trees and shrubs showing evidence of tree cutting, fire and animal browsing.

Density \( \frac{y}{ha} = \frac{(x \times 10000 \ m^2)}{\text{plot area}, \ m^2} \), where y denotes tree, shrub or stem and x is the recorded number of trees, shrubs and stems.

Girth was used to calculate basal area using the formula below and it is used to age trees were no other means are available for age class determination (18).

\[
\text{Basal area} = \frac{c^2}{4 \times 3.14}
\]

Canopy depth and canopy diameter data were used in the calculation of canopy volumes for each tree and shrub in a plot. Canopy volumes were calculated using a formulae by (19)

i. Shrub canopy volume \( (m^3) = \frac{1}{4} \pi (Ht)(D1)(D2) \):

Where Ht is height, D1 and D2 are two canopy diameters at 90°, and

ii. Tree canopy volume \( (m^3) = \frac{1}{4} (CD1)(D1)(D2) \):

Where CD is canopy depth.

4.2 Vegetation diversity indices

Species diversity was calculated by the Shannon Weiner Index using the formula:

\[
H' = \sum p_i \ln p_i
\]

\( H' \) is the Shannon Index of diversity, \( p_i \) =proportion abundances of species \( i \) and \( \ln \) is the natural log (20).

Data was tested for normality and homogeneity using Kolmogorov- Smirnov test in STATISTICA version 7 for Windows. Data on number of stems, fire, basal area, animal browsing and canopy volume for shrubs and trees, and the number of stems were \( \log_{10}(x + 10) \) transformed, where \( x \) is the vegetation variable quantity, in order to satisfy the assumptions of normality and equality of variance.
Differences in species structure and composition across the study strata were determined using one sample t-test. We considered it to be of no significance when the value of the probability of significance (P) was greater than 0.05. Principal Component Analysis (PCA) was used to show pattern of woody vegetation in relation to the attributes measured. Hierachical Cluster Analysis (HCA) using the ward’s method, was used to analyze woody species cluster across the strata to uncover the major classes that exist not ignoring those that have very low frequencies. The study variable’s means, standard deviations, standard errors and statistical results were tabulated.

5. RESULTS

5.1 Status of woody vegetation composition and structure across Sable Game Park

A total of 1 229 individual woody plants representing 25 woody species were recorded from the 30 sample plots, 917 were trees and 312 were shrubs. There was a significant difference in woody structure and composition across Sable Game Park (one sample t-test, p<0.05, Table 2).
Table 2: Summary of the statistical analyses from t-test result of the study variables in Sable Park Zimbabwe.

<table>
<thead>
<tr>
<th>Vegetation attribute</th>
<th>Mean± SE</th>
<th>t-value</th>
<th>df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density of woody plants (plants/ha)</td>
<td>722.78±214.44</td>
<td>18.46</td>
<td>29</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Tree density (trees/ha)</td>
<td>501.11±223.13</td>
<td>12.30</td>
<td>29</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Shrub density (shrubs/ha)</td>
<td>215±155.75</td>
<td>7.56</td>
<td>29</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Basal Area (m/ha)</td>
<td>729.31±1825.35</td>
<td>14.93</td>
<td>29</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Canopy volume of shrubs (m³)</td>
<td>235.66±274.42</td>
<td>28.35</td>
<td>29</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Canopy volume of trees (m³)</td>
<td>5774.03±16623.25</td>
<td>22.40</td>
<td>29</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Tree height (m)</td>
<td>5.14±1.17</td>
<td>24.0</td>
<td>29</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Shrub height (m)</td>
<td>2.16±0.32</td>
<td>36.59</td>
<td>29</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Number of stems/plant</td>
<td>238.47±1299.18</td>
<td>12.27</td>
<td>29</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Diversity (H¹)</td>
<td>1.36±0.46</td>
<td>16.30</td>
<td>29</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>
5.2 Pattern of vegetation across Sable Game Park

PCA results are shown in Figure 2 and Figure 3 with factor 1 explaining about 27.31% whereas factor 2 explains about 19.66% in woody vegetation structure and composition in sample plots across Sable Park. Factor 1 defines a gradient from sample plots with high density of plants that were browsed and high number of shrubs to sample plots with taller trees and high evidence of fire. Factor 2 defines a gradient from sample plots with high species diversity and high canopy volume of trees and number of stems.

**Figure 2:** PCA showing pattern of vegetation in relation to the attributes measured.
5.3 Classification of sample plots based on species abundance data.

The Hierarchical Cluster Analysis (HCA) dendrogram in Figure 4 shows that there were three broad clusters from the 30 sampled plots across Sable Game Park. Plots in Cluster A were comprised 4 plots (plot 30, 20, 21 5) which were characterized with *C.mopane* species. Cluster B comprised 12 sample plots with 5plots characterised of *J.globiflora* species and 7 plots with *B.boehmi*. Lastly, Cluster C comprised 14 plots with 3plots characterised by *T.sericea* and 11plots*B.spiciformis* woody species.
Figure 4: Dendrogram showing classification of sample plots into 3 clusters based on species abundance from the 30 plots across Sable Game Park. Note: P represent plot.

5.4 Species cumulative frequency

The species cumulative curve in figure 4 showed that there was an increase in species number from plot 1 to plot 11. Species number became constant with each plot number between plot 11 and plot 25. A rare species, *Vitex payos* was then identified in plot 26. No new species were identified in the last 3 plots.
5.5 Impacts of humans and herbivory

Fire and wood poaching have severely damaged Sable Game Park as shown by figure 6 and figure 7 hence affecting woody vegetation structure and composition. Tree cutting has the greatest influence on the woody vegetation structure and composition (42.8%) and the least being herbivory (13.5%) as shown by figure 5.

Figure 5: Key drivers of ecosystem change in Sable Game Park. Wood poaching has the greatest influence and herbivory the least.
Figure 6: Evidence of tree cutting. One would notice that a common hand-axe was used. Photo credit S.Bafana
Figure 7: Wood from *D. cinerea* that was loaded in a wheelbarrow by a poacher who was caught during data collection. The picture also show the impacts of fire that were started by poachers in Sable Game Park. Photo credit: S.Bafana
Figure 8: Species *T.sericea* and *B.africana* with high canopy volume and maximum height of trees, from plots that were selected between the core and the boundary of the Park.

6. DISCUSSION

6.1 Status of woody vegetation structure and Composition across Sable Park

Sable Game Park is dominated by *Julbernardia globifora*, *Brachystegia spiciformis* and *Brachystegia boehmii* a typical Miombo woodland. *Vitex payos* was one rare species that was recorded and need to be protected to avoid extinction from the Park. Woody vegetation structure and composition in the present study differed significantly across the park (table 2). All the attributes varied across the park although shrub density, shrub height was highest at the plots close to the boundary and also at the core of the park because these are areas where most wood poaching was done. Shrub density and height were higher in areas influenced by human impacts and herbivory. *C.mopane* was the dominant shrub and mainly influenced by herbivory and humans. The caterpillars of the emperor moth, *Imbrasia belina* fed on the leaves hence the signs of herbivory. The mature wood of *C.mopane* was unsustainably harvested for firewood evidenced by reduction of stems from mature trees and high number of shrubs of that same species.

The species diversity across the strata is from low to medium range (0.24493 to 1.7653) as ecosystems with H’ value of greater than 2 are regarded as medium to highly diverse (21). From the core to the boundary plant diversity increased and this is consistent with intermediate disturbance hypothesis which states that species diversity is maximised where there is intermediate disturbance, because species that thrive at both early and late successional stages can coexist (22).
6.2 Impacts of human activities and herbivory on woody vegetation composition and structure

Wood poaching at Sable Game Park has 42.88 % influence on the woody vegetation structure and composition. This is so because the fast booming of Mbizo residential area has resulted to people unsustainably harvesting wood for the purposes of firewood as some houses are still new with no electricity connected while others cannot afford to buy electricity using the prepaid electricity meters that were introduced in 2013 in all urban households.

Study results indicate that there is a gradient in tree cutting from the plots that were close to the park boundary to the plots at the core of the park. Tree cutting is more intense at the park boundary because law enforcement effort at the boundary is minimal thus there is quick access and exist from the park without the risk of being caught. Study at Mukuvisi woodlands indicated the same findings (2). Intense tree cutting is indicated by high shrub density because wood poachers prefer mature trees for their activities thus few trees reach maturity. However, there was also evidence of tree cutting at the core of the park. This might be due to that at the core there is high density of mature trees which are preferred by poachers. Speculations were made on that this might be due to less law enforcement within the park and preferable types of trees found at the core. Cutting down trees influenced woody vegetation structure and composition by reducing the number of stems desired and affected species size. The density of desired species by poachers that include *C.mopane, D.cinerea, J.globiflora and B.spiciformis* is being reduced. Previous studies indicate that these Miombo species are preferred because of their hard wood type which makes them best suitable for poles, construction, carpentry and fuel (23 and 24). The results obtained from Sable Game Park are consistent with these studies as they have also indicated that the same species are selected in making canoes and many other functions.

Previous studies have indicated that fire is the main agent shaping the savannah ecosystem (25 and 26). Results at Sable Game Park indicate high fire frequency at the boundary than the rest of the park. The fires at the boundary are not management fires but are started by poachers with the intention of burning for road clearing and increasing visibility from rangers. This is indicated by high shrub density and tall trees. Tree height in areas affected by fire was high in plots dominated by *Brachystegia boehmii* because it has a tough and strong bark that can resist fire (27) unlike *B.spiciformis* and *J.globiflora* that are not durable. Burnt sites have relatively taller woody plants than unburnt sites due to differences in woody species (28).

However, (29 and 30), found out that fire damage is negatively correlated to tree size (tree height and basal area). They state that woody vegetation affected by fire is transformed into a lower woodland community interspersed with a low density of large tress but high density of short trees. This was indicated by high shrub density in areas dominated by *J.globiflora* and *B.spiciformis*. This is so because repeated top kill makes the woody plants susceptible to the fire trap which prevents recruitment into adult size classes.

Herbivory had a low influence on the woody vegetation structure and composition at Sable Game Park. As observed by the researchers, there are only few animals left in the park as most of the animals were poached between the period of 2006 and 2008. The few that are left only have an influence on species like *C.Mopane; Burkea Africana; Monotes glaber* and *Acacia species*.

Fire damage and wood poaching have damaged the ecosystem resulting in the loss of biological diversity. Landscapes deprived of their natural vegetation cover lose aesthetic value and are prone to soil erosion which negatively impacts on the environment in general. Cases of environmental degradation are reflected by numerous patches of denuded woodland and desertified landscapes which are vulnerable to soil erosion. There is need to address these issues so as to protect the park’s resources from extinction.
CONCLUSION

Sable Game Park has a number of woody species also made up of high number of shrub species. This satisfies the alternative hypothesis which states that there is a significant difference in composition and structure of woody vegetation across Sable Game Park. However, human pressures on the majority of the species are represented by wood poaching and bush fires which are considered as an ecological and an environmental problem contributing to the degradation of vegetation at Sable Game Park. Thus the alternative hypothesis which states that human activity and herbivory have an impact on the woody structure and composition across Sable Game Park was accepted. The present study noted species density and diversity is over-graded due to anthropogenic pressure and lack of law enforcement and monitoring in the Park since its creation.

RECOMMENDATIONS

The majority of Peri-urban parks are not regulated by a specific legislation, which defines characteristics, management roles and responsibilities. Instead, they tend to be managed by a range of instruments connected to town planning and a range of sector policies therefore put them at risk of being exploited (31). Government’s policy do not make any specific mention of urban woodlands and the need to create, protect and conserve them. However, the policy does specify on the management and conservation of forests and woodlands in the country. This can be taken advantage of from the policy point of view to protect and conserve peri-urban parks (9).

There is need to provide for, nurture and restore the aesthetic value of not only Sable Game Park but other peri-urban parks in the country and region as a whole through resuscitating by afforestation of rarest and desired species and maintain a viable population size. This will also save Sable Game Park from destruction, extinction of some species and to maintain a viable population size of wildlife. The management and preservation systems including local population and successful restoration requires integration from local communities, ecologists, various disciplines and stakeholders in natural resource protection that peri-urban parks’ interests should be considered in development planning.

Moreover, considerations for small herbivores species re-introduction in Sable Game Park should consider the variations in woody vegetation structure and composition across the park. There will also be a need to assess the herbaceous plants at Sable Game Park.

We are grateful to the Sebakwe Conservation and Education Centre (SCEC) for supporting this study.
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A STRATEGY TO IMPROVE UTILISATION OF SMS-BASED MARKET INFORMATION SYSTEM BY SMALLHOLDER FARMERS IN ZIMBABWE: CASE OF MBARE MUSIKA

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ABSTRACT

Regardless of existence of bargaining power by farmers’ associations and high mobile penetration rates of 95% in Zimbabwe, Mbare Musika smallholder farmers experience unfair market conditions due to market information asymmetry. Marketing management information systems (MIS) such as short messaging services (SMS) are gaining momentum in alleviating this asymmetry. This study sought to identify the nature of SMS and factors affecting utilization of the SMS; and to establish an SMS market information utilisation strategy for smallholder farmers. Five interviews and a descriptive survey of 400 conveniently sampled smallholder farmers were conducted and a 64% response rate recorded. Mbare Musika farmers get general market prices and inaccurate weather information. SMS is lowly utilised due to farmers’ circumstances; usefulness and nature of SMS; availability of mobile devices and characteristics of the technology such as reliability and compatibility. This study proposes a strategy where a centralised database links farmers, markets and mobile operators.

Keywords: Strategy, Technology, Smallholder farmers, marketing management information systems
INTRODUCTION

Smallholder farmers require significant amount of agricultural and market information in order to remain competitive and profitable on the market (Gurmu, 2014). Unfortunately, Langat, et al. (2016) noted that developing countries have not yet provided access for its citizens to such information. Information systems are considered critical to this end. Furthermore, mobile penetration rates in developing countries such as Zimbabwe is encouraging and is considered critical to economic development and provision of information to citizens (Nyangani, 2017). This paper attempts to explore impact of mobile information systems on market decisions of smallholder farmers at Mbare Musika for purpose of informing strategies to improve utilisation of such technologies by farmers. In exploring these, the paper proffers the research objectives, background to the research problem, discusses the importance of the study and provides snapshot of previous studies. It also gives the methods adopted and budgetary and time requirements of the research.

BACKGROUND AND CONTEXT

Agriculture is globally considered a key sector of the economy (Monyau & Bandara, 2017). For instance, in India agriculture accounts for 58.5% of the country’s employment and in Zimbabwe it accounts for 11 to 14% of the gross domestic product, 45% of the exports and 60% of raw materials for the manufacturing sector and employs 70% of the active population in the country (Chifamba, 2017). Interestingly, in Zimbabwe majority of the farmers are smallholder usually referred to as peasant or communal farmers. According to Togarepi (2016) smallholder farmers constitute 70% of the farming community with majority located in rural areas and infertile lands. Their produce is mainly for consumption but usually sale some for income generation and survival. Maiyaki (2010) reports that small scale farmers produce horticultural and other produce for sale mainly to informal markets in town. Togarepi (2016) argues that majority of these farmers face challenges in marketing their products that include high transport costs, unpredictable market prices and lack of facilities to store their fresh produce. According to Chifamba (2017) smallholder farmers sell their produce at informal markets such as Mbare Musika where market conditions are highly imperfect and competitive. There is asymmetry of market information that usually disadvantages the farmers. Massey, et al. (2001) suggest that provision of proper market information may help farmers make market decisions that help them avert apparent losses. Communication technologies such as radio and mobile phones have been considered pertinent to this end (Gurmu, 2014).

Mobile communication technologies are pervasive and increasingly being accepted and used by majority of citizens across the globe. Langat, et al. (2016) report that mobile technologies are ubiquitous and have made most disadvantage people especially in the rural areas abreast with current information. The penetration rates of mobile technologies have been fascinating especially in developing countries. According to Nyangani (2017), Zimbabwe’s mobile penetrate rate is at 95% indicating that almost all Zimbabweans own at least a cellphone. Hence, citizens communicate using short messaging services (SMS), instant chats and phone calls among others (Verclas & Mechael, 2008). Mobile telecommunications companies such as Econet and agricultural marketing agencies have adopted use of SMS to convey important agricultural and market information that include rain and temperature changes, market price changes and location of markets (Masuka, et al., 2016). Gurmu (2014) argues that such communication can enhance effectiveness and efficiency of smallholder farmers’ decisions. Unfortunately, Irick (2008) laments lack of knowledge of how to design these mobile technologies so as to enhance market decisions of farmers. Furthermore, studies have
overlooked on how to effectively measure the impact of these mobile technologies on farmers’ market decisions. Gebauer, et al. (2005) concur that regardless of the challenges of mobile communication systems, their proper use may propel livelihoods of farmers and improve the quality of their market decisions.

Mbare Musika is one of the most active farm markets in Zimbabwe where smallholder farmers across the country converge with traders. According to Chifamba (2017) Mbare Musika was started in 1907 during the colonial era as market for the smallholder black farmers. It has 200 stalls and 2000 traders (farmers). The market is characterised by a hive of middlemen who capitalise on information asymmetry. The smallholder farmers have attempted to avert this by forming associations. However, information asymmetry still remains as most associations have no capacity to provide the farmer with all the relevant, timely and specific market information required by the farmer. Furthermore, Mapakame (2014) concedes that there are no proper studies and researches to inform smallholder farmers on market issues such as price variations, logistical and storage facility challenges. This has resulted in price alternating between low and high prices stimulating alternating overproduction and underproduction. Stiff competition and lack of information has hurt the smallholder farmers’ value chain system (Mapakame, 2014).

PROBLEM STATEMENT

Regardless of high mobile penetration rates of 95% in Zimbabwe (Nyangani, 2017) and protection from farmers’ associations whom they rely on for information, smallholder farmers experience market uncertainties and price fluctuations due to alternating overproduction and underproduction (Chifamba, 2017). Smallholder farmers complain of unfair prices at Mbare Musika and high costs of distribution coupled by unfair practices of intermediaries who capitalise on their lack of proper market information (Mapakame, 2014). If the situation is unabated, Chifamba (2017) reports that smallholder farmers will continue to be poor, ineffective and inefficient in their businesses. Questions remain as to what are the underlying factors that affect utilisation of SMS and how can that utilisation be improved for smallholder farmers.

OBJECTIVES

This study is premised on intention to:

- Identify the nature of SMS received and used by smallholder farmers at Mbare Musika;
- Determine factors that affect the utilization of SMS by smallholder farmers; and
- Propose SMS market information utilisation strategy for the smallholder farmers.

THEORETICAL FRAMEWORK: TASK-TECHNOLOGY FIT MODEL

This study was guided by the task-technology fit (TTF) model. TTF defines the fit as the appropriateness of an individual’s abilities and technology used to the task requirements in order to improve individual performance. Condition for performance is anchored on utilisation of the technology and fit between the tasks and technology. It is proffered that reliance on one without the other will not improve performance. For instance increasing amount of mobile phones for smallholder farmers as is the case in Zimbabwe will not necessarily improve the farmers’ decision making performance. It is needed that a fit and compatibility between the mobile phones and farmers’ decision making tasks established. Utilisation of the technology is governed by conventional adoption models.
such as technology acceptance model (TAM) which states that use of technology is determined by its usefulness, ease of use and beliefs of the farmers.

Understanding emerging communication technologies has taken a biased approach with majority of such studies seeking to understand the adoption of the technologies (Dishaw & Strong, 1999). This has resulted in an avalanche of developments and growth of technology adoption theories such as technology acceptance model, theory of reasoned action, diffusion of innovation and unified theory of acceptance and use of technology among others. Interestingly, Irick (2008) laments that majority of these have not addressed the suitability of technologies in addressing the needs and expectations of users. Gebauer, et al. (2005) argue that a lot of researches seem to marginalise the impact of technology on individual’s performance. Interestingly, Goodhue (1997) introduced the task-technology fit (TTF) theory which seeks to explain the degree to which technology affects an individual’s performance.

![Task-to-performance chain model](source: Hoehle & Huff (2012, p. 135))
Goodhue (1997) states that TTF defines the fit as the appropriateness of an individual’s abilities and technology used to the task requirements in order to improve individual performance. Gebauer, et al. (2005) define technology in the terms of functionality and interface. Furthermore, technology is taken as the computer enabled systems such as mobile phones and the support services such as training and help lines. According to Goodhue (1997) tasks are the actions carried out by users in converting inputs to outputs. Condition for performance is anchored on utilisation of the technology and fit between the tasks and technology. It is proffered that reliance on one without the other will not improve performance. For instance increasing amount of mobile phones for smallholder farmers as is the case in Zimbabwe will not necessarily improve the farmers’ decision making performance. It is needed that a fit and compatibility between the mobile phones and farmers’ decision making tasks established. In this study, the TTF is considered as the technology-to-performance chain (TPC) model. Utilisation of the technology is governed by conventional adoption models such as technology acceptance model (TAM) which states that use of technology is determined by its usefulness, ease of use and beliefs of the farmers. Irick (2008) states that evaluation of the effectiveness and fit of technology is determined by the users’ assessment of the quality of communication connection, locatability, compatibility, training, timeliness and reliability of the technology.

METHODOLOGY

A phased mixed research approach guided by constructivist philosophy as employed in information systems was employed. Majority of studies as exemplified by researchers, Langat, Litondo, & Ntale (2016), have adopted a constructivist philosophy that expounds multiple realities as each smallholder farmer perceives market conditions and make decisions. Impact of communication technologies on market decision-making capacity of smallholder farmers is a variable that can be subjectively determined, as each farmer differently perceives the market conditions at Mbare Musika. This brings in a rich set of experiences into understanding issues affecting farmer’s decisions. According to Saunders, et al. (2016) constructivism provides deeper exploration of issues and brings to fore some salient rich information that might otherwise be difficult to glean using objective means such as experiments. Though there are number of study designs that include experiments, surveys and ethnographies, this research adopted a case study as expounded by (Hartley, 2004; Yin, 2014). Reducing the discussion of impact of mobile communication technology to Mbare Musika averted the inclusion of a wide range of data sources that would otherwise cloud the discussions. Mbare Musika is hub for both local and international sellers which gives it a unique flair compared to other markets such as Machipisa. It receives some farm produce such as potatoes, watermelons and oranges from South Africa. According to Cooper & Schindler (2008) a case study provides unique and detailed information about a concept. This helps researchers to delve into intricacies of a situation as opposed to large scale surveys. The case study design was cheaper and easier to design. Furthermore, it was amenable to study of social units such as smallholder farmers in their context. Had the study included all farmers and other slightly dissimilar markets like Machipisa which is entirely made of local players, more time than given by the University would have been required and conclusions made would be highly distorted.

Bryman (2008) propounds that contemporary researches are biased towards use of mixed methods in their various forms. Mixed methods provide deeper and broader understanding of issues. A sequential mixed method was used in which the data collection was split into two: first phase was concerned with quantitative approach and the second stage concentrated on qualitative description of the numerics and statistics in phase one. According to Punch (2005) adoption of quantitative and numeric
variables reduces ambiguity in understanding some concepts. Treating the link between communication technologies and effectiveness of market decisions by smallholder farmers as objective and numerical variable enabled easy statistical analysis to be meted (Neuman, 2006). Strategies, nature of market information, Ecofarmer SMS technology and its characteristics were structured and observed using a structured questionnaire with pre-formatted questions adopted from previous studies (Tollens, 2006; Irick, 2008; Freeman & Mubichi, 2017). A five-point Likert scale was used to observe the perceptions of farmers as shown in the structured questionnaire in Appendix II. The views and perceptions of farmers were measured on a scale from 1 = strongly agree, 2 = agree; 3 = not sure; 4 = disagree and 5 = strongly disagree.

However, qualitative method was also used in the second phase where an interview directed by the interview guide in Appendix III. The questions are significantly worded and the responses of farmers recorded as intense textual descriptions that defy a numerical meaning. Farmers and the researcher construed meaning from the words expressed. The researcher engaged her personal ingenuity to derive meaning from the field notes of the interviews without resorting to some mathematical calculations. Quality of the responses and the interview process were critical to proffer meaning to the given farmer responses. According to Teddlie & Yu (2007) superimposing qualitative descriptions on numerical information provides richer set of meaning and deeper meaning to research results.

The research was carried out at Mbare Musika in Harare, which is considered one of the largest informal agricultural market in the country. Mbare is a hub to both local and international suppliers especially from South Africa of fresh produce. Given its centrality to agricultural markets in the country, Mbare Musika is representative of many such markets in the country and therefore provided data that may be extrapolated to other such similar markets.

Target population was the total number of smallholder farmers from which data was collected (Yount, 2006). In this, case the target were those farmers that come to sell their produce at Mbare Musika market. Effective strategies can be developed from affected people as opposed to distant prescriptions (Levy & Fukuyama, 2017). Attempting to make conclusions from mere reviews of literature would have provided information which is detached from the context of Mbare Musika and therefore highly misrepresentative of issues affecting that market.

Sampling

According to Teddlie & Yu (2007) researchers should sample if the population is very large for effective data collection to be done. Though there are a number of sampling methods available for any study, this study used convenience sampling as echoed by Langat, et al. (2016). Convenience sampling was easier and cheaper to conduct. It did not require rigorous statistical precision as with simple random sampling. Conveniently selecting farmers as they conducted business in Mbare Musika helped to collect relevant data as opposed to probability sampling methods that would have risked the inclusion of untargeted respondents. Consented farmers who were physically present were included in the study reducing the chance of coercing farmers into participation.

Regardless of the sampling method used, Annum (2015) proffers that the number of members of the population selected into a sample need to be determined. Determining the number of smallholder farmers for the study was determined by using the simple sample size formula of Smith (2013). According to Smith (2013), the sample size can be calculated if the researcher estimates the sampling error tolerated, the confidence level and standard deviation. In this case the confidence level was taken as 95% which is widely used by many researchers and an allowed error of 5% was adopted.
Therefore sample size \( n = (Z\text{-score})^2 \times \text{Standard deviation} \times (1 - \text{standard deviation}) / (\text{margin of error})^2 \)

Sample size \( n \) was therefore \( = (1.96)^2 \times 0.5 (0.5) / (0.05)^2 = 384.16 \).

Round off, this gave 384 smallholder farmers.

However, Teddlie & Yu (2007) suggest that sample sizes should consider some space for non-return of survey questionnaires. In this case, the researcher took 400 smallholder farmers.

Data collection

Primary data was collected through structured survey questionnaires and semi-structured interviews while secondary data was gathered through extensive literature surveys. Literature reviews were conducted in order for the researcher to understand the landscape of of current state of knowledge about smallholder farmers and utilisation of SMS technology. It also provided some ground knowledge on strategy formulation and implementation. Survey questionnaires and guided interviews were used to collect data. The questionnaire had a list of questions with standard response formats refer to Appendix II. The questionnaire had section A to G with section A for instructions to respondents, and section B with demographic profiles such as age, experience and ownership of mobile phones. Section C to G corresponded to the study objectives. A five point Likert scale with 1 = strongly agree, 2 = agree, 3 = not sure, 4 = disagree and 5 = strongly disagree.

After the design of the questionnaire, the researcher sent to the supervisor and experts for fine-tuning and standardisation. The questionnaires were, together with invitations, given in person to farmers at Mbare Musika. Only farmers who voluntarily wished to participate were given the questionnaire to complete in less than 5 minutes by way of ticking responses of their choice. Responses from farmers were then collected in person by the researcher while those farmers who wished to complete at their spare time were allowed to send feedback through the researcher’s email address shown on the questionnaire. Such subjects were given two weeks to complete the survey. Reminders were send every week. The emailed feedbacks were printed and combined with the hard copies collected in person by the researcher. Each completed questionnaire was serialised and coded to avoid duplication and double counting. Survey questionnaires were easy to design and deploy. Furthermore, to reduce response failure rates, distribution of the questionnaires was done in person.

After the questionnaires, five interviews were held with manager of Ecofarmers, chairman of the Mbare farmers’ association and three conveniently selected farmers at Mbare. The number of interviews were determined by the saturation levels which in this case was five. Most participants involved such as leader of the farmers’ association were representative of all farmers and had greater knowledge of the issues involved. Therefore, their set of knowledge is integrative and thus easily saturated as compared to members who have diverse experiences and knowledge threads. The interviews were guided by the interview schedule shown in Appendix III. Though the guide is sequential, the order and exact wording of the questions delivered to farmers and Ecofarmer manager ensued as the interviews were evolving. This allowed a flexible and natural way of gathering data from farmers. Attempt to strictly follow the interview schedule would have sometimes involved repetition of questions and monotony that may irritate interviewees. Feedback from the interviews was written as field notes. Respondents objected to audio-video recording of the entire interview proceedings on personal reasons most interviewees objected to reveal.

Data quality control
The reliability of the data was ensured through use of standardised five-point Likert scales and adoption of questions from previous studies by (Langat, Litondo, & Ntale, 2016). Furthermore, expert judgement by the supervisor helped to fine tune the meaning and scope of the survey items. That reduced ambiguity and brought to fore clear and repeatable understanding of questions.

Validity of the research was ensured through a number of strategies. First, the research objectives guided major direction point such as reviewing literature, data presentation and analysis, and also informed the conclusions that were made in this study. This brought a continuous thread of reasoning throughout the study. Furthermore, interviews that allowed interviewees to provide their own lived experience drew on gathering real life situations in their natural setting without undue researcher influence. This increased validity of the study.

Data analysis

The collected and coded data were captured into statistical package for social scientists (SPSS) version 20. SPSS enabled statistical analysis to be done on data. First, demographic and response rate information were analysed using pie charts and summary frequency tables. Furthermore, data pertaining to research objectives were analysed mainly through use of bar graphs, factor analysis and correlational and Chi-square association analysis. Mean score for some individual questions were done - such statistics are easy to understand. Furthermore, visual display provided pictorial presentation of data that is easy to understand and interpret. Factor analysis and correlational analysis provided some hidden patterns in data that propelled better understanding of meaning of responses from subjects.

Data collected as field notes from interviews were analysed using thematic analysis. The rich textual and descriptive field notes obtained in the interviews. Fields notes were read and re-read in order to build major themes that could efficiently describe the views of the farmers and Ecofarmer manager. According to (Alholjailan, 2012) (Javadi & Zarea, 2016) there are different ways of conducting thematic analysis which thrown some confusion in the academic field. However, Braun & Clarke (2006) suggested a 6-step framework which has arguably been the most influential approach over the decades. It is much clearer and usable than its competitors. The goal of the thematic analysis being to find interesting and relevant themes. However, Clarke & Braun (2013) suggest that researchers must avoid common pitfalls of adopting research questions as the themes. Latent themes must be filtered away from the seemingly semantic themes usually apparent in the research questionnaires. In this study the researcher had to follow the 6-steps by Braun & Clarke (2006). Guided by the research questions, the study adopted the theoretical (top-down) thematic analysis and opposed to bottom-up (inductive approach) in which the research questions in Appendix III were used to identify the codes upon which the themes were driven. Part of the codes (brief description of the interviewee transcription) included codes such as ‘SMS should show wider information that include geolocation, seasonal weather and market forecasts’ and ‘small screens of most available phones do not display complete information.’ The researcher first familiarised with the information from the interviewees and made transcriptions of the field notes from which manual deductions of codes was done. The codes were then grouped into common groups. Each group was given a meaningful theme as guided and driven by the theoretical framework used in this study. This resulted in major themes such as strategies (action plans); characteristics of SMS technology and the necessary mobile phones; and farmers’ circumstances and characteristics. Codes such as reliability, easy of use and always connected were related to the theme of characteristics of the technology. Once all the themes were identified and defined, a review of the themes was done to fine tune them with regard to the research
problem and objectives of the study. Finally the results were reported as indicated in the results section of the paper.

Ethical considerations

Ethics being the right and wrong values of any study, this researcher first sought permission to study from the University in order to comply with the requirements of the Institution. Upon data collection, consent was sought from respondents to avoid coercing participants into the study. In addition, the researcher attempted to explain the purpose and nature of the study to respondents to protect respondents from information prejudice. Responses from subjects were treated as confidential and private to protect their right to privacy.

RESULTS

Responses from questionnaires were captured on SPSS and statistical analysis done on the data. Mean scores and summary frequencies were used to identify possible strategies to improve utilisation of SMS technologies. Bar graphs and percentages were used to describe nature of SMS market information for smallholder farmers at Mbare Musika. Mean scores and frequencies were also used to understand factors that affect utilisation of SMS technology by smallholder farmers at Mbare. Confirmatory factor analysis was also done to understand the major factors that affect utilisation of SMS technology as predicted by the task-performance theory. Mean scores and frequencies were also used for understanding the characteristics of SMS mobile technology that affect smallholder farmers’ decisions. Presenting data on graphs and summary statistics provides visual displays that are easier to interpret and which extract hidden patterns of data as enunciated by Gray (2013).

Response rate and demographic issues

Four hundred questionnaires were distributed to smallholder farmers at Mbare Musika for a period of three weeks and 256 were returned representing a response rate of 64%. However, 44 of the returned questionnaires were unusable due to a number of factors. Twenty-six of these unusable questionnaires were incomplete and 18 of them were spoiled. The gross errors on these questionnaires led to these questionnaires being excluded from the main analysis in section 4.4. Response rate obtained in this study was well above those prior studies by Cotlman (2007) who got 32% and Coltman, Devinney, & Midgley (2011) who obtained 21%. Interestingly, these prior studies focused on executives of financial institutions that included commercial banks and insurance companies. However, this study focused on all employee ranks including the executives. Furthermore, the contexts of these studies are different. SIRDC is a research oriented institute that better understands research issues. This could have led to higher response rates. In addition, the researcher deployed a multiple distribution of questionnaires (face-to-face and email) which promoted flexible options for responses. Weekly follow-ups also encouraged respondents to participate.

Excluding the 44 spoiled questionnaires, the analysis then used 256 completed questionnaires. The demographic features of the respondents were recorded as shown in Table 14 below.
Table 14: Gender, age, qualification, experience and frequency of use of SMS

<table>
<thead>
<tr>
<th>Demography</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>127</td>
<td>60</td>
</tr>
<tr>
<td>Female</td>
<td>85</td>
<td>40</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>212</td>
<td>100</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18 years and below</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>19-39</td>
<td>137</td>
<td>65</td>
</tr>
<tr>
<td>40-60</td>
<td>66</td>
<td>31</td>
</tr>
<tr>
<td>Above 60 years</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>212</td>
<td>100</td>
</tr>
<tr>
<td><strong>Qualification</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diploma and below</td>
<td>84</td>
<td>40</td>
</tr>
<tr>
<td>Undergraduate degree</td>
<td>59</td>
<td>28</td>
</tr>
<tr>
<td>Masters and above</td>
<td>60</td>
<td>28</td>
</tr>
<tr>
<td>Others</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>212</td>
<td>100</td>
</tr>
<tr>
<td><strong>Experience</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 to below 10</td>
<td>113</td>
<td>53</td>
</tr>
<tr>
<td>10 to below 15</td>
<td>42</td>
<td>20</td>
</tr>
<tr>
<td>15 years and above</td>
<td>57</td>
<td>27</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>212</td>
<td>100</td>
</tr>
<tr>
<td><strong>Frequency of use of SMS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>More frequently</td>
<td>93</td>
<td>44</td>
</tr>
<tr>
<td>Frequently</td>
<td>70</td>
<td>33</td>
</tr>
<tr>
<td>Less frequently</td>
<td>48</td>
<td>23</td>
</tr>
<tr>
<td>Never or stopped using SMS</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>212</td>
<td>100</td>
</tr>
</tbody>
</table>

The surveyed indicated a relatively comparable number of females (40%) to males (60%). However, the study shows that more males are smallholder farmers than females. Furthermore, a significant percent of theses (95%) are young people aged below 60 years. Only a negligible 4% were older people above 60 years. Fifty-six percent of the respondents are educated people with at least an undergraduate degree. This shows that a large number of unemployed youths are engaged in smallholder farming. A significant number of respondents (75%) have at least some significant experience in using SMS for farming decisions. They have 15 years and less experience. Twenty-seven percent stated that they have greater than 15 years using SMS for farming decisions. This was reflected by 78% of the respondents reporting that they at least frequently use SMS to make market decisions at Mbare Musika. Only a meagre 1% of the farmers alluded to having abandoned the use of SMS for market decisions.

In summary, Mbare Musika is frequented by young, educated and experienced smallholder farmers fairly distributed between males and females who use SMS for making majority of their market decisions. According to Goodhue (1997) and Gebauer, et al. (2005) abilities of a person may stimulate one to adopt and use some technology. It is the fit between individual features such as young age, educational qualifications and experience that may predict the adoption of SMS for market decision making by farmers at Mbare Musika.

Reliability analysis

Reliability being the consistency and internal coherence of a research instrument. This study used the Cronbach’s alpha test which is widely used for that purpose as shown in Table 15. Reliability was
tested for the research items as per the research questionnaire in appendix II (excluding demographic items). A reliability value of 0.745 was recorded showing a high degree of internal consistency of the questionnaire items. According to Reynaldo (1999) an alpha value above 0.7 highlights satisfactory level of reliability of the measurement scales. This suggests that the questionnaire items have relatively high internal consistency.

Table 15: Reliability of research items

<table>
<thead>
<tr>
<th>Item</th>
<th>Cronbach's Alpha</th>
<th>N of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>0.745</td>
<td>21</td>
</tr>
<tr>
<td>Characteristics of SMS information</td>
<td>0.734</td>
<td>6</td>
</tr>
<tr>
<td>Factors affecting utilization</td>
<td>0.714</td>
<td>6</td>
</tr>
<tr>
<td>Characteristics of SMS technology</td>
<td>0.723</td>
<td>4</td>
</tr>
<tr>
<td>Strategies</td>
<td>0.810</td>
<td>5</td>
</tr>
</tbody>
</table>

MAIN RESULTS

The following sections (4.3.1 to 4.3.5) highlight the results as per the research objective. The data was analysed in the form of frequency tables and bar graphs obtained from SPSS version 20 analytics. Factor analysis for main elements of customer relationship management was also done. Mean score was used to calculate the significance of the overall scores for each research questionnaire item. Weighted mean is calculated by first weighting the scale where weight is range of Likert scale divided by maximum of the scale. In this study, a five point Likert scale was used and therefore the range is 5 - 1 = 4 and the maximum value is 5. Therefore, each of the Likert scale is weighted with 4/5 = 0.80. Thus each scale value is adjusted with 0.80 to get 1 = 1.80; 2 = 1.80 + 0.80 = 2.60; 3 = 2.60 + 0.80 = 3.40; 4 = 3.40 + 0.80 = 4.20 and 5 = 5. Thus mean score calculations use the weighted equivalents for each scale value. For instance considering encouragement of farmers element in Table 4.3, the mean score is calculated as follows: 9 persons who strongly disagreed (9x1.80 = 16.2), 4 persons disagreed (4 x 2.60 = 10.4); 28 persons were not sure (28 x 3.40 = 95.2); 25 persons agreed (25 x 4.20 = 105) and 34 persons strongly agreed (34 x 5 = 170). The total score is 396.8. The total is divided by the total percentage which is 100 as shown in the Table 4.3. therefore, the mean score becomes 3.97 which relates to a Likert scale of 4 to the nearest. Scale of 4 means agree. Thus majority of the respondents agreed that encouragement of farmers improves uptake and effective use of SMS systems.

The nature of SMS received and used by smallholder farmers at Mbare Musika

In this section the respondents and interviewees were asked to provide information on the characteristics of the SMS market information that they receive, characteristics of the technology used for SMS and characteristics of the individual farmers who use Mbare Musika as their market. The responses from surveys and themes drawn from the interview transcripts as shown in Appendix II and III respectively helped to identify the nature of SMS received and used by the smallholder farmers.

The results indicated that 51% of the respondents agreed that they regularly receive SMS alerts while 35% of them were not sure and a meagre 14% disagreed. At the same time, 57% of the respondents
agreed that the current SMS alerts only provide prices for market products and a meagre 10% disagreed while 33% of them were not sure. Fifty-six percent of the respondents disagreed that SMS alerts provide demand information. A relatively large number, 41% agreed that SMS provide demand data and a meagre 3% were not sure.

Furthermore, as shown in Figure 2, 68% of the respondents disagreed that they receive timely information while 24% agreed with 8% not sure. Furthermore, 61% of the respondents disagreed that they receive relevant information and 23% were neutral while 16% agreed that they get information that addresses their market decision making processes. In addition, 80% of the farmers stated that the information they receive through SMS does not meet their marketing and farming decisions. Only a negligible number, 3% were uncertain while 17% agreed that they get information necessary for decision making. Interviewees also indicated that most of the information which farmers get through SMS is generic and delayed such that it is less effective in influencing their marketing decisions. One respondent had this to say, “The SMS information comes past the right time. For instance, the information on growing potatoes came to me when I had already passed the farming season.” With regard to relevance of the received information, the farmers lamented that they do not get the much needed information on diseases, weather forecasts and market demand statistics.

Surveyed literature Dishaw & Strong (1999) and Irick (2008) concur with research findings in this study. Gebauer, et al. (2005) and Irick (2008) argue that any technology such as SMS information management system should be characterised such as to fit the nature of the task at hand. SMS alerts should provide timely and relevant information. One of the interviewees lamented that current SMS systems provide information which is inaccurate to some specific times and areas. For instance one of the respondent said, “most of the SMS data is received when the farmers would have passed the stage of production.”

Surveyed prior studies by Gurmu (2014) and Togarepi (2016) concur with this study that SMS technology is skewed and not holistic in addressing issues affecting farmers’ marketing decisions. This has caused majority of smallholder farmers not to utilise the technology.
In addition, the farmers were asked to identify the characteristics of the SMS technology itself with respect to issues such as reliability, compatibility and availability. Responses from the surveys are recorded in Table 3. In this section, respondents were asked to assess the characteristics of the SMS technology. According to Goodhue (1997) characteristics of technology and the users should fit the task to be implemented. Responses of the survey were recorded in Table

Table 16: Characteristic of mobile SMS technologies that affect smallholder farmers’ decisions

<table>
<thead>
<tr>
<th>Characteristics of mobile SMS</th>
<th>Percentage frequency</th>
<th>Mean</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Always connected</td>
<td>9</td>
<td>4.02</td>
<td>Agree</td>
</tr>
<tr>
<td>Compatible with needs of farmers</td>
<td>51</td>
<td>2.40</td>
<td>Disagree</td>
</tr>
<tr>
<td>SMS is reliable</td>
<td>5</td>
<td>4.01</td>
<td>Agree</td>
</tr>
<tr>
<td>SMS are available</td>
<td>4</td>
<td>3.92</td>
<td>Agree</td>
</tr>
</tbody>
</table>

Seventy-eight percent of the respondents agreed (mean score of 4.02) that SMS is always connected while 79% (mean score of 4.01) showed that SMS technology is reliable. It was found that 79% (mean score of 3.92) agreed that availability of SMS stimulates growth of the use of SMS for marketing. However, 69% of the respondents (mean score of 2.40) disagreed that current SMS are compatible with the needs of farmers. This was echoed by responses from interviews. One of the participants reported that current SMS provides inaccurate information and does not allow for feedback which most farmers would prefer.

According to Nincevic, Krajnovic, & Bosna (2016) require no data connection which makes SMS affordable. Furthermore, Shang, Chen, & Chen (2007) reiterate that short message services (SMS) increase smallholder farmer’s yield by 11.5%. This clearly shows that mobile SMS platforms have quite significant impact on marketing and production decision of farmers. According to Musungwini (2016) reports that the mobile penetration rate is above 106% which suggest the ubiquity of SMS technology. However, Strom & Vendel (2012) contradict observations from this study by arguing that regardless of the higher mobile penetration rates the adoption of SMS marketing information system is deplorably low. But the authors quickly mention that delivery of market information through extensive workers is constraining and disappointing.

Factor Analysis

Factor analysis was carried out to understand how various elements of SMS that stimulate market decision making of smallholder farmers. SPSS version 20 was used and principal component analysis was used as shown in Table 17. As shown in Table 17, a number of components were extracted. Four factors were confirmed by the confirmatory factor analysis. Using the task-to-performance theory, it could be discovered that the four components are: technology characteristics, individual characteristics and utilisation determinants (driven by adoption theories such as TAM).
Table 17: Factor analysis of nature of SMS

<table>
<thead>
<tr>
<th>Component Matrix*</th>
<th>Component 1</th>
<th>Component 2</th>
<th>Component 3</th>
<th>Component 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMS alerts</td>
<td>-0.386</td>
<td>0.043</td>
<td>0.731</td>
<td>3.85</td>
</tr>
<tr>
<td>SMS offer prices</td>
<td>0.721</td>
<td>0.212</td>
<td>0.181</td>
<td>0.438</td>
</tr>
<tr>
<td>SMS show demand statistics</td>
<td>0.559</td>
<td>0.551</td>
<td>0.384</td>
<td>-0.406</td>
</tr>
<tr>
<td>SMS is timely</td>
<td>0.640</td>
<td>0.463</td>
<td>0.205</td>
<td>0.362</td>
</tr>
<tr>
<td>SMS offer relevant information</td>
<td>0.559</td>
<td>0.541</td>
<td>-0.270</td>
<td>-0.026</td>
</tr>
<tr>
<td>SMS meet farmers’ decision making needs</td>
<td>0.171</td>
<td>0.813</td>
<td>0.288</td>
<td>-1.55</td>
</tr>
<tr>
<td>Expected consequence</td>
<td>0.319</td>
<td>0.785</td>
<td>0.198</td>
<td>-0.145</td>
</tr>
<tr>
<td>Affection</td>
<td>0.009</td>
<td>-0.362</td>
<td>0.267</td>
<td>0.844</td>
</tr>
<tr>
<td>Influence from other farmers</td>
<td>0.470</td>
<td>0.559</td>
<td>0.549</td>
<td>-0.026</td>
</tr>
<tr>
<td>Cost of SMS</td>
<td>0.006</td>
<td>0.878</td>
<td>0.153</td>
<td>-1.191</td>
</tr>
<tr>
<td>Experience of use of SMS</td>
<td>0.537</td>
<td>-0.105</td>
<td>-0.340</td>
<td>0.704</td>
</tr>
<tr>
<td>Availability of mobile devices</td>
<td>-0.282</td>
<td>0.904</td>
<td>-0.069</td>
<td>0.261</td>
</tr>
<tr>
<td>SMS is always connected</td>
<td>0.823</td>
<td>0.441</td>
<td>0.281</td>
<td>-1.50</td>
</tr>
<tr>
<td>SMS compatible with needs</td>
<td>0.681</td>
<td>0.306</td>
<td>-0.391</td>
<td>0.475</td>
</tr>
<tr>
<td>SMS is reliable</td>
<td>0.619</td>
<td>0.237</td>
<td>0.133</td>
<td>-0.566</td>
</tr>
<tr>
<td>SMS is available</td>
<td>-0.108</td>
<td>0.272</td>
<td>-0.831</td>
<td>0.374</td>
</tr>
</tbody>
</table>

Extraction Method: Principal Component Analysis.

a. 4 components extracted.

As shown on Table 17, there are four (4) underlying factors that can explain the variation in the adoption of SMS technology. Component refers to the characteristics of the technology such as its compatibility to the needs, reliability, timeliness, and provision of relevant information. Component 2, refers to task characteristics that include ability to meet the decision making requirements. The cost of the SMS is also determining its ability to meet the information requirements of smallholder farmers. Component 3 denotes the individual features predicted by their affection to receive SMS for decision-making. Component 4 relates to the utilisation phenomenon as predicted by the task-to-performance theory. According to Goodhue (1997) the four components should link such that individual characteristics coupled by enabling technology should enable achievement of the task. However, other factors such as influence from other farmers stimulate adoption and performance outcomes. This study confirmed that TTF is predicted by four components.

Factors that affect the utilization of SMS by smallholder farmers

In this section, respondents were asked to identify some common factors that determine the utilisation of SMS systems for farmer’s market decision making processes. The responses are recorded in Table 18.
Table 18: Factors that determine utilisation of SMS

<table>
<thead>
<tr>
<th>Factor</th>
<th>Percentage frequency</th>
<th>Standard deviation</th>
<th>Mean</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected consequences</td>
<td>9 10 5 15 59</td>
<td>1.24</td>
<td>4.17</td>
<td>Agree</td>
</tr>
<tr>
<td>Affection for SMS</td>
<td>22 5 7 40 26</td>
<td>.717</td>
<td>3.77</td>
<td>Agree</td>
</tr>
<tr>
<td>Influence from other farmers</td>
<td>0 7 15 73 5</td>
<td>1.205</td>
<td>3.75</td>
<td>Agree</td>
</tr>
<tr>
<td>Cost of the SMS system</td>
<td>1 18 3 17 62</td>
<td>.953</td>
<td>4.01</td>
<td>Agree</td>
</tr>
<tr>
<td>Experience</td>
<td>5 22 10 17 46</td>
<td>.743</td>
<td>4.04</td>
<td>Agree</td>
</tr>
<tr>
<td>Availability of the mobile devices</td>
<td>1 12 0 19 68</td>
<td>.961</td>
<td>3.59</td>
<td>Agree</td>
</tr>
</tbody>
</table>

Majority of respondents (74%) concurred that they utilise SMS based on its consequences such as improvement of the effectiveness of their decisions. SMS enable them to get market information that may help them reduce losses. A mean score of 4.12 was recorded reflecting an agreement that expected consequence of a piece of technology might explain utilisation pattern. Furthermore, a mean score of 3.77 was recorded for affection for SMS. This shows that smallholder farmers concurred that affection is important in determining utilisation levels. Influence from other farmers was recorded (mean score of 3.75) as important in stimulating utilisation of SMS by farmers. Furthermore, cost (mean score of 4.20), experience (mean score of 4.04) and availability of mobile devices (mean score of 3.59) were considered as important in determining the utilisation of SMS technology. Feedback from interviews showed that influence of other farmers is very important. One interviewee stated farmers need to encourage each other through exchange of information and experiences.

Strom & Vendel (2012) lament that regardless of the higher mobile penetration rates the adoption of SMS marketing information system is deplorably low. Chaitoh & Gyau (2016) then came to conclude that due to the constraints of traditional marketing and production methodologies, sub-Saharan has the highest incidence of poverty in the rural areas. Mutami (2015) suggests that improving smallholder farming can push up the livelihoods of about 70% of the population of the country. SMS systems impact positively on decision making and less costly to implement (Nyangani, 2017).

Proposed SMS market information utilisation strategy for the smallholder farmers

In this section respondents were asked to suggest some possible strategies to improve the uptake of SMS technologies for market decision making. Also interviewees provided some possible methodologies that can stimulate utilisation of SMS. The questionnaire responses are indicated in Table 19.
Table 19: Percentage frequency and mean scores of strategies to improve uptake of SMS

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Percentage frequency</th>
<th>Mean</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encourage farmers</td>
<td>9  4  28  25  34</td>
<td>3.97</td>
<td>Agree</td>
</tr>
<tr>
<td>Avail mobile devices to the farmers</td>
<td>4  0  34  9  53</td>
<td>4.26</td>
<td>Agree</td>
</tr>
<tr>
<td>Train farmers on the value of SMS</td>
<td>16  0  4  54  26</td>
<td>3.99</td>
<td>Agree</td>
</tr>
<tr>
<td>Provide relevant and timely information</td>
<td>0  27  9  30  34</td>
<td>3.97</td>
<td>Agree</td>
</tr>
<tr>
<td>Use other strategies not identified in this study</td>
<td>0  0  28  57  15</td>
<td>4.10</td>
<td>Agree</td>
</tr>
</tbody>
</table>

Where 5 = strongly agree, 4 = agree, 3 = not sure, 2= disagree, 1= strongly disagree

While 59% agreed that encouraging farmers may improve uptake of SMS, 28% were not sure and a negligible 13% disagreed. The mean score for the responses was 3.97 indicating that respondents concur that encouragement of farmers is important. One of the interviewees had this to say, “Promotion is required such that those farmers who use SMS frequently can get farm inputs and lure others.” Furthermore, 62% reported that availing of the necessary mobile devices determines the utilisation levels. However, a significant percent, 34% were not certain while only 4% disagreed. A mean score of 4.10 was recorded. Respondents were of the opinion that farmers should be trained on how to use SMS for the value addition in making market decisions. This was reflected by a mean score of 3.99 where 82% of the respondents agreed and 16% thought otherwise. One of the interviewees reported that farmers need to be educated on importance and value of SMS. Farmers require education that solve problems of disease control. Another interviewee stated that awareness programmes down to grassroots are required. Furthermore, interviewees reported that farmers might also need to share important information about the value of SMS technologies in enhancing market information transparency. In addition, 64% of the respondents reported that farmers need relevant and timely information and 27% disagreed. A mean score of 3.97 was recorded. Interestingly, the respondents felt that there are other strategies that can be adopted to improve uptake of SMS. A mean score of 4.11 was recorded indicating agreement among the farmers for adoption of such strategies. Interviewees highlighted that SMS information of area information as opposed to current generic data are needed. Such specific information will provide specific and accurate information for targeted smallholder farmers.

Findings from this study concur with prior studies. According to Gebauer, et al. (2005) majority of the poor decisions made by small scale farmers is influenced by lack of proper strategies. Gurmu (2014) and Chifamba (2017) propound that common strategies to reduce market information asymmetry include adoption of modern mobile technologies, availing communication systems to the farmers, provide timely data to farmers, store their perishable products in appropriate places and train the farmers of how information asymmetry can be reduced. Mobile handsets that are not linked to real-time market data will not improve the decision making matrix of smallholder farmers (Musungwini, 2016). In addition, Nincevic, Krajnovic, & Bosna (2016) and Freeman & Mubichi (2017) report that farmers need timely information that enable them to make informed decision on the market they can sell their products. Musungwini (2016) suggests that a central marketing information systems should be connected to mobile phones of farmers such that each farmers receives
real-time market information updates. Freeman & Mubichi (2017) suggest that SMS alerts can boost smallholder farming revenue by 11.5%. Tsokota & Rossouw (2014) suggest encouragement of the use of SMS-based payment systems that are predominantly mobile money payment systems such as Ecocash, OneWallet and Telecash in Zimbabwe. Arinloye et al. (2016) suggest that smallholder farmers need training in the use and application of SMS alerts in order to maximise their market decision making capabilities. Tsokota & Rossouw (2014) suggest a cocktail of measures to increase the use of ICTs such as SMS. Thus Tsokota & Rossouw (2014) suggest that users of ICT need to be trained on how to capitalise on such, require financial support to install necessary ICT infrastructure, and increase the quality and availability of services. Furthermore, the authors suggest that power outage that is common in Zimbabwe and even pronounced for rural and remote places where most smallholder farmers are situated require boost in power supplies. Mobile phones require electricity to power up. Electricity has to be made available to farmers in order to enhance adoption of SMS-based systems.

The proposed strategy

Based on the results from this study and strategy formulation approach suggested by Gcaza & Rossouw (2017) and Tsokota, von Solms, & van Greunen (2017), this study proposes a strategy to be adopted to help farmers improve their marketing decisions at Mbare Musika as shown in Figure 20. In this study, it is suggested that a diagnosis of the environment was done by empirically asking farmers on issues affecting their decisions and identifying the coherent actions to be taken by farmers and or farmers’ associations and mobile phone operators who are the main players in the SMS system.
Strategy implementation

This study does not intend to implement the proposed strategy but contend to suggest some implementation plan as shown in Figure 4.3 below. According to Gcaza & Rossouw (2017) and Tsokota et al. (2017) a plan of action that shows clear steps to be followed by specific stakeholders is needed to ensure that the envisaged strategy is transformed into reality and concrete results and outcomes. Particularly, Tsokota et al. (2017) propound that implementation of a strategy is one of the most critical aspects of strategy development. Required resources, human capital and materials should be specified so as to show how the strategy will be operationalised. In this study the key players responsible for implementing the strategy were identified as shown in Figure 4.2 who are the mobile operators and the farmers. This approach is also echoed by Horwath (2006) and Aurik, Fabel, & Jonk (2014) contend that strategy has to be conceived as clear steps and stages with well identified stakeholders and implementation steps. Tsokota et al. (2017) expound that implementation clarity is better defined diagramatically. This study took this approach which is clearer and rigorous.

Figure 20: Proposed strategy to improve smallholder farmers’ decision
As shown in Figure 21, developers have to design and develop the database incorporating geolocation facilities to enable to provide location specific information for farmers. Furthermore, the developers have to design an SMS server system integrated to the geolocation information and an analytical server that helps provide farmers’ profiling and analysis in order to understand their information needs. Thus the implementation project will be sequential at start where the central database has to be designed and implemented. Second stage is to market the SMS market system to farmers through the marketing team. Once this is completed, farmers are connected to the SMS system through their mobile phones and provide feedback into the central database which information is used for both farmer analysis by marketing team and database enhancement by the developers. Marketing team liaison with the developers to also improve the quality and functionality of the central database for better farmer experience and marketing decisions.

**Validity of the framework**

Tsokota et al. (2017) reiterates that the rigor exerted when designing a strategy ensures that its valid and relevant to ensure achievement of the intended goals. Interestingly, Gcaza & Rossouw (2017) and Tsokota et al. (2017) echo that clarity in the steps and single argument strand shown by steps that are coherent as shown in Figure 4.1 will ensure that intended goals remain aligned within the actions to be taken. Thus the rigorous process recommended by Tsokota et al. (2017) ensured that the proposed framework remains visible with the vision to improve farmers’ marketing decisions.

This study has shown the growing importance of marketing management information systems (MMIS) mostly mobile based. The marketing fraternity may understand the characteristics of the MMIS that may stimulate market response as driven from experience of the users as opposed to the current prescriptive approach as is the current scenario at Mbare Musika.
Limitations of the study

The study was limited by the convenience sampling technique and surveys used. Convenience sampling was highly subjective and risked producing results that are statistically insignificant. The researcher sought to counter these limitations by increasing the sample size to 400 in order to increase the statistical accuracy of the results. Furthermore, surveys were carried out for farmers that were doing business as opposed to using list from farmers’ database. Such database might have included farmers that were no longer active. Survey questionnaires were rigid and less flexible and were likely to produce less rich set of information. The researcher improved the richness of the data by using a standardised five-point Likert scale that have been widely used by prior researchers over a large space of farmers. Thus, rich set of data was gathered and reduced the effect of rigidity inherent in such tools.

CONCLUSION

Currently farmers at Mbare Musika lament inadequacy, ineffectiveness and inefficiency of market information being provided by mobile operators. A strategy is therefore required where mobile operators may need to design and develop a central database to allow for handling farmers’ feedback and to capture timely market products information. The central database should analytics and relevant information that is customized based on location and needs of individual farmers if full utilization of SMS is to be realized. The SMS technology should be designed guided by its characteristics; circumstances of the farmers and their associations; and the facilitating conditions such as availability of compatible mobile devices.

RECOMMENDATIONS

A large sample size of farmers from different similar such markets with both international and local outlook may be required in order to gain a more holistic and perspective of the marketing issues. Future research can also focus on the use of mobile applications, as opposed to SMS technology, to suit and assist the agriculture marketing fraternity.

REFERENCES


Aurik, J., Fabel, M., & Jonk, G. (2014). *From The Art of War to the War of Talent, strategy has been evolving for centuries*. USA: ATKearney.


Appendices

Appendix II: Consent form

I ______________________________________________________________________________________________ (full names of participant) hereby confirm that I understand the nature of the research project, and I consent to participating in the research project. I understand that I am at liberty to withdraw from the project at any time, should I so desire.

_________________________ ______________________
Signature of Participant Date

Appendix III: Survey questionnaire

My name is Rebecca Mandaza (rebeccamandaza@gmail.com) doing a research entitled “Strategy to improve utilisation of SMS-based market information system by smallholder farmers in Zimbabwe: Case of Mbare Musika” The purpose of the study is to identify strategies to improve the adoption and utilisation of mobile SMS technology by smallholder farmers who sell farm produce at Mbare Musika in Harare, Zimbabwe. Therefore, the objectives of the study are to: Determine mobile SMS alerts that affect smallholder farmers’ market decisions; Identify the nature of market information smallholder farmers at Mbare Musika receive from mobile SMS technologies; Examine factors that affect the utilisation of mobile SMS by smallholder farmers; and Describe the characteristic of mobile SMS technologies that affect smallholder farmers’ decisions.

SECTION A: INSTRUCTIONS

a. Please answer the following questions as openly as possible.
b. All answers will be treated in strictest confidence.
c. Do not mark or indicate any identifying information on this paper – all responses should be anonymous.
d. The survey will take no longer than 10 minutes.
e. Use a cross (x) or tick (✓) to indicate your answer where applicable

### SECTION B: DEMOGRAPHIC DETAILS

<table>
<thead>
<tr>
<th>1. Gender</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. Age</th>
<th>18 years and below</th>
<th>19 to 39</th>
<th>40 to 60</th>
<th>Above 60 years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. Qualification</th>
<th>diploma and below</th>
<th>others</th>
<th>Undergraduate degree</th>
<th>Masters and above</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4. How frequent do you use mobile SMS services</th>
<th>More frequently</th>
<th>Frequently</th>
<th>Less frequently</th>
<th>Never or stopped using</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5. Experience in using mobile SMS technologies</th>
<th>5 years and below</th>
<th>6 to 10</th>
<th>11 to 15</th>
<th>16 years and above</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### SECTION C: Mobile SMS alerts that affect smallholder farmers’ market decisions

<table>
<thead>
<tr>
<th>Alert</th>
<th>Strongly disagree</th>
<th>disagree</th>
<th>Not sure</th>
<th>agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alerts about weather</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alerts on prices of products</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alerts on demand statistics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### SECTION D: Nature of mobile SMS information received

<table>
<thead>
<tr>
<th>May you please state your level of agreement of the nature of mobile SMS information you receive</th>
<th>Strongly disagree</th>
<th>disagree</th>
<th>Not sure</th>
<th>agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>9. The SMS is timely received to make effective decision</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. The SMS is relevant to Mbare Musika market</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. The SMS meets your market decision needs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SECTION E: Factors affecting utilisation of mobile SMS platform

<table>
<thead>
<tr>
<th>State your level of agreement that the following factors affect usage of mobile SMS services</th>
<th>Strongly disagree</th>
<th>disagree</th>
<th>Not sure</th>
<th>agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>12. The expected consequence of using the SMS affects your decision to use mobile SMS technologies</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>13. Your affection for mobile SMS technologies affects your usage of the system</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>14. Influence from other farmers, colleagues and family members is affecting your usage of mobile SMS technologies</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>15. The cost of the mobile SMS is affecting its usage</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>16. Your experience of the use of SMS technology influence your utilisation of mobile SMS technologies</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>17. Availability of mobile devices is affecting your decision to use mobile SMS technologies</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

Section F: Characteristics of mobile SMS technology that affect its adoption

<table>
<thead>
<tr>
<th>State your level of agreement that the following factors affect usage of mobile SMS technologies services</th>
<th>Strongly disagree</th>
<th>disagree</th>
<th>Not sure</th>
<th>agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>18. mobile SMS technologies is always connected</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>19. mobile SMS technologies is compatible with your needs</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>20. mobile SMS technologies services are the reliable</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>21. mobile SMS technologies services are timely to allow effective market decisions</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>22. mobile SMS technologies services are available</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>
## SECTION G: Strategies to promote effective use of mobile SMS technologies services for market decision making

<table>
<thead>
<tr>
<th>State your level of agreement that the following strategies in improving usage of mobile SMS technologies services</th>
<th>Strongly disagree</th>
<th>disagree</th>
<th>Not sure</th>
<th>agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>23. Encourage farmers to adopt mobile technologies</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>24. Avail the mobile SMS technologies services to smallholder farmers</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>25. Train and make aware smallholder farmers on the value and use of mobile SMS technologies</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>26. Provision of timely market information</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>27. Other strategies</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

## Appendix IV: Interview guide to leader of farmers’ association at Mbare

### SECTION A: WELCOME

<table>
<thead>
<tr>
<th>Interview item</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date, Time, Venue</td>
<td>Observation: ……………………</td>
</tr>
<tr>
<td>Gender</td>
<td>Observation: ……………………</td>
</tr>
<tr>
<td>Age</td>
<td>Observe age range (18 years &amp; below; 19 to 39; 40 to 60; or above 60)</td>
</tr>
<tr>
<td>Researcher introduces himself and the subject: ✓ States her full name, contacts, student status ✓ States purpose of the research, ✓ States ethics considered (confidentiality, privacy, voluntary)</td>
<td>Asks interviewee for permission to write down notes during the interview Accepted……Not accepted ……….</td>
</tr>
</tbody>
</table>

### SECTION B: MARKET INFORMATION RECEIVED FROM MOBILE SMS

<table>
<thead>
<tr>
<th>1. What range of market information do you get from mobile SMS?</th>
<th>Follow-up question: 2. Is the information adequate to your needs? Explain. Take down type of information as points.</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. In your opinion, what type of information should mobile SMS provide in order to make your market decisions effective?</td>
<td></td>
</tr>
</tbody>
</table>

### SECTION C: FACTORS THAT DETERMINE ADOPTION OF SMS

| 4. From your experience, what influences your decision to use SMS for market decision making process? | Hint: Issues to do with ease of use, security, compatibility, usefulness, and cost. |
5. What may be hindering factors to the adoption of SMS for market decisions by farmers who sell at Mbare?

Probing question to check if the answers tally with 4 above.

<table>
<thead>
<tr>
<th>SECTION D: WHAT STRATEGIES CAN BE ADOPTED IN ORDER TO PROMOTE EFFECTIVENESS OF SMALLHOLDER FARMERS’ MARKET DECISIONS?</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. What can mobile operators do to improve usage of SMS by farmers?</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>7. What do farmers require to do in order to improve uptake of SMS for effective market decisions</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>8. What else do you think needs to be done in general in order to improve farmers’ market decisions?</td>
</tr>
</tbody>
</table>

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THE IMPLEMENTATION OF FIRE CONTROL MEASURES IN RESETTLEMENT FARMING AREAS OF HWEDZA, ZIMBABWE.

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ABSTRACT

Despite fire control in Zimbabwe’s resettlement farming areas, fire continues to damage the environment, property, crops and cause loss of lives. This paper investigates fire control measures implemented by resettled farmers in Hwedza. Primary research data were obtained through questionnaires and interviews targeting households and key informants. Records from government institutions were sources of secondary data. Chi-square tests were conducted to establish the relationship between fire control measures and fire trends. Research findings show that fire breaks, fire beaters, water dowsing, firefighting teams, and counter-firing were implemented to control fire. Fire occurrence responded to control measures when burnt area declined by 24.1\% for the period 2011 – 2014 when the number of farmers implementing control measures increased from 131 to 701. A negative association between fire control measures and fire trends (number of fires and burnt area) was found. Improving fire monitoring and education and awareness are critical in fire control.

Keywords: veld fire, pre-suppression, suppression, fire control measures, fire break, fire beater
1. INTRODUCTION
Globally, fire has been used for millennia as a land management tool. Today fire is still essential especially in developing countries where resource constraints limit alternatives for example in land clearing. Fire is very pronounced in Africa which is regarded as a ‘fire continent’ primarily because vast landscapes of tropical and subtropical savannahs are fire-prone (1). In the agricultural system, fire is used for land clearing; weeds, pests and diseases control; and control of pastures. Although fire is important in many societies, it sometimes gets out of hand and becomes uncontrollable resulting in damage to the environment, property, crops, and loss of lives in some instances (2). Large fires that are referred to as ‘mega-fires’ or veld fires sometimes develop due to inappropriate use of fire. For example, in 2008, a ‘mega-fire’ occurred in Botswana where 3.6 million ha of land with an estimated value of US$239 000.00 were burnt in the Central Kalahari Game (3). Between 2009 and 2012, Zimbabwe lost approximately a million ha of grazing land annually to veld fires (1). In Manicaland, approximately 190 km\(^2\) of pine plantations were lost to veld fires in 2008 (4). In 2005, a veld fire burnt seven school children to death in Matabeleland (5).

Veld fires are mainly due to anthropogenic causes, which can be divided into two categories which are deliberate and accidental fires. In both cases, their spread (veld fires) is due to poor control such as the failure to put in place adequate and effective fire containment measures such as fire breaks. Deliberate fires include fires used for land clearing, hunting and improving grazing. Arson, hunting and smoking out bees during harvesting of wild honey are some of the deliberate fires. Accidental fires include throwing away smoldering cigarette butts and ash as well as the use of fire to burn rubbish in homes (6).

Phiri et al (4) blame Zimbabwe’s land resettlement programme for an upsurge in veld fires. More than 80% of veld fires in the country are recorded in resettlement farming areas despite the farmers reportedly employing some fire control measures (7). Thus the fire control measures implemented by farmers in resettlement farming areas need to be investigated (8). In addition, there is a dearth of information on fire control measures in resettlement farming areas which calls for an investigation.

The control of fire is generally poor in the country hence the proliferation of veld fires in resettlement farming areas. Farmers are blamed for the outbreak and failure to contain the runaway fires. However, there are reports of resettled farmers taking up fire control as an important component of addressing the fire problem. This is seen by an increase in fireguard construction in some areas (9). These fire control measures, however, need to be investigated to appreciate how they are being employed and performing.

Fire control is an important component of environmental management. It reduces the loss of biodiversity, lives, and property. Mudekwe (8) stresses that fire control should be centered on early detection, quick reaction, and suppression. Unless fire is properly managed it will continue causing land degradation in the country. Thus investigating fire control measures in land resettlement farming areas helps to appreciate how fire is being managed and suggest ways of improving it.

2. OBJECTIVES
The study sought to:

- Identify fire control measures implemented by resettled farmers in Hwedza.
- Evaluate the performance of fire control measures implemented by resettled farmers in Hwedza.
To determine the relationship between fire control measures and fire trends (number of fires and burnt area) in Hwedza resettlement farming areas.

3. METHODOLOGY
The study was confined to Hwedza which is approximately 136.6 km south of the capital, Harare. The location map of the study area is shown in Figure 1.

Figure 1: Location of the study area

Hwedza is one of the country’s 20 districts with resettlement farming areas classified by the Environmental Management Agency (EMA) as veld fire ‘hot spots’. The EMA is a government department which is responsible for monitoring the environment including veld fire. Hwedza, the study area was purposively selected based on its characteristics i.e. resettlement and veld fire thus representative of other resettlement farming areas. From Hwedza, Ward 1 was randomly selected from the three resettlement wards in the district. Ward 1 is approximately 60 km from Hwedza Business Centre in the western direction, along Fair Adventure road. It is usually referred to as Watershed West. It is a former commercial farming area which is predominantly a semi-intensive farming area. Maize and tobacco are the major cash crops grown mainly through rain-fed agriculture. Livestock rearing is also practiced in the area with cattle ranching being dominant. Annual rainfall amounts range from 650 mm to 800 mm. These high rainfall amounts promote the growth of fire-prone vegetation which is mainly grass. High rainfall amounts also promote crop production. This results in high fuel load in the form of crop residues such as maize. High fuel load increases fire risk. The production of tobacco promotes veld fire outbreaks when farmers prepare tobacco seedbeds using fire. According to ZimStat, Ward 1 has a total population of 4813 people comprising 2613 males and 2200 females. It comprises 21 farms with 1136 households each with an average size of 4.2.

The study adopted both quantitative and qualitative research designs. This triangulation was done to overcome intrinsic biases. The quantitative research design was adopted in order to describe and test relationships between variables such as the number of fires and the burnt area from questionnaires and satellite data. The qualitative research design was adopted to cater for farmer perceptions on fire control measures. Qualitative data were mainly collected using key informant structured
interviews and questionnaires. A survey approach was used to gain insights into fire control measures in resettlement farming area. Results for the period before fire control measures were intensified i.e. 2009 – 2010 were compared with results for the period 2011 – 2014 when fire control was improved.

A total of 143 questionnaires were administered to plot holders or their representatives. The questionnaires had both closed and open-ended questions. Questionnaires were administered to get information on the fire situation and management interventions in the study area. Targeted respondents were males and/or females from 16 years of age and above who had resided in the area for at least five years and had a history of the fire situation of the area. A multi-stage random sampling approach was employed in the selection of questionnaire respondents. Out of the 21 farms in Ward 1, three farms - Chard, Collace and Fair Adventure were randomly selected. These farms had a total of 526 plots. From these plots, 143 (27.2%) households were randomly selected. Random selection afforded farmers an equal opportunity for participating in the questionnaire survey. From each farm, 25% of the households were selected. This was taken as the size of a sample adequate to draw statistical inferences from. The size of the sample for the questionnaire survey considered the minimum number of 30 required according to the Rule of the thumb by Creswell (13). Table 1 shows the number of plot holders and the number of selected respondents per farm.

Table 1: Questionnaire survey respondents

<table>
<thead>
<tr>
<th>Farm name</th>
<th>Number of plot holders</th>
<th>Number of selected respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chard</td>
<td>251</td>
<td>63</td>
</tr>
<tr>
<td>Collace</td>
<td>201</td>
<td>50</td>
</tr>
<tr>
<td>Fair Adventure</td>
<td>74</td>
<td>30</td>
</tr>
<tr>
<td>Total</td>
<td>526</td>
<td>143</td>
</tr>
</tbody>
</table>

The consent of respondents and permission from government departments, local authorities, and traditional leaders was sought for the research to proceed. Names of respondents and or plot numbers were kept anonymous during the study – at data collection and eventual analysis to ensure confidentiality. The respondents were assured that the information they provided was for academic purposes only. All reports from relevant departments were not taken out of offices during use and returned to responsible authorities.

A pilot study was undertaken to pre-test the instruments using ten randomly selected respondents from the study area. This was done to validate the research instruments as recommended by Dominowski (14). The pilot study checked on how long it took the respondents to respond to questions, assessed the interpretation of questions and whether there was any need to tune or rephrase some of the questionnaire items. Draft questionnaires were also assessed by two EMA provincial officers for determining whether they were reliable tools for data collection in this study. The pilot study revealed that there was a need to separate fire control measures into pre-suppression and suppression for the focus to be clear and to adequately cover issues at hand. The questions that were ambiguous, for instance, one on the extent to which fire control measures were implemented needed a brief explanation to clarify the meaning of various extents. The open-ended questions were closed to allow the respondents to answer within a shorter period of time and made it possible to quantify the responses options were introduced for most of the questions.
Interviews were conducted with key informants to collect data to confirm responses from questionnaire respondents. They were conducted with five government departments responsible for fire control in the district - EMA, Forestry Commission (FC), AGRITEX, Zimbabwe Republic Police (ZRP) and Hwedza Rural District Council. The departments were in charge of monitoring and assisting communities in tackling the fire challenge in the study area. Face to face interviews was conducted.

Qualitative data was first coded and classified. This was done to make sense of the data and to highlight the important findings. The transcripts used to record the responses were read through and notes were made when interesting or relevant information was found. The findings were summarized into themes and the individual themes were summarized or put together to build integrated explanations. The findings were presented as descriptive statements under relevant sections and included graphical presentations.

Chi-square tests were carried at a 95% significance level out to determine the relationships between fire control measures and fire trends. For the Chi-square test, the Null Hypothesis (H₀) and the Alternative Hypothesis (H₁) were first specified. Research data (observed values) were then tabulated and expected frequencies were calculated for each observed value. The test static was calculated and compared against the critical value and a decision was made whether to reject H₀ or not. Finally, a conclusion was made on the relationship between fire control measures and fire trends.

The collected data are presented in tables, graphs, and maps. Tables and graphs were meant to show frequencies of fire control measures and compare fire trends. Fire maps were used to show the extent of area burnt by fire for each year.

4. RESULTS AND DISCUSSION

Data on household respondents’ characteristics, fire suppression measures, trends in the burnt area, fire frequency, losses to fire, the performance of control measures and the relationship between fire control and fire trends are presented and discussed in this section.

4.1 Household respondents’ characteristics

A total of 143 farming households were sampled during the questionnaire survey. A total of 114 respondents were males whilst 29 were females. Respondents comprised 117 plot holders, 19 supervisors/foremen and 7 who were wives, children or relatives of plot holders. The highest number of household respondents (44) was in the 35 – 44 age range whilst the least number (10) was more than 55 years old. The period of residence in the study area was more than 10 years for 89 household respondents. A total of 54 household respondents had lived in the area for a period of 5 – 9 years. No household respondent had lived in the area for less than five years. A total of 93 household respondents had attained secondary education, 27 had attained primary education, 15 had tertiary education and 8 had no formal education. The characteristics of respondents are shown in Table 2.
Table 2: Respondents characteristics

<table>
<thead>
<tr>
<th>Gender</th>
<th>Age (Range)</th>
<th>Period of Residence (Years)</th>
<th>Level of Education</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>16-24</td>
<td>&lt;1</td>
<td>Tertiary</td>
<td>114</td>
</tr>
<tr>
<td>Female</td>
<td>25-34</td>
<td>1-4</td>
<td>Secondary</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>35-44</td>
<td>5-9</td>
<td>Primary</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>45-54</td>
<td>10+</td>
<td>None</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td>55+</td>
<td>89</td>
<td>Tertiary</td>
<td>30</td>
</tr>
</tbody>
</table>

Source: Research Findings (2015)

4.2 Fire pre-suppression measures

The study solicited for the suppression measures implemented in the study area. The results are shown in Figure 2.

![Figure 2: Fire pre-suppression measures.](image)

Source: Field survey (2015)

The results show that farmers implemented two fire pre-suppression measures to control fire in the study area. These measures were fire breaks and firefighting teams. There was however more preference for use of fire breaks which were implemented by 86% of the farmers. An insignificant proportion (2%) of the farmers did not implement any pre-suppression measures. Shaffer (15) also
revealed that the use of fire breaks was a common fire pre-suppression measure implemented by farmers in the Madjadjane and Gala areas of Mozambique. The high use of firebreaks could be attributed to training by EMA (9).

The positive response on pre-suppression measures indicates that the probability of controlling fire outbreak is high. Nonetheless, an assessment of burnt area and number of fires would be used to evaluate the performance of fire control measures in the study area.

4.3 Fire suppression measures
Measures implemented by farmers to suppress fire were sought for in the study. The measures are shown in Figure 3.

![Figure 3: Fire suppression measures](image)

The results show that to suppress fire farmers used fire beaters, counter firing and dowsed fire with water. Fire beaters and dowsing fire with water were the dominant fire suppression measures confirmed 92% and 85% of the farmers respectively. Counter firing was implemented by only 1% of the farmers. Farmers augmented rubber fire beaters with brushwood fire beaters. The EMA pointed out that the use of rubber fire beaters became noticeable in the study area and other resettlement farming areas in the country at large because of awareness campaigns and fire awareness launches which were introduced in districts and wards (9, 16). Farmers also pointed out that where water was available they had used it to douse fire. They had used knapsack sprayers, watering cans and any available water containers to fetch water from shallow wells in vegetable gardens, streams, and dams. Farmers who did not implement any fire control measure contributed to the spread of any fires that could be started as a result of lack of control. In some instances, these farmers were issued with tickets for failing to implement fire suppression measures but they remained passive.
4.4 Trends in the burnt area

The study sought to establish trends in the burnt area for the period 2009 – 2014. The results are shown in Figure 4.

![Figure 4: Area burnt by veld fire for the period 2009 –14.](image)

Source: EMA (17)

Burnt area data were obtained from the United States (US) Geological Survey derived from Moderate Resolution Imaging Spectro-radiometer (MODIS) for free at a spatial resolution of 250m × 250m and processed using a computer-based Quantum Geographic Information System (QGIS) software. Burnt area scars data in the form of shapefiles for the whole country for the period 2009 – 2014 were downloaded then exported to QGIS. Hwedza district wards boundaries were overlaid on the country data and then Ward 1 data was clipped. Burnt area (in hectares) was calculated for each year using a measuring tool.

Results show that a total of 5 337.88 ha of land were burnt in 2009, rose by 88.8% to 10 079.33 ha in 2010 but declined by an average of 24.1% thereafter until 2014. Between 2009 and 2010, approximately 85% of the farmers either had no or had inadequate fire control measures. Fire control was lacking despite the presence of traditional institutions and government institutions mandated to manage natural resources (18). It was only after 2010 mainly due to awareness raising and capacity building from EMA that more farmers started to appreciate fire control (9). The continued rise in fire incidences and fire losses also motivated farmers to implement fire control measures to safeguard their livelihoods (18). For example, the use of fire breaks became widespread in the study area afterward.

Before 2011, regulatory authorities had not engaged the farmers to control fire in the study area. There was also no strict enforcement of penalties to fire offenders in resettlement farming areas thus the offenders were not deterred from starting fires (18). The increase in fires before 2011 could be attributed to a break up of strict fire control by former commercial farmers. Former commercial farmers also had the equipment to make fire breaks and extinguish fires (18, 19). However, between 2011 and 2014, a steady decline (24.1%) in the annual burnt area was recorded.
4.5. Trends in the number of fires

Data on fire frequency were collected to explain the prevalence of veld fires in the study area. The results are shown in Figure 5.

![Figure 5: Number of fires](image)

Source: EMA (17)

The study results show an upward trend (42.9%) in the recorded number of fires between 2009 and 2010 in the Ward. After 2010 there was a decline of 88% from 50 to 6 fires. The highest number of fires was in 2010 when a total of 50 fires were recorded. The highest decline of 60% was recorded between 2010 and 2011.

The decline in the number of fires after 2010 may be attributed to the implementation of fire control measures by more farmers in the study area. As more and more farmers became aware of the dangers of fire, a reduction in the number of fires was achieved. Goldammer et al (20) also observe that in the East Caprivi, when the number of fires decreased by 70% due to fire awareness and public education campaigns, a 54% reduction of burnt area was experienced annually. The study area however still continued to experience fires despite all the fire measures that were implemented. This may be attributed to accidental fires during land clearing or to arson. Nyamadzawo et al. (1) stress that smallholder scale farmers in Zimbabwe use fire to clear land for cultivation and in some instances, fires get out of control and degenerate into veld fires. It is also almost impossible to achieve zero fires as long as fire is still part of the farming system.

4.6 Trends in fire losses

The research sought to establish fire losses recorded in the study area, the results are shown in Table 3.
Table 3: Area burnt and veld fire losses

<table>
<thead>
<tr>
<th>Year</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area burnt (Ha)</td>
<td>5377.88</td>
<td>10079.33</td>
<td>6966.96</td>
<td>4866.61</td>
<td>4766.02</td>
<td>3186.23</td>
</tr>
<tr>
<td>Human deaths</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Cattle deaths</td>
<td>0</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Housing structures</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vegetable gardens</td>
<td>3</td>
<td>5</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>Tree plantations (Ha)</td>
<td>0.5</td>
<td>0.5</td>
<td>0.25</td>
<td>0.5</td>
<td>1.0</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Source: EMA (17)

The results show that other than one related fire death, there were losses in livestock (cattle), housing structures, gardens and tree plantations. One fire-related loss of human life was experienced in the study area after 2010. The death was unfortunate since it occurred when there was an improvement in fire control with an increasing number of farmers implementing fire control measures. It must, however, be noted that following a further decline in the number of fires and burnt area no deaths were experienced in 2014. The trends in fire losses show that there was a decline in losses to fire in response to measures that were implemented.

A total of seven goats were lost to veld fire in 2010, none occurred thereafter. Loss of livestock occurred in 2010 when there was an 88.8% increase in burnt area. This suggests that an increase in fire provided more chances for loss of livestock. Brooks and Matchett (21) point out that dominant dense thatch grass in former commercial farming areas which is prone to fire threatens the security of livestock not only due to deaths but also the loss of pastures. After 2010, a reduction in fire-related livestock deaths may be due to an increasing number of farmers implementing fire control measures or that the farmers had become wiser and now safeguarded their livestock from veld fire.

Loss of housing structures to veld fire declined over the six-year period in the study area. The highest number of houses (4) lost to fire were recorded in 2009. There was a 50% decline in the houses in 2010 despite an increase in burnt area. In 2011, there was a further decline of 50%. No housing structure was lost to fire after 2011. The research results suggest that an improvement in fire control between 2011 and 2014 resulted in a decline in the number of housing structures lost to fire. Trends in loss of housing structures generally suggest a strong link between fire control measures and loss of housing structures to fire. The number of housing structures burnt by fire in 2009 and 2010 could be attributed to poor fire control.

There was an average increase of 31.14% in the number of gardens lost to fire for the period 2009 - 2014. This was despite an improvement in fire control after 2010. When preparing gardens for planting, farmers normally use fire but sometimes fail to effectively manage it properly resulting in the proliferation of veldt fires. This is also supported by (2) who pointed out that in the agricultural system in developing countries such as Zimbabwe, fire is used for land clearing due to resource constraints which limit alternatives for example in land clearing.

The area of plantation affected by fire was constant (0.5 ha) between 2009 and 2010. The area decreased by 50% in 2011 after more farmers started to implement fire control measures. It further declined by 50% the following year, later increased by the same margin in 2013 before declining by a further 50% in 2014. The marginal effect on plantations persisted during the study period. When the burnt area increased in 2010, the plantation area burnt remained constant. This is in contrast to the
case of Manicaland Province in Zimbabwe where the plantation area lost to fire increased from 2,908 ha to 9,586 ha in 2010 and 2011 respectively when fires increased (1).

4.7 Performance of fire control measures
This section seeks to assess the performance of the main fire control measures that were implemented in the study area. Fire control measures are shown against the burnt area in Table 4.

Table 4: Trends in the area burnt and the number of farmers implementing fire control measures.

<table>
<thead>
<tr>
<th>Year</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burnt area (ha)</td>
<td>5377.88</td>
<td>10079.33</td>
<td>6966.96</td>
<td>4866.61</td>
<td>4766.02</td>
<td>3186.23</td>
</tr>
<tr>
<td>Fire breaks</td>
<td>16</td>
<td>21</td>
<td>40</td>
<td>53</td>
<td>57</td>
<td>78</td>
</tr>
<tr>
<td>Firefighting teams</td>
<td>0</td>
<td>0</td>
<td>9</td>
<td>12</td>
<td>15</td>
<td>24</td>
</tr>
<tr>
<td>Fire beaters</td>
<td>20</td>
<td>31</td>
<td>54</td>
<td>68</td>
<td>70</td>
<td>88</td>
</tr>
<tr>
<td>Counter firing</td>
<td>15</td>
<td>18</td>
<td>31</td>
<td>13</td>
<td>21</td>
<td>3</td>
</tr>
<tr>
<td>Dousing with water</td>
<td>3</td>
<td>7</td>
<td>10</td>
<td>20</td>
<td>14</td>
<td>21</td>
</tr>
</tbody>
</table>

Source: EMA (17) and Field survey, 2015

The results show that the number of farmers that implemented fire control measures increased from 131 for the period 2009 – 2010 to 701 after 2010. For the period 2009 – 2010 there was low uptake of fire control measures. At the same period, there was an increase in area burnt from 5377.88 Ha to 10079.33 Ha. However, since 2011 there was a steady increase of farmers who adopted fire breaks, established firefighting teams and used fire beaters to control the spread of fire. This may be attributed to awareness raising and training from EMA and other government departments (16).

An increase in the number of farmers implementing fire control measures corresponded with a decline in area burnt by fire. Until 2011, few farmers (37) used fire breaks, possibly because they did not understand their importance and lacked knowledge on how to construct them. Moreover, the fire breaks which were constructed were less than the stipulated width of 9 m and were possibly breached by fire. After 2010 and until 2014, farmers controlling fire using fire breaks increased to 228 and this corresponded with a decrease in burnt area from 10,079.33 ha in 2010 to 3,186.23 ha in 2014. The decline in the burnt area may thus be attributed to an increase in the construction of standard fire breaks.

The results, therefore, show that fire breaks played an important role in fire control when an increasing number of farmers constructed them. When the number of farmers participated in fire break construction among other measures increased in Namibia’s Eastern Caprivi Region in 1996, the following year as 54% reduction in burnt area was achieved in 1997 (20). It must, however, be realized that veld fires continued to affect the area despite the increase in fireguard construction during the period 2011 - 2014. This may be attributed to some poorly constructed fire breaks which could have been breached by fire.

The absence of firefighting teams in 2009 and 2010 coincided with an increase in burnt area from 5,377.88 ha to 10,079.33 ha for the same period. The first decline in the burnt area was experienced
in 2011 when firefighting teams were initially established with assistance from EMA (22). When the number of firefighting teams increased after 2010 until 2014 to 60, the burnt area also followed the same trend. This, therefore, suggests that firefighting teams were important measures in fire control in the study area. Despite the establishment of firefighting teams, fires continued to affect the Ward. This may be attributed to other factors such as lack of adequate firefighting equipment.

The number of farmers who used fire beaters increased from 51 for the period 2009 – 2010 to 280 for the period 2011 - 2014. This corresponded with a decline in area burnt by fire during the same period. Although fire beaters were used to suppress veld fires before 2011, the burnt area did not decrease. It was only after 2010 when farmers started to use rubber fire beaters that a decline in veld fires was recorded. Before 2011, the usually ineffective brushwood was used to suppress veld fires. The fire trends also suggest that the type of fire beaters had an effect on the burnt area. It should, however, be noted that although the largest proportion of farmers in the Ward increasingly used rubber fire beaters in suppressing veld fires, the research revealed that veldt fires continued to affect the area. Possible explanations to this phenomenon could be that the fire beaters were not adequate, were not properly used or just failed to work in high-intensity veld fires.

Counter firing and dowsing fire with water complimented other discussed fire management measures. Research findings revealed that 33 farmers had applied counter firing to control fire for the period 2009 – 2010. During the same period, the burnt area increased. Between 2011 and 2014 counter firing increased to 68 farmers. Farmers, however, lacked the skill to use it. There were however contrasting responses from the few who reportedly used it. Some said that the measure was important in controlling fire whilst others pointed out that it actually increased area burnt when they failed to contain the ‘new’ fire.

Before the period 2009 - 2010 only 10 farmers dowsed fire with water. The number of farmers using water to control fire however increased to 65 for the period 2011 – 2014. When the number of farmers using water to control fire increased after 2010, the burnt area decreased. This seems to suggest that water was important in fire control. Lack of modern water hydrants, water hoses, and water bowsers however affected the use of water in fire control. Farmers had to rely on the use of knapsack sprayers which however had limited pressure and any other available water containers to douse a fire. Water was fetched from wells in vegetable gardens, streams, and dams in the area. Water could however only be carried over short distances to douse fire thus could not be used to control fires which occurred far away from water points. Where fires occurred close to water points and the fire intensity was low, farmers pointed out that dowsing fire with water eliminated fire. However, water failed to control high-intensity fires which occurred during windy and hot days.

4.8 Relationship between fire control measures and fire trends

The study sought to determine the association between fire control measures and fire trends using Chi-square test at a 95% level of significance.

The hypotheses were specified as:

1. The number of fires and fire pre-suppression measures:
   \[ H_0: \text{There is no relationship between the number of fires and fire pre-suppression measures} \]
   \[ H_1: \text{There is a relationship between the number of fires and fire pre-suppression measures} \]

2. Burnt area and fire suppression measures:
   \[ H_0: \text{There is no relationship between the burnt area and fire suppression measures} \]
**H1: There is a relationship between the burnt area and fire suppression measures**

4.8.1 Relationship between the number of fires and fire pre-suppression measures

The data that was used in conducting the Chi-square test are tabulated in Table 5.

### Table 5: Number of fires*Fire pre-suppression measures

<table>
<thead>
<tr>
<th>Fire pre-suppression measures</th>
<th>Number of Fires</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of fire breaks</td>
<td>None</td>
<td>49</td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
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<td>59</td>
</tr>
<tr>
<td></td>
<td>&gt; 20</td>
<td>44</td>
</tr>
<tr>
<td>Firefighting teams</td>
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<td></td>
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<td>16 - 20</td>
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<tr>
<td></td>
<td>&gt; 20</td>
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<tr>
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<td></td>
<td>&gt; 20</td>
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</tr>
<tr>
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<td>618</td>
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</tr>
</tbody>
</table>

Source: Research findings (2015)

The test statistic ($\chi^2 = 34.9$) was compared to the tabulated value (10.85). Since the test statistic was greater than the tabulated value ($\chi^2 > 10.85$) a decision was made to reject $H_0$. It was therefore concluded that there was sufficient evidence that there was a negative association between the number of fires and fire pre-suppression measures for the period 2009 - 2014. As more farmers implemented fire pre-suppression measures, the number of fires observed was generally reduced to between none and 1 - 5. However, the implementation of more fire pre-suppression measures did not completely eliminate fire.

4.8.2 Relationship between burnt area and fire suppression measures

Chi-square test was done using the tabulated data in Table 6.

### Table 6: Burnt area*Fire suppression measures
The test statistic \( \chi^2 = 192.06 \) was compared to the tabulated value \( (7.26) \). Since the test statistic was greater than the tabulated value \( (\chi^2 > 7.26) \) a decision was made to reject \( H_0 \). It was therefore concluded that there was sufficient evidence that there was a negative association between burnt area fire and fire suppression measures. When the number of farmers implementing fire suppression measures increased, a general decrease in the burnt area was experienced.

### 5. CONCLUSIONS

The findings presented and discussed in this paper show evidence of fire control by resettlement farmers from Hwedza for the period 2009 – 2014. The measures were implemented before (pre-suppression) and during (suppression) fire occurrence. The main fire pre-suppression measures were the use of fire breaks and firefighting teams. The use of fire beaters, use of water, counter firing and early warning were the fire pre-suppression measures implemented. The use of fire beaters was the most prevalent fire suppression measure. Fire control measures implemented in Hwedza brought about a reduction of fire frequency and burnt area when the number of fire control measures and farmers implementing the measures increased.

When the number of fire control measures and farmers implementing fire control measures increased after 2010, there was a general decline in the burnt area, number of fires and other losses. Therefore a negative association existed between fire control measures and fire trends. The general decline in the number of fires, burnt area, and other losses after 2010 suggest that fire control measures implemented performed better when compared to the period 2009 – 2010 when increases were recorded. This suggests that it is possible to tackle the fire challenge in Hwedza and other resettlement farming areas through improved fire control. Farmers in resettlement farming areas can effectively control fire if they diversify and increase the uptake of fire control measures.
6. RECOMMENDATIONS
The recommendations are derived from the farmers, key informants, and the researchers’ expertise.

The participation of all farmers is important for effective fire control in the study area. EMA and other government departments should encourage farmers to participate in fire control through education, awareness raising, and training. These would also enhance their knowledge, skills as well as increase their fire preparedness. When more farmers participate in fire control the chances of eliminating fire and fire losses increase.

To also ensure that all farmers implement fire control measures and reduce veld fires, law enforcement is important. EMA should ensure that all farmers comply with Statutory Instrument 7 of 2007 on Environmental Impact Assessment and Ecosystem Protection which compels users, owners and occupiers of a given piece of land to put in place fire suppression measures (24). Council should enforce their fire control by-laws. Traditional leaders should also enforce local by-laws in areas of their jurisdiction.

Government and farmer organizations should support farmers with more firefighting equipment to augment fire beaters and knapsack sprayers which were the only equipment which was used by farmers to control fire in the study area. This firefighting equipment should include water bowsers, blowers, grass cutters, slashers, sickles, water hydrants, and water hoses. Fire control is improved when farmers have adequate firefighting equipment.

Fire control measures which were rather limited in the study area should be diversified to include early warning and reduction of fuel load among other measures. Government departments and farmers’ organization should encourage farmers to undertake for example hay baling to reduce fuel load and provide fodder for their livestock at the same time. These will complement the already existing fire control measures and help to further reduce veld fires. EMA should assist communities to improve local level fire monitoring and early detection. Nyamadzawo et al. (1) also cited the need for early warning systems at a more local level in Zimbabwe. At a broader level, there is need to utilize earth observation systems and Geographical Information Systems combined with data from districts and the public domain data to spatially investigate, understand, and map the fire occurrence and recurrence interval (23).

In order to reinforce the strengths and improve on the shortcomings of fire control measures in resettlement farming areas, there is a need to improve the implementation of fire control measures. There should be co-ordination and co-operation between key stakeholders and farmers (20, 23). Other key stakeholders such as traditional leaders, councilors, FC, AGRITEX, Council, ZRP, Department of Livestock, Ministry of Youth, Ministry of Lands and Rural Resettlement should augment efforts by EMA. Successful fire control is dependent on the cooperation and coordination among governments’ agencies and the local community (2).

Although the study only investigated fire control measures, there are however other knowledge gaps that need to be plugged through more research. There are currently no detailed studies that have assessed the capacity of accelerated land reform farmers to manage fire. Although some research on the impacts of fire on ecosystem services have been conducted by scholars such as Nkomo and Sassi (25), there is a need for more research on this aspect. The economic impacts of fires are largely unquantified especially in accelerated land reform farming areas which are vital for the country's agro-based economy. An assessment of the determinants of farmers’ choices of fire control measures is also important.
REFERENCES
POTENTIAL OF LOCALLY ADAPTED GUAVA LINES UNDER IRRIGATED AND RAINFED CONDITIONS FOR COMMERCIAL PRODUCTION IN THE SOUTH EAST LOWVELD OF ZIMBABWE.

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ABSTRACT

Fifteen locally adapted guava lines were evaluated for growth and yield under irrigated and rain fed conditions in the South East Lowveld of Zimbabwe. Quality traits of the lines were also measured under irrigated conditions. There were significant differences in yield among the lines under both irrigated and rain fed conditions. The red fleshed lines gave the highest yield GXC 15 (40.48 kg/tree), GXC 9 (35.33 kg/tree) GXC 13 (32.33kg/tree) and GXC 2 (27.7kg/tree) under irrigated conditions and under rain fed conditions GXC 15 (25.13 kg/tree), GXC 9 (26.34 kg/tree), GXC 13 (22.33kg/tree) and GXC 2 (15.43kg/tree). Significantly high plant height, canopy diameter and stem girth were also observed in red lines. GXC 15 received the lowest rating for general acceptability and had a significantly high acid percentage 0.72%. The red fleshed lines have a potential for commercial production for processing. GXC 2 also has potential for the fresh market.

Key words
Guava, line evaluation, irrigated, rain fed
1. INTRODUCTION

Guava (Psidium guajava) is hardy and prolific bearing, it requires less water, can be grown on a variety of soils which range from sandy loam to clay loam with a pH of 4.5-8.2 (1) and is not affected by adverse climatic conditions (2), (3). Hence it has become naturalised in some areas of Zimbabwe. Processing companies collect the fruit from its natural habitat mainly from Manicaland Province (Chipinge) and Masvingo West (Zaka and Bikita). This has made it difficult for the processing companies to realise the importance of developing guava as a commercially cultivated crop for a long time. Sustainable supply from this source is not guaranteed, due to on-going stumping to expand crop field. Veld fires are also destroying guava bushes and the companies processing guava are increasing and expanding production (4) therefore the future of guava processing lies on sustainable commercial production.

The major producers of guava in the world are India, Pakistan, Sudan, Brazil, Mexico, Indonesia, Bangladesh, South Africa, Venezuela, Phillipines and New Zealand (5), (6). They are also among the leading producers of commercial guava for export. Counties like South Africa, India and Malaysia have developed their own guava cultivars (7). Some of the major producers of guava have advanced in guava research and they have also breed varieties of guava rootstocks that suite their environments (8). The cultivars are developed for processing into many products like clarified juice, canned guava, Jam Jelly, nectar (9) butter paste, puree, powder, toffee and flakes (10). Guava is sold mainly as a puree (8-10 0Brix) and as a concentrate (200 Brix) frozen but also in aseptic packs. Main suppliers include South Africa, Malaysia and India. (11).

There are positive indications for further increase in demand for guava for processing in the future in Zimbabwe. The country is taking this opportunity by commercialising guava production, improving the quality and promoting its value addition by processing into juice. With the raising awareness of healthy drinks people are likely to spend more on 100% guava juices. Guava is very rich in vitamin C (12), (13) and a good source of Vitamin A and relatively high fibre content.

Currently our processing industries do not have enough guavas to feed the factories. Most of the companies are operating below 60% production capacity (4) Processing companies are encouraging farmers to consider guava as a commercial crop. Some companies contract farmers to grow guava from seed. There is great genetic and morphological variability within and among trees grown from seed because guava is open pollinated and heterozygous crop (14). The variability of guava trees affects the uniformity and quality of harvested fruits this in turn affects the fruit yield (15), (16). Proper selection of varieties for different agro-climatic Zones is very essential for obtaining good yield and quality of guava (17) (2). In South Africa, nurseries are using three methods of propagation namely cuttings, grafting and air layering (5).These asexual propagation methods fix the superior traits of the selected lines and varieties. Famers should get high returns by going for high yielding varieties with uniform ripening to maximise returns. A few farmers venturing in commercial guava productions usually import planting material from South Africa to establish their own plantations.

Commercialising the fruit will help supplement the fruit collected from the wild and the factories will be very sure of the quantities they will get for processing each season rather than wait for unknown quantities from the forest. Harvesting season for guava harvested from the wild begins from February to April but if grown as a commercial crop with supplementary irrigation harvesting period can be extended to July (18) because the guava tree normally produces as many as two crops in a year which is a unique phenomenon of the tropical and the subtropical regions (19).
Therefore there is need to identify cultivars adaptable to local conditions (20), (21) and evaluate their performance both under irrigated conditions and rain fed conditions. Some local guava processing companies are interested in fruit attributes such as fruit colour, they prefer intense pink colour (red fleshed), less seed per fruit and a minimum fruit diameter of 40mm. Release of guava varieties will help guava grow into a commercial crop in the country for the fresh market and processing.

2. OBJECTIVES
The objectives of this trial are:
1. To evaluate the performance of selected guava lines from Chipinge forests under irrigated and under rain fed conditions.
2. To select lines that can be introduced as varieties/lines for commercial production in Zimbabwe.

3. METHODOLOGY
The experiment was carried out in the South East Lowveld of Zimbabwe at Chiredzi Research Station. The guavas lines used in this experiment are locally adapted. They have gone through selection in their natural habitat in Chipinge. Several lines were selected for evaluation in Chiredzi. Further selection was done on the basis of fruit size, taste and percentage of seed. From the evaluation fifteen lines were recommended for further evaluation. A commercial variety from South Africa (Piet Retief) was in cooperated in the evaluation as the control.

The trial was designed in a randomised complete block design and replicated three times. The treatments were the fifteen locally collected guava lines and one commercial cultivar (Piet Retief) spaced at 3m x 3 m. Each plot consists of one tree. From first year of planting to the fifth year the trees were irrigated according to crop water requirements. From the sixth year irrigation was only applied in September, October and November without scheduling to the eighth year. The trees grew under rain fed conditions from 9 to 11 years. Molasses and Malathion were used as baits to control fruit fly.

Measurements of annual marketable fruit yield (kg/tree), non marketable yield (kg/tree) and number of marketable fruits were taken under irrigation and under rain fed conditions over three years of consecutive study. Other measurements taken were fruit diameter (mm), flesh colour, sugar %, plant height, stem girth, canopy diameter, % acidity and consumer preference under irrigation.

Twenty individuals were used to assess the taste of the lines using the hedonic scale ranging from 1=dislike extremely to 9 like extremely according to Scudamore-Smith (22). Canopy diameter was calculate by the formula (East-West) + (North-South)/2. Stem girth was measured using the callipers at 10 cm above the ground the callipers was also used to measure fruit diameter. Acidity was estimated by acid alkali titration method suggested by A.O.A. C (23). TSS was also determined as per standard procedures given by A.O.A.C.

The data obtained was statistically analysed using Gen Stat 14th edition. Data recorded as percentages were transformed before analysis. Significant differences among means were distinguished according to the Duncan Multiple range Test range.

4. RESULTS
The yield, number of fruits and average fruit size under irrigated and rain fed conditions is presented in Table 1. Yield of the different lines varied significantly P<0.001 among the lines both under irrigated and under rain fed conditions. Under irrigated conditions GXC 15 gave the highest yield (40.48 kg/tree) and GXC12 had the lowest yield (9.25 kg/tree). Under rain fed conditions GXC 15 had the highest yield (25.13kg/tree) and GXC7 had the lowest yield (2.55kg/trees).
The red fleshed lines consistently gave the highest yield under both irrigated and rain fed conditions, GXC 15 (40.48 kg/tree), GXC 9 (35.33 kg/tree) GXC 13 (32.33kg/tree) and GXC 2 (27.7kg/tree) under irrigated conditions and under rain fed conditions GXC 15 (25.13 kg/tree), GXC 9 (26.34 kg/tree), GXC 13 (22.33kg/tree) and GXC 2 (15.43kg/tree).

The red fleshed lines GXC15, GXC9, GXC13 and GXC2 gave significantly high yields compared to the white fleshed lines.

Table 1. Yield and number of fruits and average under irrigated and under rain fed conditions for 15 lines and Piet Retief

<table>
<thead>
<tr>
<th>Line</th>
<th>Yield kg/tree</th>
<th>Number of fruits /tree</th>
<th>Average fruit size (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Irrigated</td>
<td>Rain fed</td>
<td>Irrigated</td>
</tr>
<tr>
<td>GXC1</td>
<td>10.72 c</td>
<td>3.13 e</td>
<td>52.3 c</td>
</tr>
<tr>
<td>GXC2</td>
<td>27.76 b</td>
<td>15.43 bcd</td>
<td>102.6 b</td>
</tr>
<tr>
<td>GXC3</td>
<td>9.34 c</td>
<td>7.32 de</td>
<td>42.7 c</td>
</tr>
<tr>
<td>GXC4</td>
<td>9.39 c</td>
<td>6.23 de</td>
<td>43.6 c</td>
</tr>
<tr>
<td>GXC5</td>
<td>11.32 c</td>
<td>12.56 cde</td>
<td>48.9 c</td>
</tr>
<tr>
<td>GXC6</td>
<td>9.83 c</td>
<td>5.22 de</td>
<td>60.3 c</td>
</tr>
<tr>
<td>GXC7</td>
<td>9.31 c</td>
<td>2.55 e</td>
<td>65.7 cd</td>
</tr>
<tr>
<td>GXC8</td>
<td>10.53 c</td>
<td>5.54 de</td>
<td>44.3 c</td>
</tr>
<tr>
<td>GXC9</td>
<td>35.33 ab</td>
<td>26.34 a</td>
<td>142.2 a</td>
</tr>
<tr>
<td>GXC10</td>
<td>11.44 c</td>
<td>5.33 de</td>
<td>43.3 c</td>
</tr>
<tr>
<td>GXC11</td>
<td>9.29 c</td>
<td>3.78 e</td>
<td>41.9 c</td>
</tr>
<tr>
<td>GXC12</td>
<td>9.25 c</td>
<td>4.36 e</td>
<td>47.3 c</td>
</tr>
<tr>
<td>GXC13</td>
<td>32.33 b</td>
<td>22.33 abc</td>
<td>130 ab</td>
</tr>
<tr>
<td>GXC14</td>
<td>9.34 c</td>
<td>2.71 e</td>
<td>60.6 c</td>
</tr>
<tr>
<td>GXC15</td>
<td>40.48 a</td>
<td>25.13 ab</td>
<td>114.1 ab</td>
</tr>
<tr>
<td>Piet Retief</td>
<td>15.74 c</td>
<td>15.57 bcd</td>
<td>69.8 c</td>
</tr>
</tbody>
</table>

|        | Irrigated     | Rain fed               |                   |                   |                   |
| mean   | 16.34         | 10.22                  | 69.3               | 87.4               | 138.1               | 115.6               |
| P. value | <0.001    | <0.001                 | <0.01              | <0.001             | 0.246               | 0.657               |
| Lsd    | 7.3           | 9.223                  | 30.70              | 43.98              | 34.09               | 29.63               |
| CV%    | 23.3          | 36.5                   | 29.6               | 14.8               | 11.0                | 7.5                 |
| Significance | ***         | ***                    | ***                | ***                | NS                 | NS                 |

*NB. Means in the same column followed by the same letter are not significantly different

There were significant differences (p<0.001) in number of fruits per tree both under irrigated and rain fed conditions. GXC 9 gave the highest number of fruits (142.2 fruits per tree) and GXC 11 gave the lowest number of fruits (41.87 fruits per tree) under irrigated conditions. Under rain fed conditions GXC 9 gave the highest number of fruits per tree (217 Fruits per tree) and GXC 7 gave the lowest number of fruits per tree (22.67 fruits per tree). The red Fleshed lines had significantly high number of fruits per tree compare to the white fleshed lines both under irrigated and rain fed conditions.
There were no significant differences in the average fruit size both under irrigated and rain fed conditions. The average fruit size ranged from 160.7 g (GXC 15) to 115g (GXC 7) under irrigated conditions. Under rain fed conditions average fruit size ranged from 137.3 g (GXC 3) to 101 g (GXC 1).

Results for fruit diameter, tree height, canopy diameter, stem girth and percentage of marketable yield for Piet Retief and 15 guava lines under irrigated conditions are presented in Table 2.

### Table 2. Fruit diameter, tree height, canopy diameter, stem girth and percentage of marketable yield for Piet Retief and 15 guava lines under irrigated conditions.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Fruit diameter (mm)</th>
<th>Tree height (m)</th>
<th>Canopy diameter (m)</th>
<th>Stem girth (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Irrigated</td>
<td>Irrigated</td>
<td>Rain fed</td>
<td>Irrigated</td>
</tr>
<tr>
<td>GXC1</td>
<td>61.3 abd</td>
<td>2.60 b</td>
<td>4.10 def</td>
<td>3.50 cde</td>
</tr>
<tr>
<td>GXC2</td>
<td>67.7 a</td>
<td>3.95 a</td>
<td>5.20 bc</td>
<td>4.25 abc</td>
</tr>
<tr>
<td>GXC3</td>
<td>65.10 ab</td>
<td>2.20 c</td>
<td>4.40 de</td>
<td>2.02 g</td>
</tr>
<tr>
<td>GXC4</td>
<td>62.3 abc</td>
<td>2.70 b</td>
<td>4.30 def</td>
<td>3.07 def</td>
</tr>
<tr>
<td>GXC5</td>
<td>65.97 a</td>
<td>3.20 b</td>
<td>4.53 d</td>
<td>3.50 cde</td>
</tr>
<tr>
<td>GXC6</td>
<td>63.07 abc</td>
<td>2.63 b</td>
<td>4.00 efg</td>
<td>2.57 fg</td>
</tr>
<tr>
<td>GXC7</td>
<td>59.40 bc</td>
<td>2.87 b</td>
<td>3.93 efg</td>
<td>2.80 ef</td>
</tr>
<tr>
<td>GXC8</td>
<td>63.90 abc</td>
<td>2.73 b</td>
<td>3.90 fg</td>
<td>2.60 fg</td>
</tr>
<tr>
<td>GXC9</td>
<td>62.10 abc</td>
<td>3.87 a</td>
<td>5.03 c</td>
<td>3.67 c</td>
</tr>
<tr>
<td>GXC10</td>
<td>61.70 abc</td>
<td>2.73 b</td>
<td>4.30 def</td>
<td>2.73 efg</td>
</tr>
<tr>
<td>GXC11</td>
<td>57.53 c</td>
<td>3.03 bc</td>
<td>4.35 def</td>
<td>2.87 ef</td>
</tr>
<tr>
<td>GXC12</td>
<td>66.10 a</td>
<td>2.70 b</td>
<td>3.90 fg</td>
<td>2.70 fg</td>
</tr>
<tr>
<td>GXC13</td>
<td>64.43 ab</td>
<td>3.87a</td>
<td>5.40 abc</td>
<td>4.50 a</td>
</tr>
<tr>
<td>GXC14</td>
<td>59.33 bc</td>
<td>2.53 c</td>
<td>3.8 g</td>
<td>2.71 fg</td>
</tr>
<tr>
<td>GXC15</td>
<td>62.32 abc</td>
<td>3.87 a</td>
<td>5.53 ab</td>
<td>4.23 ac</td>
</tr>
<tr>
<td>Piet Retief</td>
<td>62.20 abc</td>
<td>4.47 a</td>
<td>5.70 a</td>
<td>3.65 c</td>
</tr>
<tr>
<td>Mean</td>
<td>62.77</td>
<td>3.12</td>
<td>4.52</td>
<td>3.21</td>
</tr>
<tr>
<td>Lsd</td>
<td>5.522</td>
<td>0.66</td>
<td>0.428</td>
<td>14.5</td>
</tr>
<tr>
<td>CV %</td>
<td>5.3</td>
<td>6.3</td>
<td>5.7</td>
<td>0.775</td>
</tr>
<tr>
<td>Significance</td>
<td>*</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
</tbody>
</table>

*NB. Means in the same column followed by the same letter are not significantly different

There were significant differences (p<0.05) in fruit diameter. GXC 2 recorded the highest fruit diameter of 67.7 and GXC 11 had the lowest fruit diameter of 57.53 mm under irrigated conditions.

There were significant differences (P<0.001) in plant height, canopy diameter and trunk girth among the lines both under rain fed and irrigated conditions. Piet Retief had the highest plant height both under irrigated and rain fed conditions 4.47m and 5.70 m respectively. GXC 3 and GXC 11 had
the lowest plant height under irrigated and rain fed conditions 2.2 m and 3.8 m respectively. GXC had the biggest canopy diameter both under irrigated and rain fed condition 4.50 m and 5.05 respectively. GXC 3 and GXC 14 had the lowest canopy dimensions under irrigated and rain fed conditions 2.02 m and 2.78 m respectively. Trunk girth was highest in Piet Retief (39.00 mm) and was lowest in GXC 11 (57.53 mm).

A significant difference was also observed on percentage of marketable yield. The percentage of marketable yield was reduced by fruit fly damage. Fruit fly damage ranged from 14% to 49% of the total weight harvested.

Table 3. Flesh colour, general acceptability, average % acid, Total sugar %, pH, and % of marketable yield of Piet Retief and 15 guava lines under irrigated conditions.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Flesh colour</th>
<th>General acceptability</th>
<th>Average acid</th>
<th>Total Sugar %</th>
<th>PH</th>
<th>Marketable yield %</th>
</tr>
</thead>
<tbody>
<tr>
<td>GXC1</td>
<td>White</td>
<td>00 a</td>
<td>286 c</td>
<td>.22 d</td>
<td>17 abc</td>
<td>9.4 d-f</td>
</tr>
<tr>
<td>GXC2</td>
<td>Red</td>
<td>67 a</td>
<td>275 cd</td>
<td>.78 b-d</td>
<td>81 d</td>
<td>9.9 b-e</td>
</tr>
<tr>
<td>GXC3</td>
<td>White</td>
<td>66 a</td>
<td>259 de</td>
<td>.87 a-d</td>
<td>15 abc</td>
<td>9.6 ab</td>
</tr>
<tr>
<td>GXC4</td>
<td>White</td>
<td>00 a</td>
<td>113 j</td>
<td>.43 cd</td>
<td>17 abc</td>
<td>7.4 ab</td>
</tr>
<tr>
<td>GXC5</td>
<td>White</td>
<td>67 a</td>
<td>161 fgh</td>
<td>.95 a-d</td>
<td>17 abc</td>
<td>4.1 a-d</td>
</tr>
<tr>
<td>GXC6</td>
<td>White</td>
<td>67 a</td>
<td>147 hi</td>
<td>.34 cd</td>
<td>18 abc</td>
<td>5.9 a-c</td>
</tr>
<tr>
<td>GXC7</td>
<td>White</td>
<td>33 a</td>
<td>159 f-i</td>
<td>.63 b-d</td>
<td>29 a</td>
<td>1.6 ef</td>
</tr>
<tr>
<td>GXC8</td>
<td>White</td>
<td>67 a</td>
<td>148 hi</td>
<td>.9 a-d</td>
<td>09 c</td>
<td>5.2 a-c</td>
</tr>
<tr>
<td>GXC9</td>
<td>Red</td>
<td>33 b</td>
<td>137 i</td>
<td>.323 ab</td>
<td>86 d</td>
<td>9.1 ab</td>
</tr>
<tr>
<td>GXC10</td>
<td>White</td>
<td>00 ab</td>
<td>173 fg</td>
<td>.45 cd</td>
<td>14 abc</td>
<td>5.3 a</td>
</tr>
<tr>
<td>GXC11</td>
<td>White</td>
<td>33 a</td>
<td>180 f</td>
<td>.42 cd</td>
<td>12 bc</td>
<td>7 e</td>
</tr>
<tr>
<td>GXC12</td>
<td>White</td>
<td>00 ab</td>
<td>158 gh-i</td>
<td>.63 b-c</td>
<td>26 ab</td>
<td>1.3 d-f</td>
</tr>
<tr>
<td>GXC13</td>
<td>Red</td>
<td>00 ab</td>
<td>239 e</td>
<td>.94 a-d</td>
<td>81 d</td>
<td>4 a-c</td>
</tr>
<tr>
<td>GXC14</td>
<td>White</td>
<td>67 ab</td>
<td>173 fg</td>
<td>.49 cd</td>
<td>20 abc</td>
<td>5.8 e</td>
</tr>
<tr>
<td>GXC15</td>
<td>Red</td>
<td>0 c</td>
<td>724 a</td>
<td>3.05 a-c</td>
<td>10 e</td>
<td>5.1 a-c</td>
</tr>
<tr>
<td>Piet Retief</td>
<td>Red</td>
<td>67 ab</td>
<td>310 b</td>
<td>3.53 a</td>
<td>93 d</td>
<td>2.9 ab</td>
</tr>
</tbody>
</table>

Mean: 5.46 0.227 0.43 4.03 71.1
Lsd: 2.06 0.02 0.632 0.13 15.84
CV%: 22.7 8.3 3.9 0.04 13.4
P value: *** *** * *** ***

*NB. Means in the same column followed by the same letter are not significantly different

Significant differences were observed (P<0.001) for the general acceptability of the fruit and average % acid. The highest value of % acidity was recorded in GXC 15 (0.72%) which was followed by Piet Retief 0.31% and the lowest % acidity of 0.113% was recorded in GXC 4.

Mean panel scores of 6.0 and above were regarded as acceptable for general acceptability by consumers. There was a significant difference (p<0.05) between the lines on consumer preference for the lines. There were no significant differences among most of the lines except for GXC 15 and GXC 9 which were rated very sour and sour respectively.

There were significant differences in sugar % among the lines. Piet Retief had the highest sugar % of 10.53 % and GXC 1 had the lowest sugar % of 9.23 %. There were significant difference P<0.01 in
the pH of the lines. GXC 7 had the highest pH of 4.29 and GXC 15 had the lowest pH 3.10. The pH of the red fleshed lines was significantly lower than the pH of the white fleshed lines.

Under rain fed conditions the crop received a maximum rainfall of 550mm per year. Under irrigation the guava lines received a minimum of 1000 mm per year.

5. DISCUSSION
All the guava lines gave higher yields under irrigated conditions compared to under rain fed conditions. Under rain fed conditions the lines did not fully express their potential. Leiderman (24) and Dubey (25) obtained similar results that irrigated guava orchards had higher yield potential compared to rain fed conditions. The low yield was because of the drought stress experienced under rain fed condition. The rainfall was not evenly distributed. Water stress influenced a number of molecular and biochemical processes such as transpiration, photosynthesis, stomatal closure and, pigment content resulting in restriction of growth and development (26). The red fleshed lines were hardy and prolific bearers compared to the white fleshed lines because of their ability to produce satisfactory yield both under rain fed and irrigated conditions. The variation in yield, growth and fruit quality among the lines might be due to genetic variability (20).

The high number of fruits per tree in some of the lines under rain fed conditions might be due to a high number of flower buds formed. The plant height and canopy dimensions continued to increase from the time irrigation was stopped to the time when fruits were harvested under rain fed conditions. Despite the high number of fruits produced by some of the lines under irrigated conditions, the yield decreased because the fruit size was smaller than fruit size for irrigated fruits. The variation in total number of fruits among cultivars might be due fruiting behaviour as affected by the genetic characters as well as the agro-climatic conditions. This also suggests that the orchards raised through seedlings are likely to be inferior to those raised through asexual plants (16).

The range for fruit diameter for the lines is similar to the fruit diameter recorded by Babu et al. (27). The acid % is in the range observed by Gosh et al. (2). Line 15 was not generally acceptable to consumers because of the high acid %. The red fleshed lines had the highest canopy dimensions which might have contributed to the high yield. The fruit fly traps used in the experiment were not very efficient for the control of the fruit fly because the % of non marketable fruits due fruit fly damage for all the lines was very high.

6. CONCLUSION
GXC 2 is superior to other cultivars in terms of yield and consumer acceptability. Although GXC 9, GXC 15 and GXC 13 are not preferred by consumers as a fresh fruit the lines can be good for processing because they were the highest yielders. The high yielding guava lines are vigorous in growth. The high yield for the lines was attributed to the high canopy diameter and plant height. Guava lines with high yields are the way forward to improve the productivity of this fruit in Zimbabwe. The lines show good fruit quality and fruit yield potential comparative. The yield of the red fleshed lines outperformed the control.

Line GXC 2 is the best line for the fresh market because it is high yielding and preferred by most of the people who did organoleptic taste tests. The white fleshed lines were generally low yielding compared to the red fleshed lines although they were generally accepted by consumers. GXC 9 and GXC 15 are high yielding but not preferred because of the bitter taste. The bitter taste was due to the high acid % of the lines.

Guava production requires intensive control of fruit fly since losses from fruit fly damage are very high. Huge efforts have to be made to control fruit fly in the southeast low veld of Zimbabwe in guava production. Since a farmer can lose up to 85% of the yield to fruit fly damage.
7. **RECOMMENDATIONS**

GXC 15, GXC 9, GXC 13 and GXC 2 are promising lines for commercial cultivation. Farmers venturing into commercial production of guava should be encouraged to grow guava seedlings propagated asexually.

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FACTORS INFLUENCING THE UTILISATION OF MOBILE APPLICATIONS IN AGRICULTURAL MARKETING AMONG COMMUNAL FARMERS IN ZIMBABWE: THE CASE OF MASHONALAND CENTRAL PROVINCE.

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ABSTRACT

Market information allows farmers to make informed marketing decisions, it is therefore paramount for farmers to have access to up-to-date information. In a bid to increase market information access, new market information systems based on mobile application are being developed. However, despite the proliferation of these mobile applications in agricultural marketing, the majority of communal farmers are not yet utilising these applications to receive market information. Concurrently, the available literature provide scant empirical evidence on the factors influencing utilisation of these mobile applications among communal farmers in Zimbabwe. Therefore the main goal of this study was to determine the factors affecting utilisation of mobile applications in agricultural marketing by communal farmers in order to fill the knowledge gap. Data used in this study was collected from 96 randomly selected communal farmers in Mt Darwin and Muzarabani districts through a structured questionnaire as the main instrument. The findings showed that only a small proportion (44%) of interviewed farmers were using mobile applications in agricultural marketing. The binary logistic regression results revealed that farmers’ years of education, total farm income, awareness about mobile applications and lack of network coverage were the major factors significantly affecting the likelihood of a communal farmer to use mobile applications to receive agricultural marketing information. Therefore in order to propel the utilisation of mobile applications among communal farmers, capacity building is required to train farmers on how to use these new applications; developers of these mobile applications should embark on awareness campaigns and mobile operators and government should improve mobile network coverage in rural areas.

Key words: Mobile applications, agricultural productivity, food security, market information, poverty eradication.
1 INTRODUCTION

Market access and participation remains both a cause and consequence of economic development in developing countries like Zimbabwe (1). However despite being the most significant factor influencing economic development through triggering agricultural productivity and profitability, lack of market information has traditionally constrained communal farmers to participate and reach lucrative markets in developing countries (1, 2, 3, 4, 5). This is generally because, lack of market information results in high transaction costs (such as search cost) thereby limiting smallholder farmers’ market participation (6, 3, 5). Thus there is a critical need for provision of real time market information to communal farmers in order to enhance their market access (3, 4, 7, 8, 9). Concurrently, facilitating market access has been an issue of major concern to agricultural policymakers and development practitioners in developing countries like Zimbabwe (3, 5). Such efforts include implementation of market liberalisation policies (1, 2).

However it has been noted that, liberalisation of markets has failed to enhance market access and participation among communal farmers in marginalised rural communities (2). The failure of liberalisation efforts to spur significant impact shifted attention to enhance transparency and efficiency in agricultural marketing in order to reduce exploitation of communal farmers by middlemen (3). This has led to the development of Information and Communication Technology (ICT) agricultural marketing information systems specifically mobile applications aimed at providing market price information to communal farmers thereby empowering them for bargaining with traders and make informed decisions to choose among market opportunities (7, 8, 10, 11). These mobile platforms include among others, e- soko in Ghana (3, 5) and eco-farmer in Zimbabwe developed by Econet (12).

Nonetheless, despite these vast opportunities being ushered by mobile applications, the majority of communal farmers are not yet utilising these applications to access market information. Concurrently, the determinants of mobile application utilisation among communal farmers in agricultural marketing has not been rigorously and empirically addressed in Zimbabwe and study area in particular. Thus, there is still a knowledge gap about the drivers of mobile application utilisation among communal farmers to access lucrative markets in Zimbabwe. Notwithstanding the studies by (3, 5, 7, 13) which analysed the factors affecting the use of mobile applications in agricultural marketing, however these studies were conducted in other African countries and thus cannot be generalised to give insights to Zimbabwe communal farmers’ context. Hence calls for context specific analysis in order to contextualise the findings and provide practical policy inferences which might
help to propel the utilisation of mobile applications among communal farmers in agricultural marketing in Zimbabwe. Concurrently, bearing in mind that, availability of such mobile platforms can only translate into improved market efficiency if and only if farmers are using these platforms to access market information (7), it is important to determine the factors influencing their utilisation among communal farmers.

Therefore, it is against this background which prompted this research study in order to bridge the knowledge lacuna by exploring factors which determines the utilisation of mobile applications among communal farmers in agricultural marketing in Mashonaland Central province of Zimbabwe. The paper is therefore not aimed at restating the well-known evidence that the use of mobile applications significantly helps communal farmers to access lucrative markets and boosting their profit margins (3, 4, 8) but the approach is rather to reveal the determinants of mobile application utilisation among communal farmers. To this end the drivers influencing the utilisation of mobile application to access market information were analysed in order to probe the idea.

Owing to the contentious nature of defining mobile application, it is suggested that for the purposes of this study mobile applications should be considered as mobile phone based softwares designed to improve market linkages among communal farmers through provision of market information such as prices via short message services (SMSs) (10, 14, 15).

2. **OBJECTIVES OF THE STUDY**

This research study was shaped by the overall goal of determining the drivers of mobile application utilisation among communal farmers to receive agricultural marketing information. The specific objectives of the study were (i) estimating the extent of mobile application utilisation and (ii) to determine the factors influencing the utilisation of mobile application in agricultural marketing among communal farmers. It was hypothesised that, farmers’ socio-economic characteristics such as years of education and income levels positively influence mobile application utilisation among communal farmers.
3 METHODOLOGY

3.1 Source of data
Secondary data was employed in this study to determine the factors affecting the utilisation of mobile application in agricultural marketing among communal farmers in Mashonaland Central Province. Both quantitative and qualitative data was collected for the baseline survey conducted by Bindura University in July 2016. The main purpose for the baseline survey was for a situational analysis to determine the current status quo as far as the use of mobile applications in agricultural marketing is concerned among communal farmers in the province. This was also in a bid to assist the implementation of SMART Connect, an online agricultural marketing initiative in Mashonaland Central Province.

A multi-stage sampling technique was employed. Firstly, purposive selection of Muzarabani and Mt Darwin districts for the baseline survey due to their remoteness where farmers are more vulnerable to exploitation by middlemen hence a need to enhance the use of mobile applications for them to access lucrative markets. Secondly, the data was collected from randomly selected 96 farmers in Muzarabani (48) and Mt Darwin (48). Random selection of farmers was done with the aid of excel package through generating random numbers of farmers in an excel database of farmers obtained from field extension officers (FACHIG Trust). The main instrument that was used for data collection was the structured questionnaire consisting both qualitative and quantitative questions. The survey was participatory in nature hence respondents were participating in giving responses.

3.2 Analytical framework and variables specification
The descriptive statistics specifically percent distribution tables were used to analyse and present farmers’ socio-economic characteristics and the extent of mobile application utilisation among communal farmers to receive market information. The binary logistic regression model was employed to determine the drivers of mobile application utilisation in agricultural marketing among communal farmers.

3.3 Binary logistic regression model
The central objective that was analysed in this study was to reveal the factors influencing mobile application utilisation to receive market information among communal farmers. The dependent variable was specified as farmer mobile application utilisation status and it assume a value of 1 if the farmer use the mobile application and 0 otherwise. Such binary choice models are usually analysed through employing binary logistic or probit regression models (3).
Nevertheless, since it was noted that binary or probit models basically yield similar predictions, to explore this relationship the binary logistic model was estimated due to its mathematical simplicity (9, 16, 17, 18, 19). More specifically, the binary logistic model also concurs with the random utility framework and is a common model employed in adoption studies in which the likelihood of a dichotomous outcome (utilising or non-utilising) is related to a vector of independent variables (3, 5, 7, 9, 11, 17).

Basically the random utility model is the major identified theoretical framework employed to model farmers’ adoption to a certain agricultural technology (16, 17). Thus in relation to this study, the major assumption made here is that, farmers use mobile application in agricultural marketing only when perceived utility or benefits from using it are greater than not utilising the mobile application (5, 11). It is also important to note that, regardless the fact that utility of the farmer is not directly observed but his/her actions will be observed through the choices s/he made (18). Therefore, in this study the binary logistic model was used following the underlying assumptions of random utility framework.

Considering where \( P_i \) denotes the probability of the \( i \)th farmers’ decision whether to use mobile application and \((1-P_i)\) is the probability of non-utilising, the odds of utilising \((Y=1)\) versus the odds of non-utilising \((Y=0)\) can be defined as the ratio of the probability that a farmer use \( (P_i) \) to the probability of non-using \( (1-P_i)\), namely odds= \( P_i/(1-P_i) \). Taking natural logarithms the prediction function for an individual farmer will be given as:

\[
\ln \left( \frac{P_i}{1 - P_i} \right) = b_0 + \sum_{i=1}^{n} b_i X_{ki} = Z_i \ldots (1)
\]

On equation (1) above, \( Z_i \) is referred to as the odds ratio in favour of mobile application utilisation in receiving marketing information, \( b_0 \) is the intercept term and \( b_i \) are the coefficients to be estimated associated with each of the \( k \) explanatory variables \( X \) (17).

The \( X \) vector of explanatory variables consists of socio-economic variables and institutional factors assumed to influence the likelihood of an individual farmer to use the mobile application or not. For instance it was hypothesised that, farmers’ awareness about mobile application (eco-farmer) positively influence the utilisation of mobile application among the communal farmers. Evidence from previous studies indicated that farmers who are aware of mobile applications are more likely to use them in agricultural marketing (7).
Farmers’ years of education was assumed to positively influence the likelihood of communal farmers to use mobile application in agricultural marketing. Earlier findings noted that, education is expected to have a positive relationship with the decision to use mobile application thus those farmers with more years of education would be able to understand the benefits of such new technologies (3, 7). Similarly, access to extension service is expected to positively influence the use of mobile application in agricultural marketing. According to (5) it was revealed that, farmers with contact with extension agents are more likely to use mobile applications since extension agents can help to explain complex terminologies to farmers.

Availability of mobile network coverage was also hypothesised to positively influence the utilisation of mobile application in agricultural marketing. This was based on earlier findings which indicated that, access to infrastructure such as electricity and network facilities greatly influence the use of ICT based applications in agriculture (7). Furthermore our prior expectation was that, farmers with higher farm incomes are more likely to use mobile application to access agricultural market information as compared to their counterparts. This is generally because farmers with more incomes have higher purchasing power and the capacity to buy a mobile phone and subscribe to mobile applications (7).

Likewise, it was also hypothesised that farmers who belong to a farming group are more likely to use mobile application in agricultural marketing. This is due to the fact that, membership into a farming group entails more social capital and opportunities for farmer to farmer extension in disseminating information about the advent of novel mobile applications to access markets (7).

Also interaction with other farmers build personal trust and relationships hence recommendations from other fellow farmers significantly increases the likelihood of mobile application utilisation among communal farmers (5). Last but not least, gender of the farmer was also assumed to play a pivotal role in the use of mobile applications in agricultural marketing. It was assumed that male farmers are more likely to use mobile applications basically because of high influential power with regards to decision making than their female counterparts. A complete description of variables is outlined as shown in table 1 below.
3.4 Ethical considerations

With regards to ethical issues, the purpose of the study was clearly explained to farmers and local leaders. Also the respondents were asked for their willingness to participate in the study and those who were willing to participate were interviewed. It is also more important to note that, farmers were assured that all the information provided in this study was for the purpose of this study only and strictly confidential.

Table 20: Description of variables used in binary regression model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Measurement</th>
<th>Expected sign</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent variable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mobile application utilisation status</td>
<td>Whether the farmer use the mobile application to receive market information or not</td>
<td>Dummy variable (1 if the farmer use mobile application and 0 otherwise)</td>
<td></td>
</tr>
<tr>
<td>Independent variables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farmers’ awareness about mobile applications</td>
<td>Whether a farmer is aware and have knowledge of mobile applications in agricultural marketing</td>
<td>Dummy variable (1 if the farmer is aware and 0 otherwise)</td>
<td>+</td>
</tr>
<tr>
<td>Farmers’ years in education</td>
<td>Actual number of years spend in education</td>
<td>Continuous</td>
<td>+</td>
</tr>
<tr>
<td>Frequency of extension agent access per week</td>
<td>Number of times a farmer meets with extension agent per week</td>
<td>Continuous</td>
<td>+</td>
</tr>
<tr>
<td>Availability of network coverage</td>
<td>Mobile network availability and accessible within the area where the farmer resides</td>
<td>Dummy variable (1 if the network is available and 0 otherwise)</td>
<td></td>
</tr>
<tr>
<td>Farmers’ annual income</td>
<td>Actual amount of the farmers’ annual income</td>
<td>Continuous</td>
<td></td>
</tr>
<tr>
<td>Membership in a farming group</td>
<td>Whether a farmer affiliates to any farming group or not</td>
<td>Dummy variable (1 if the farmer belongs to a farming group and 0 otherwise)</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>Gender of the farmer</td>
<td>Dummy variable (1 if male and 0 otherwise)</td>
<td></td>
</tr>
</tbody>
</table>

Source: Survey data, 2016
4 RESULTS

4.1 Socio-economic characteristics of farmers

The results showed that 86 percent households were male-headed and with respect to age-wise, 80 percent of all interviewed farmers were above 40 years of age showing that the youth are less engaged in agricultural production in these 2 districts. At the same time, majority of households (68 percent) have households size between 5-9 members.

Regarding education level, 43 percent of farmers achieved secondary education while 6 percent attained tertiary education and 45% only completed primary level and the remaining 6% never go for education. With respect to incomes the majority of interviewed farmers had an annual income of below $1000 with 33% and 22% living off a total of less than $500-999 and $500 a year respectively. These results are summarised in table 2 below.

Table 21: Demographic and socio-economic characteristics of farmers

<table>
<thead>
<tr>
<th>Variable</th>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender of household</td>
<td>Male</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>20</td>
</tr>
<tr>
<td>Age of household head</td>
<td>20-29</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>30-39</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>40+</td>
<td>80</td>
</tr>
<tr>
<td>Household size</td>
<td>1-4</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>5-9</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>10+</td>
<td>5</td>
</tr>
<tr>
<td>Education</td>
<td>Not educated</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Primary</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Secondary</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>Tertiary</td>
<td>6</td>
</tr>
<tr>
<td>Estimated total annual income (USD)</td>
<td>0-499</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>500-999</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>1000-4999</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>5000+</td>
<td>14</td>
</tr>
<tr>
<td>Total annual income from agriculture</td>
<td>0-499</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td>500-999</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>1000-4999</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>5000+</td>
<td>12</td>
</tr>
<tr>
<td>Total off-farm annual income</td>
<td>0-499</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>500-999</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>1000-4999</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>5000+</td>
<td></td>
</tr>
</tbody>
</table>

Source: Survey data, 2016
4.2 Crop and livestock production status

A total of 64 percent of farmers were affiliated to one or more farming groups, with 56 percent belonging to a FACHIG farmer group and 8 percent belonged to either tobacco and cotton contract groups. All the interviewed farmers own at least a hectare where they produce both crops and livestock. The major crops grown by farmers are maize, groundnuts, soybean, tobacco and cowpea among others. With regards to livestock production, most farmers produce cattle, goats, indigenous chicken and broilers. The majority of interviewed farmers keep at least 1 cattle, 2 goats and 2 indigenous chickens.

4.3 Extent of mobile application utilisation among communal farmers

With regards to the extent of mobile application utilisation, the findings indicated that only a small proportion of communal farmers (44%) use mobile applications to receive market information whilst 56% of interviewed farmers were not using mobile applications in agricultural marketing. These findings agree with our prior hypothesis and also corroborates with prior studies conducted in other African countries such as Malawi which indicated that majority of communal farmers were not using mobile based information services due to lack of awareness about the importance of these novel initiatives (7, 13). Therefore, more efforts are needed to advance the use of mobile applications in agricultural marketing among communal farmers.

4.4 Binary logistic regression results

In order to reveal the factors influencing the use of mobile application in agricultural marketing among communal farmers a binary logistic model was employed. We estimate the estimated the logistic model with mobile application utilisation status as the dependent variable (1 if the farmer use the mobile application to receive market information and 0 otherwise). The Nagelkerke Pseudo R-square of 0.887 and the p-value of 0.000 for Wald test shown that the model fits the data quite well.

Basically, the results indicated that among explanatory variables included in the model farmers’ awareness about mobile applications, farmers’ years of education, availability of mobile network and farmers’ annual income significantly influence the utilisation of mobile applications in agricultural marketing among communal farmers. The results of binary logistic model are outlined in table 3 below.
**Table 22: binary logistic regression results on factors affecting mobile application utilisation**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>Wald</th>
<th>Significance</th>
<th>Exp (B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farmers’ awareness about mobile applications</td>
<td>3.570</td>
<td>1.992</td>
<td>3.211</td>
<td>.073**</td>
<td>35.5</td>
</tr>
<tr>
<td>Farmers’ years in education</td>
<td>.984</td>
<td>.323</td>
<td>9.261</td>
<td>.002*</td>
<td>2.67</td>
</tr>
<tr>
<td>Frequency of extension agent access per week</td>
<td>-1.131</td>
<td>1.607</td>
<td>.495</td>
<td>.482</td>
<td>.323</td>
</tr>
<tr>
<td>Availability of network coverage</td>
<td>4.038</td>
<td>1.779</td>
<td>5.152</td>
<td>.023*</td>
<td>56.7</td>
</tr>
<tr>
<td>Farmers’ annual income</td>
<td>.006</td>
<td>.003</td>
<td>3.781</td>
<td>.052**</td>
<td>1.00</td>
</tr>
<tr>
<td>Membership in a farming group</td>
<td>.348</td>
<td>1.446</td>
<td>.058</td>
<td>.810</td>
<td>1.41</td>
</tr>
<tr>
<td>Gender of the farmer</td>
<td>.420</td>
<td>1.416</td>
<td>.088</td>
<td>.767</td>
<td>1.52</td>
</tr>
<tr>
<td>Constant</td>
<td>-12.665</td>
<td>4.529</td>
<td>7.819</td>
<td>.005</td>
<td>.000</td>
</tr>
<tr>
<td>Nagelkerke R Square</td>
<td>0.887</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**DISCUSSION OF FINDINGS**

From the binary logistic results presented above it was noted that, availability of mobile network positively influence the use of mobile applications among communal farmers in the study area (p-value < 0.05). More specifically it was revealed that, farmers located in areas where there is strong network coverage are 56.7 times more likely to use mobile application (eco-farmer) in agricultural marketing as compared to their counterparts. This corresponds to our prior expectations and other findings with indicated that strong access to services such as electricity and network significantly influence the use of ICT based technologies in agricultural marketing (7).

Furthermore, it was also noted that farmers’ awareness about the mobile applications positively influence the use of mobile application to access agricultural marketing information (p-value <0.1). Precisely, it was revealed that if a farmer is aware about mobile applications is about 35.5 times more likely to use mobile application to receive agricultural marketing information. This agrees with the prior expectations and other findings which indicated that awareness of ICT based information services in agriculture is a critical factor affecting the use of mobile applications in agricultural marketing (3, 7, 10).
Likewise, farmers’ years of education was found to positively affect the likelihood of mobile application utilisation in agricultural marketing among communal farmers which agrees with our prior expectations (p-value< 0.05). It was noted that, farmers with more years of education are 2.68 times likely to use mobile applications in agricultural marketing as compared to their counterparts in Mashonaland Central province. This also corroborates with other prior studies which revealed that farmers with more years of education would be able to understand the benefits and how to use mobile applications hence a positive relationship with mobile application utilisation in agricultural marketing (3, 7, 9, 11). These findings suggest that education level of the farmer is integral with respect to the use of mobile applications to receive market information among communal farmers hence a need for farmer training on how to use mobile applications. Indeed, technology embracing and use literature has long acknowledged the importance of education on adoption of new novel initiatives among communal farmers (3, 9).

Last but not least, the study findings revealed that farmers’ income positively influence the use of mobile application (eco-farmer) to receive agricultural market information which agrees to our prior expectations (p-value < 0.1). It was noted that farmers with higher incomes are 1.01 times more likely to use mobile application in agricultural marketing. Similar findings were also noted in other African countries which indicated that farmers’ income is positively related to the use of mobile application in agricultural marketing among communal farmers (3, 6, 7). This is generally because farmers with high incomes are financially stable and they have capacity and ability to buy mobile phones and subscribe to mobile applications to receive market information (6).

7 CONCLUSION
This study was aimed at exploring the extent of mobile application and determining the drivers influencing the utilisation of such mobile applications in agricultural marketing among communal farmers in Mashonaland Central Province in Zimbabwe. With regards to the extent of mobile application, it was noted that small proportion of farmers (44%) were using mobile application (eco-farmer) to access agricultural market information during the period under review. Therefore in order to answer why such a small proportion of communal farmers use mobile applications, a binary logistic regression model was employed to figure out the drivers of mobile applications utilisation in agricultural marketing. The findings revealed that farmers’ awareness about mobile application, years of education, availability of mobile network coverage and farmer’s annual income were the factors significantly and positively influence farmers’ likelihood of mobile application utilisation in agricultural marketing. Consequently, it was concluded that farmers’ education level and income as
well as prior knowledge and awareness about mobile application plays a pivotal role with regards to the use of mobile application in agricultural marketing. Likewise, it was noted that mobile network availability in farmers’ localities in this case Econet mobile network significantly affect the use of mobile application in agricultural marketing among communal farmers in Muzarabani and Mt Darwin districts.

8 RECOMMENDATIONS
The findings of this study implies that, in order to boost the utilisation of mobile application and break the digital divide in communal farming areas it is crucial for the developers of these novel initiatives to embark on massive awareness campaigns and capacity building workshops to advertise and train farmers on how to use these new applications thereby enhancing transparency and efficiency in agricultural marketing. Concurrently, mobile operators and government should improve mobile network coverage in rural areas to stimulate the use of mobile applications among communal farmers since in areas without network coverage farmers cannot send and receive text messages from mobile applications.

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HOUSEHOLD WELFARE IMPACTS OF SORGHUM PRODUCTION DIFFERENTIALS IN SEMI-ARID ZIMBABWE: TOWARDS STRENGTHENING CLIMATE CHANGE ADAPTATION

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ABSTRACT

Attaining food and income security remains a challenge in rural Southern Africa. Sorghum production is regarded as a gateway out of poverty in arid and semi-arid zones. The paper uses propensity score matching and endogenous switching regression to estimate impacts of sorghum land allocation differentials on welfare. Household dietary diversity score and household food insecurity access score were used as proxies for food security. Productivity and net income gains were also adopted for analysis. Data were generated from 380 households in a representative survey conducted with five purposively selected wards in Mid Zambezi Valley of Zimbabwe. Analysis of the data shows that number of associations to which household members belonged, market prices, household income, age of principal decision maker, dependency ratio, ownership of draught power and storage facilities have implications on income and food security. Counterfactual analysis shows that farmers who allocate more land towards sorghum are relatively better off in food diversity and access, productivity and net returns. To enhance these gains, social networking could be strengthened through local, government and private partnerships. Market size can also be increased so as to improve the prices offered to farmers.

Key words: food security, land allocation, smallholder farmers, propensity score matching, endogenous switching regression
1 INTRODUCTION

Sorghum (*Sorghum bicolor* (L.) Mench) has generally been marginalised from mainstream development strategies in Southern Africa (1,2). However, sorghum driven food and income security remain important discussion points in the rural development debate in the region (3,4,5). Most countries in Southern Africa, including Zimbabwe are small open economies experiencing food insecurity due to limited livelihood options triggered by high costs of production and trading (6). Zimbabwe also inherently depend on agricultural activities for GDP, forex generation and employment (7). In the advent of declining performance in the sector and increased incidences of food insecurity and malnutrition, a number of interventions have been implemented by both the public and private domains to support the subsector (8). Re-embracing sorghum in the land allocation decision making processes has evidently emerged especially in the arid and semi-arid zones (9,10,11). It is however important to examine the welfare impacts of these decisions among farming households.

(12) reported the welfare effect of adopting high yielding and hybrid seed in Sudan Savanna of West Africa. They noted that adoption of the seed resulted in higher yields, harvest share that is sold and dietary diversity.

Mechanisms for enhancing sorghum productivity through adoption of innovations and strengthening market linkages have been embraced at different administrative, spatial and temporal scales. The aim is to design and sustain strategies which address both the means and dimensions for attaining household welfare improvement. One approach simultaneously addressing these aspects is by integrating smallholder farmers into sustainable commercial food systems (13). This has been attempted through strengthening institutions and policies which catalyse low cost identification and intensification of viable sorghum based innovations (14,15). As noted by (16) and (17), similar transitions have however mainly been driven by policy shifts, albeit in a preferentially biased manner. Notably, food security policies in Zimbabwe have been primarily anchored on maize production, processing, marketing and consumption systems. This is the case even in marginalised areas where the crop is not as strategically competitive as small grains including sorghum (18). The mentality has compromised effectively beneficial crop and livestock intensification prospects and worsened the poverty status of farming households whose main livelihood is agriculture.

(16) and (19) define food security as a stable state in which all people perpetually have both physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for a healthy and active life. In most parts of rural Zimbabwe, households have been reported to be food insecure primarily because they cannot guarantee access to their food requirement through socially acceptable means (2). The observable consequences of food insecurity are on nutrition status, health and overall economic productivity (20). With unpredictable rainfall patterns, unstable prices for cereal crops and reduced government control in markets expected to push maize out of arid and semi-arid zones of Africa (21,22,12), there is imminent need to identify and support strategies that provide new avenues for enhanced food and income security in these areas (23). This matrix demands informed and responsive land allocation decisions based on appropriate crop choices.

The immediate option is reverting to sorghum production which once dominated the crop mix in these climate change sensitive environments (24,25). The crop has resilient capabilities to climate adversities coupled with
multiple potential uses including domestic consumption, stock feed, provision of energy and beer brewing (12,26). Despite its economic and health related potentials, value chain stakeholders including farmers shun the enterprise due to inadequate institutional support and high transaction costs. This induces poor enterprise performance primarily due to limited investment effort by farmers and other value chain actors alike (2). On one hand, farmers cultivate the crop on small pieces of unproductive land using low yielding varieties which are also susceptible to incidences of pests and diseases. On the other end, processors and consumers are invisible to the farmers along rewarding value chains leading to exploitation by middlemen (27). The result is that in most parts of semi-arid Southern Africa, the welfare enhancing space for sorghum is therefore presently missing and/or untapped.

In response to this, several sorghum seed development, financing, production and marketing support programs have been implemented by a number of partners in the mid-1990s (15). These efforts left residual positive externalities in the farming communities. We hypothesise that in such environments, farmers are at least aware of the potential benefits of increasing land under sorghum. There is widely held consensus that opportunities exist to pick up from these efforts and increase land allocated towards sorghum production for income and food security benefits (21,18). The expectation is that it will emerge as a livelihood stability enhancing strategy for improving household welfare and general economic development. However limited studies (see for example (12) have examined the welfare impacts of sorghum production decisions on household welfare. To bridge this gap, the study adopts a combination of propensity score matching (nearest neighborhood) and endogenous switching regression modeling to ascertain causality of increased sorghum land allocation on welfare as shown by prime indicators of income, productivity and food security gains.

2 OBJECTIVES

The objective of the study was to examine the household welfare (food access and food diversity, income, productivity) impacts of differential sorghum production scales in the small-scale sector of the Mid Zambezi Valley in Zimbabwe.

3. METHODOLOGY

3.1 Description of study area

The study was conducted in the Mid-Zambezi Valley of Zimbabwe which stretches along Kanyemba at the Zambezi River in the North to the Muzengezi River near Mahuwe in the East. Specifically, Mbire district (Figure 3.1), located at Degrees Minutes Seconds (DMS) coordinates -16°09'32" S and 30°34'21" E or -16.1589 and 30.5727 in Decimal Degrees (DD) or Universal Transverse Mercator (UTM) coordinates of 36K 240249.9488 and 8211076.5675 was selected for the study. The district is in Mashonaland Central Province and is the youngest district in Zimbabwe established in 2001 with 17 administrative wards. The area lies at an average elevation of 373m above sea level and is semi-arid receiving below average and erratic rainfall coupled with high temperatures. Mbire has a population of 82 380 inhabitants and a density of 17.54/km² which is increasing at an average of 1.09/year (28). There is a balanced composition of males and females in the area with a 50 % representation in the active 15-64 years’ category.
Temperatures in the area average 30°C with no significantly distinct seasonal variations even though winters can be as cold as 8°C in June and July in the mornings and evenings. An annual rainfall ranging from 350 to 550 mm is received in Mbire district. Extreme water scarcity is experienced in the long dry season which stretches from April to October. Availability of water improves in the wet season spanning from November to March. Despite the poor sandy soils, erratic rainfall and crop destruction by wildlife, households in the Mid Zambezi Valley still depend on agriculture for subsistence and cash income. Cotton has for long dominated livelihood options alongside sorghum, maize and soyabean. However due to the global decline in cotton market prices, livestock rearing which has also been practiced in the area mainly with goats and cattle has become a very strong option for income generation. Wildlife ranching also forms a core of the livelihood strategies for the local communities. Communities also depend on informal trade in clothing, fruits and locally produced hardware. These activities are dampened by the limited infrastructural development initiatives in road networks and ICT platforms which tend to isolate these communities from mainstream markets.

Mid Zambezi Valley, also known as the Dande area, is a blend of different cultures including Korekore, Chikunda, Doma and immigrant Karanga ethnic communities. These have varied livelihood strategies with for example the Doma being nomadic hunters and Karanga known to accumulate cattle and use modern technologies in agriculture (29). These cultural dimensions can have a significant influence on multiple crop production decisions by the households. Flooding is also common in the area and farmers have adopted the retreating approach as a coping strategy. Three major rivers namely Angwa, Hunyani and Monozi cut across the district and people who live along these rivers are usually affected by the flooding which also destroys infrastructure. The area is located away from the main urban trading areas and is 200km North-East of Harare and 100km from Mvurwi. As such, farmers mainly depend on informal local markets with intermittent traders coming into the communities to trade at the farm gate during some marketing seasons.

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2Programmes including CAMPFIRE and REDD+ have been implemented in these areas. The Lower Guruve Development Association (LGDA) has partnered with other NGOs such as Action Plan to sustain these efforts.

3As floods approach farmers retreat to highlands and when the floods have subsided they return to their homesteads to benefit from the moisture and flood debris which usually improves soil fertility. For a detailed explanation of the practice. For more detail on the practice, see (30).
Sampling frame and sample selection

The study area was selected purposively as it is a major sorghum producing zone in the Mid Zambezi Valley where the crop has the potential to generated income and food security gains. The population was made up of small scale farming households in the Mid Zambezi Valley of Zimbabwe. A multistage sampling approach with purposive selection of five wards which are dominant sorghum producing areas and population based proportionate selection of farmers was used since there was population variability across the sampled wards.

Five Wards namely Chisunga (Angwa), Mahuwe, Gonono, Chikafa and Chitsungo were purposively selected. The first four are dominant sorghum producing areas. Gonono and Chikafa are close to the border with Mozambique and their inclusion offers an opportunity to understand decisions in communities with mixed cultures and relations. Mahuwe is centrally located while Chisunga (Angwa) is at the periphery of the Mid Zambezi Region and close to Zambia. Chitsungo is a unique Ward where sorghum production is minimal due to the cultural inclination of the inhabitants who believe that maize should remain the staple cereal crop. This inspired its inclusion in the sample so as
to understand the hurdles faced by potential sorghum farmers who can benefit from networking with others in dominant sorghum producing wards.

A representative sample was then randomly selected to get 380 farmers\(^4\) who participated in a survey which generated cross sectional data in April 2016. The sample size calculator with a known population of 14,500 farmers was used to come up with the sample size. This was also validated using a standard sample size table. The specific sample sizes per ward which were calculated proportionately are as follows, with the number of farmers in parenthesis as Ward 2 (80); Ward 4 (79); Ward 10 (50); Ward 12 (70) and Ward 15 (101). These farmer numbers represented the relative farmer populations per ward and by acknowledging the population differences across the wards, the proportionate sampling increased sample representativeness.

3.3 Data collection procedures

This study made use of both primary and secondary data sources. Primary data on existing networking arrangements, land allocation, crops produced, subsidy access and market conditions were collected using a structured questionnaire as the main data collection tool. The questionnaire document consisted of question items that solicited information from a subject to facilitate objective research analyses. The questions were specifically focusing on the demographics of the households, household production patterns, income and asset base structures, the marketing decision making frameworks, the food sourcing, consumption and security patterns and perceptions of households on their relationships with various value chain stakeholders. Triangulation was done using a Focus Group Discussion.

3.4 Measuring food security

Food security is universally acceptable as an integral component of welfare and can be analysed at varied global, regional, national, community and household levels (31,32,8). Food secure households do not necessarily depend on emergency food aid or other socially unacceptable ways of acquiring food. The study isolates a number of variables from welfare indicators related to the income and food security domains. These include household food access and diversity, productivity and household income. Significant work has been done to understand food security dimensions (32,33) and the most commonly used indicators of food security revolve around consumption and the associated expenditure. We borrow from this mentality and as further guided by (8) who adopted the Household Food Insecurity Access Prevelance (HFIAP) in the Eastern Cape Province of South Africa, the study uses the diversity of consumed food and adequacy of food access.

Adopting the Coping Strategies Indicators\(^5\) has not been widely used in food security studies. The Coping Strategy Index (CSI) was however successfully used in some studies (32,34). The technique reduces the chances of categorising food insecure households as being food secure. The Food Security Ratio (FSR) has also been used in a study by (35) to show how own production and purchases can

\(^4\)A sample size of 252 is reported in the results and discussion section (Chapter 4) since the study censored non-adopters from the total sampled households (380) and analysed behavior of adopters in terms of their proclivity to either intensify sorghum production or not before examining the income and food security differentials. There was variability in farmer populations across the wards and representative proportions were selected from each ward.

\(^5\)The current study could not use the Coping Strategy Index (CSI) since farmers could not easily recall the strategies adopted during the review period.
meet household energy needs. However it is usually inaccurate since determining the exact values of the two inputs is a challenge with most social science based studies.

The household dietary diversity score (HDDS) and the household food insecurity access score (HFIAS) have widely been used as proxies for food security (20,33). The study adopted the Food and Nutrition Technical Assistance Project guidelines to develop these food security surrogates. There is widely held consensus that these two indicators of food insecurity can adequately accommodate the dimensions of food insecurity, namely uncertainty and anxiety about food, insufficient quantity and inadequate quality (32).

3.4.1 Household dietary diversity score (HDDS)

The advocacy for using the HDDS as a measure of food security is not new in food security studies. The HDDS is defined as a measure based on a recall of all food or drink items consumed by the household members during the last 24 hours. It is a useful proxy for food security and has widely been used in literature across the world in various contexts (33,36). Its main strength is that it has a very strong co-relationship with key food security indicators such as the adequacy of a household’s intake of proteins, calories and other nutrients. Literature acknowledges that analysing dietary diversity using individual foodstuffs has a weaker nutrient adequacy prediction capacity than when using food groups (20). The argument is that for example an isolated energy adequacy observation might not be enough to sustain an active life since some nutrients might be missing in the diets. It therefore becomes integral to factor in key nutritional quality indicators in household food security studies.

Dietary diversity is a varied and composite consumption based indicator showing nutrient availability and reflects on the household’s income capacity (as shown by per-capita income) to consume multiple food stuffs. Empirical evidence shows that a high HDDS can be confidently used to reflect on balanced diets and lower incidences of malnutrition (20). High intakes of starch based diets will yield low HDDS values which are an indication of limited micro nutrients (8). In a study by (33) the HDSS was generated from 14 food groups consumed within the household excluding those consumed outside the household. However (20) used a scale of 0-6 in a study conducted in Taiwan. We adopted the six-point scale given the limited diversity observed from the universe of food items which yielded 93 items.

The score was then computed as the total sum of the food groups consumed in the household. An equal weighting of one is given to each food group. The major weakness of the score is that it does not allow for estimates to be made with respect to how much food is lacking in a diet because it cannot directly quantify the amount of food consumed. Additionally, the measure does not explain causality for observed consumption patterns (36). There are also methodological shortfalls associated with the measure in terms of universally acceptable food groups and food types to include (see for example (20) and (33). Additionally, even though HDDS as a measure of food security can effectively be used to trace changes in dietary energy uptakes, it cannot adequately be used to explain nutrient adequacy. The study used 252 households and questions were presented to them so that they recalled food and drink stuffs consumed in the past 24 hours. We then classified the foods into 6 distinct categories with

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A net sample of 252 households was used. Refer to section 3.2 above.
a score of 1 for yes and 0 for no. The classifications were grains and rice, fat and oils, dairy, meats, vegetables and fruits.

\[ HDDS = \sum_{i=1}^{n} x_i \]  

(1)

Where:

- \( HDDS \) is the score
- \( x_i \) is the food group consumed by household member.

### 3.4.2 Household food insecurity access score (HFIAS)

According to (33), (32) and (8), the HFIAS is a continuous access measure of the degree of household food insecurity over the past 30 days. The measure is an indicator of household food insecurity in terms of insufficient food supplies and assumed quality thereof. It also factors in anxiety about household food insecurity which is an important indicator. (8) noted that HFIAS is a more subjective measure since it captures the household members’ perception about the consumed diets and this may completely miss the nutritional composition of these diets. The score pays attention to consumption-related strategies and is concerned with the household members’ behavioural and psychological responses to food insecurity as they perceive it. Using the survey, a score was generated based on a much-held assumption that based on long-term consumption experiences, respondents were able to relate to their food insecurity status with some level of confidence. Eight distinct categories of occurrences were isolated in the study as:

- “1 = Anxiety about food (in)adequacy; 2 = Eating foods of a limited variety; 3 = Eating less-preferred foods; 4 = Inability to eat even the less-preferred foods; 5 = Eating smaller meals than needed; 6 = Eating fewer meals in a day; 7 = Going to bed hungry; 8 = Failing to obtain food of any kind during the whole day or night”.

The progression from 1 to 8 shows increasing insecurity. A binary response was used as yes (1) and no (0) depending on whether any of the 8 occurrences were encountered in the household over the past 30 days. A severity question which was based on frequency of occurrence was assigned as a follow up to the occurrence observation over the same period. A scale was developed as, “1 = rarely, 2 = sometimes, and 3 = often”. This implies that the range for the HFIAS was 0-24. Guided by (31), the HFIAS is therefore computed as:

\[ HFIAS = \sum_{i=1}^{8} x_i f_i \]  

(2)

Where:

7A household whose HFIAS score is high has high levels of food insecurity. Different ranges have been reported in literature (for example 33,34) but the present argument still holds. We adopt the narrower spectrum of the responses since wider ranges would imply more possible responses which can compromise the ability of respondents to place their response in a particular specific category.
- $HFIAS$ is the score
- $X_i$ is the food insecurity occurrence observation
- $F_i$ is the frequency of occurrence.

### 3.5 Effects of sorghum production intensification

Attempts to estimate the impact of an innovation on household welfare can be done using indicators such as income, consumption and yield changes (37,38,39). The study uses the same approach with differential land allocation decisions towards sorghum in semi-arid rural areas of Zimbabwe. Doing this from non-experimental events is usually challenging since we have to deal with the unobserved outcome dimension for the inclusion state in the event that farmers who have allocated more land towards sorghum had not done so (40). This challenge is easily addressed in experiments by randomly assigning a control whose outcomes represents the pseudo non-intensification state. However, it is imperative to note that deciding to allocate more land towards sorghum as a state is not randomly distributed in a sample but peculiar to an individual household’s potential to utilise the available information and resources. This implies potential systematic differences between farmers who intensify and those who do not intensify sorghum production. It is therefore necessary to use econometric techniques which account for this potential selection bias whenever innovation impact evaluation studies are carried out (38,41).

Some studies have attempted to use Average Treatment Effects (ATE) k-factors to understand the impact of agricultural technology. However, employing these approaches may not be the best if farmers are rational and profit maximising agents. ATE has been reported to be zero even in cases where the k-factors are large enough to justify high impact technologies. This distorts the meaning of the k-factors as for example the measures of productivity increases induced by a change in practices. Additionally, attempting to evaluate innovation impact on this basis limits the scope of the evaluation since it is an effective toolkit for the binary definition of adoption which does not clearly cater for the intensity component of adoption. This becomes inappropriate in this study since the objective is to trace intensity of sorghum land allocation and its effects on income and food security.

The matching approach which is also technically based on the ATE philosophy has also been adopted in some studies. This study used a combination of matching techniques with Average Treatment Effect on the Treated (for the observable outcome) and endogenous switching regression (for the unobservable outcome). This approach has also been successfully used in agricultural innovation impact evaluations (42,43). Switching validates the matching results and this eliminates the challenge of having non-zero treatment effects (for example as is the case with large k-factors) which do not necessarily reflect the direct impact of an innovation but other factors including non-separability. Switching therefore eliminates hidden selection bias that might set in due to some latent variables (44). The choice of this analytical toolkit was also influenced by the nature of the sample which is fairly large enough to overcome the dimensionality problem and has substantial overlap between the control and treatment categories. In the present context, confounding is also assumed to be minimal.

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8For more detailed use of propensity score matching, see (45)
since we controlled for alternative, non-causal explanations for anticipated observations in the relationship between the dependent and independent variables.

4 RESULTS AND DISCUSSION

4.1 Food security indicators

The data indicated significant variations within the isolated categories for both Household dietary diversity score (HDDS) and Household food insecurity access score (HFIAS) (Table 1).

<table>
<thead>
<tr>
<th>Indicator category</th>
<th>Proportion (%)</th>
<th>Difference-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non-intensifiers</td>
<td>Intensifiers</td>
</tr>
<tr>
<td><strong>Household dietary diversity score (HDDS)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 to 2</td>
<td>97.30</td>
<td>2.70</td>
</tr>
<tr>
<td>3 to 4</td>
<td>96.41</td>
<td>3.59</td>
</tr>
<tr>
<td>5 to 6</td>
<td>22.97</td>
<td>77.03</td>
</tr>
<tr>
<td><strong>Household food insecurity access score (HFIAS)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 to 5</td>
<td>33.0</td>
<td>67.0</td>
</tr>
<tr>
<td>6 to 10</td>
<td>70.6</td>
<td>29.4</td>
</tr>
<tr>
<td>11 to 15</td>
<td>88.6</td>
<td>11.4</td>
</tr>
<tr>
<td>16 to 20</td>
<td>88.6</td>
<td>11.4</td>
</tr>
<tr>
<td>21 to 25</td>
<td>100</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Notes: ***; ** and * indicate p-values significant at 1 %, 5 % and 10 % levels respectively (for intensifiers versus non-intensifiers).

A significant proportion of households which did not intensify sorghum production had lower HDDS values, accounting for about 97 % in the 1-2 and 3-4 ranges. The reverse could be said for the HFIAS values where the sorghum production non-intensifying households had high food insecurity as indicated by higher values as compared to their intensifying counterparts.

4.2 Economic impacts of sorghum production intensification

Table 2 shows the real mean costs and returns for intensifiers versus non-intensifiers. This is a simple picture of the absolute differences in the selected indicators. There is evidence from the data that intensifiers had significantly higher productivity (p<0.05), market prices, gross margins and net returns per hectare (p<0.01) but they however had significantly lower variable costs per hectare of sorghum produced (p<0.05) (Table 2).
Similar results were also reported by (33) in Mudzi District of Zimbabwe. However (20) noted higher expenditures and food security among the elderly in Taiwan. The variations in the outcomes can be attributed to the inherent differences in the contexts within which the studies were conducted, with Taiwan being a relatively higher income country compared to Zimbabwe.

**Table 2: Absolute economic benefits of sorghum production intensification**

<table>
<thead>
<tr>
<th>Economic indicator</th>
<th>Intensifiers</th>
<th>Non-intensifiers</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Productivity (kg/ha)</td>
<td>944.344 (42.562)</td>
<td>691.167 (116.419)</td>
<td>253.178** (108.859)</td>
</tr>
<tr>
<td>Price ($)</td>
<td>40.139 (0.829)</td>
<td>33.605 (0.795)</td>
<td>6.53469*** (1.289)</td>
</tr>
<tr>
<td>Gross value ($/ha)</td>
<td>377.992 (17.949)</td>
<td>254.208 (50.627)</td>
<td>123.78*** (46.224)</td>
</tr>
<tr>
<td>Variable costs ($/ha)</td>
<td>48.623 (1.675)</td>
<td>58 (4.025)</td>
<td>9.377** (4.175)</td>
</tr>
<tr>
<td>Net returns ($/ha)</td>
<td>329.328 (17.218)</td>
<td>196.250 (50.547)</td>
<td>133.08*** (44.764)</td>
</tr>
</tbody>
</table>

**Notes:**
- Generated by authors from 2016 sorghum survey data using STATA.
- Bootstrapped standard errors using 100 replications of the sample.
- Absolute value of the z-statistic is placed in parenthesis.
  - **,** and * indicate p-values significant at 1 %, 5 % and 10 % levels respectively.

The comparison in Table 2 could be misleading since it does not accommodate the counterfactual condition. This approach assumes that sorghum intensification is determined exogenously but in practice it can be a potential endogenous variable. Unobservable characteristics of the sampled households could be the cause for the observed differences. For example the observed differences in the indicators might be a case where a more skilled farmer could have generated higher net returns per hectare without necessarily intensifying sorghum production (Table 3).

**Table 3: Counterfactual impact analysis using nearest neighbor method**

<table>
<thead>
<tr>
<th>Welfare indicator</th>
<th>Actual (household intensify)</th>
<th>Counterfactual (household did not intensify)</th>
<th>Treatment Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Productivity (kg/ha)</td>
<td>944.34 (42.562)</td>
<td>700.75 (11.549)</td>
<td>243.60** (124.081)</td>
</tr>
<tr>
<td>2. Net returns ($/ha)</td>
<td>329.33 (17.218)</td>
<td>229.44 (5.141)</td>
<td>99.89* (55.499)</td>
</tr>
<tr>
<td>3. HFIAS</td>
<td>4.57 (0.504)</td>
<td>11.53 (0.071)</td>
<td>6.96*** (0.692)</td>
</tr>
<tr>
<td>4. HDDS</td>
<td>5.49 (0.059)</td>
<td>3.63 (0.012)</td>
<td>1.86*** (0.131)</td>
</tr>
</tbody>
</table>

**Notes:**
- Generated by authors from 2016 sorghum survey data using STATA.
- Bootstrapped standard errors using 100 replications of the sample.
  - Absolute value of the z-statistic is placed in parenthesis.
  - **,** and * indicate p-values significant at 1 %, 5 % and 10 % levels respectively.
There is statistical evidence that households who intensify sorghum production have significantly higher productivity and net returns per hectare (p<0.05). The same observation was made for the food security indicators of HDDS and HFIAS (p<0.01). In a study conducted by (46), similar observations were made for adopters of conservation practices as opposed to their non-adopter counterparts. In a rice intensification study conducted by (41), similar patterns were also reported were intensive rice farmers were better off. (47) however reported that it is population density in farming communities which directly determine the intensification and associated productivity gains. A study conducted by (48) pointed towards the need to adopt more sustainable practices to grease the benefits from intensification.

5 CONCLUSIONS AND IMPLICATIONS FOR POLICY

The mainstay of the study was to examine the effect of allocating more land towards sorghum on net income and food security for rural households. Proxies for food security were the HDDS and the HFIAS. The physical productivity and net returns per hectare of sorghum produced were also included in the analyses. From the counterfactual analysis, it can also be reported that farmers who decide to allocate more land towards sorghum are relatively better off in terms of food diversity and access, productivity and net returns from the enterprise.

Given these observations, there is space for development of locally driven cooperatives which accommodate diverse households. These platforms should catalyse the generation and dissemination of information regarding production and marketing of sorghum and other related income sources. This starting point should be followed by infrastructural development initiatives such as seed banks and storage facilities which unlock the avenues for smallholder farmers in arid marginalised zones to interact efficiently and effectively with link-agents and consumers. Additionally, human capital development options need to be opened up so that the farmers are able to effectively access and interpret information. Farmer groups can be developed within the cooperative model so that adult education oriented training programmes which capacitate farmers are designed and scaled up and out. Youth empowerment initiatives need to be realigned with the potentials of migrating towards market driven sorghum systems. Overall, reducing transaction costs of doing business can help increase the productivity, net returns and food security status for the households. Since the study area is arid, experiencing low rainfall, high temperatures and limited livelihood options, sorghum intensification can offer a gateway out of food and income insecurity. The government needs to facilitate partnerships of farmers with the private sector players along the sorghum value chain so as to grease the relationships among these strategic stakeholders. For example, farmers need to access highly rewarding markets if the benefits from intensification are to be enjoyed. This whole matrix of strategies can be effective if sorghum is to be re-embraced in climate change adaptation frameworks.
REFERENCES


THE USE OF HONEY BEES (*APIS MELLIFERA*) AS A BIO-INDICATOR OF ENVIRONMENTAL CHANGE INDUCED BY ANTHROPOGENIC ACTIVITIES ON A SOUTHERN AFRICA SEMI-ARID SAVANNA ECOSYSTEM

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ABSTRACT
Globally, concerns over a decline in insect pollinator abundance have been raised. Awareness and policy actions have been raised in-order to secure sustained pollination in the agriculture system. The study explored the use of honey bees (*Apis mellifera*) as effective bio-indicators of anthropogenic impact on the ecosystem. The study argues that honey bees strongly interact with water, air and vegetation and as a result any changes to these elements will translate directly or indirectly to honey bees survival. A mixed methods design was adopted within a case study framework and data was collected during the dry season (September to October 2018) in Nyamakate communal lands. One hundred and fifty (150) questionnaires were self-administered to communal farmers in three villages. In addition participatory observation and literature review were used in this study. The study pointed out that there is a strong relationship between honey bee mortality and forage, water and vegetation availability. The experiment observed that high levels of honey bees’ mortality associated with an increase in distance from a major water source in dry season could be used as a bio-indicator of the state of an ecosystem.

Key words: bio-security, climate change, conservation, food security, honey bees, sustainability.
1. INTRODUCTION

The use of bio-indicators to establish the nature of environmental conditions is not new in natural resources conservation; biologists have recently embraced the concept as an effective and economical way of monitoring local environmental and global conditions (1). A bio-indicator is any species or group of species whose function, population or status can reveal the qualitative status of the environment (1). There are many types of biological organisms which can be used as indicators to the state of the environment. The use of insects as bio-indicators may involve observations of deviations from the normal physiological, biochemical, behavioral and anatomical functions as well as the changes in population dynamics (2). Water, air and soil are the media on which biota, including man, depend on for survival. If there are any deviations of the condition of these media it will cause biological changes to take place and it is easier and more effective to measure these changes in biota rather than to directly measure changes in the chemical or physical composition of the media (1, 2).

In this regard, the simple observation of sensitivity of honey bees (Apis mellifera) to changes induced by anthropogenic activities will act as an economic and effective bio-indicator to the environment. Bio-indicators are sensitive to any disturbance in the environment thus making them reliable and cost effective means to monitor environmental changes (3). The quality of an ecosystem can be judged by an organism which is an indicator of the health of the environment.

Changes in the honeybee foraging ground will directly impact on their health and populations dynamics (4). The use of fertilizers which lead to reduced use of legumes in crop rotation affects the bees forage ground (3, 6). Due to increased demand for raw materials and goods, monoculture has become a common practice in both subsistence and commercial farming as the need to raise income from agro-business rises. Monoculture cause poor nutrition result in bees lacking nutrients required for bees survival (3, 6). Crops such as tobacco (Nicotiana tabacum) and cotton (Gossypium hirsutum) require intensive application of fertilizers to increase yields and can be grown with limited crop rotation. The need to increase yields by subsistence farmers has resulted in the increased use of herbicides to control weeds which reduces flowers with pollen and nectar needed by foraging bees (4). There are arguments that honey bees still survive in mono-cultural practices when colonies are used for crop pollination in agriculture (6). However, the fact that balanced diet is important for any living organism remains an important fact in honey bee conservation. Lack of balanced diet from the honeybee forage can result in colony malnutrition thus exposing the colony to diseases like Nosema apis.

Unsustainable agricultural practices have been noted to cause a decrease on the availability of suitable honeybee sites (5, 1). Honeybees in agricultural ecosystems visit a wide variety of flowers thus
making them more susceptible to poisonous pesticides and herbicides (2). Global environmental
degradation has been noted for adding stress to honeybee colonies in finding suitable forage resources
(5, 1), thus leading to their decline in numbers. In order to maintain honeybee populations it is
important to ensure the conservation and management of sufficient forage resources within
agricultural and surrounding natural landscapes.

Honey bees are ever active throughout the area surrounding their nests collecting pollen in the
flowered nearby fields or over long distances (5). Honey bees can have a home range of 10 kilometers
under exceptional circumstances and a single bee hive can have a sphere of influence of about seven
square kilometers (5). More than 10,000 of the 40,000 bees in a normal hive will be active pollinators
thus interacting with the flora of an area (5, 6). A single honey bee can complete 12 to 15 flights in a
day thus presenting a high level of interaction with the environment (5, 6).

Honey bees are effective bio-indicators since they have high reproduction rate and a relatively short
average lifespan of 6 weeks for worker bees (4, 5) which enables the colony to have a continuous
regeneration thus enabling easy monitoring of any changes to the environment. A queen bee could
live up to five years whereas a drone could die after mating the queen (5, 6). As honey bees fly around
the surrounding area they pick up airborne particles with their body hairs and also pick any
contamination while busily harvesting flowers nectar and pollen (7, 8). In this regard, honey bees act
as effective sample collectors from a wide range of sources, for example; gathering propolis from the
buds of various botanic species, gathering nectar and pollen from such flowers, honeydew from the
aphids of infested plant and water from wells and irrigation trenches (1). Their great mobility enables
them to monitor vast areas thus increasing efficiency in ground survey per day as they interact with
all environmental factors (7, 8).

The collected pollen and nectar will be stored in the hive as food for the bees and developing larvae.
With time, the accumulated residues in honey bee bodies will become effective biological indicators
by stockpiling effect of contaminants (5). Honey bees bio-indicate the state of the environment either
through high mortality rates or through the residues found in honey, larvae and pollen among other
substrates (1). An increase in bee mortality above the threshold act as an X-ray of the state of the
environment surrounding the bee hive (1).

1.1 Honey bee mortality as bio-indicator.
Censuses of dead bees in communal areas in the dry season help in bio-indication of the state of
ecosystem (1, 6). The concept of employing honey bees as bio-indicators dates back around 1935 as
honey bees were used to monitor the state of the environment (5). During the rainy season unsustainable farming practices are noticed in both communal and commercial areas, where the intensive use of pesticides and herbicides is also heightened.

Some of these chemicals may be poisonous to kill such bees in the field and thus making it very difficult to assess bee mortality as illustrated in Fig 1. On the other hand, if the chemicals used in the fields have a gradual effect, the majority of foraging bees will succeed in returning to the hive and die as a result of poisoning or impairment (3). Slow poisoning chemicals’ lethal effects will result in a progressive, often unapparent, depopulation of the colony that the beekeeper cannot detect in a short period of time (3).

Honey bees mortality is not only caused by direct or indirect poisoning from poor farming practices. Serious environmental degradation triggered by intensive clearance of forest for farming lands has resulted in loss of habitat for bees’ survival (5, 1). Unavailability of water and food for bees’ colonies has not been well researched in Africa to assess its impact to honey bees’ mortality (3). Uncontrolled veld fires play a negative role in destroying the ecosystems of honey bees thus increasing mortality of such bees (2). Apart from that, the side effects of climate change like increases in temperature which can result in heat waves have negative impacts to the survival of honey bees (3, 5). In this regard, to avoid bias of chemical poisoning, a study was carried out in Nyamakate in dry season where there was less or no farming done in communal areas (5, 1).

Fig 1. Chart of polluting substance diffusion in the environment. Honey bees may capture pollutants diffused in the air, deposited on plant surfaces and on the soil, and assimilate them from water, as shown in the dark area indicating the environmental sectors visited by the bee (1).
Taking census of dead honey bees as bio-indicators to the state of the environment has challenges in that it only captures the bees that have managed to return to the hive and are expelled, on dying, by other living bees in the hive (1). A certain number of bees die in the field and some get lost and fail to return to the hive and such numbers are not counted or assessed (1). All honey bees which die in the field are difficult to ascertain their number and their actual cause of mortality will not be known. There are several factors which may affect honey bees mortality such as the strength of the family, season and the surrounding environment. The number of eggs which the queen lays determines the strength of the colony.

1.2 Objectives.

The study assessed the possibility of using honey bees as bio-indicators of anthropogenic impact on a savanna ecosystem. Specifically, the objectives of the study were to: (1) investigate the relationship between honey bees mortality in relation to distance to major water sources during the dry season, (2) assess the impacts of veld fires and deforestation on honey bees mortality and, (3) investigate the impact of ants on bee hives in relation to bees abscondance.

2. MATERIALS AND METHODS

Study area

Hurungwe district lies within farming regions III with rainfall amounts ranging from 500-800mm, with an estimated human population of 329 197 and covers about 19,200 km² (9, 10). The district experiences periodic seasonal droughts, prolonged mid-season dry spells and unreliable starts of the rainy season. Hot summer temperatures which range between 25°C to 40°C are experienced from October to April (9). Anthropogenic impact to the environment are noticeable through farming of maize (Zea mays), tobacco, cotton, beans (Phaseolus vulgaris), sorghum (Sorghum bicolor) and groundnuts (Arachis hypogaea) in addition to animal husbandry are produced on a semi-intensive scale (10). The vegetation comprises of mopane and miombo woodland (10)

Two honey bee hives were randomly chosen by picking assigned numbers to bee hives which were found in the Nyamakate area. Village 28, Village 31 and Village November were sampled during the study. One hundred and fifty (150) questionnaires were introduced to farmers to assess the anthropogenic impact to honey bees conservation in communal areas. A modified underbasket was used to trap dead honey bees. An underbasket was developed from Gary bees trapping cages and this is more efficient in returning dead bees and protecting them from predation (13). A total of six natural hives were fitted with an underbasket as it is an effective trap most suitable in retaining dead bees
(12, 13). The underbasket was set in such a way that it could not interfere with the flight and the normal activities of bees, prevent access to possible predators and allow easy counting of bees. The underbasket was checked once a week for a period of one month and the numbers of dead bees were recorded. The study was done in dry season in August 2018 to avoid disparities from chemical poisoning from agricultural practices. The underbasket was assessed to check if honey bees mortality rate was not exceeding the critical threshold of 250 bees per week per station (5, 13). An increase in honey bee mortality is equally a good bio-indicator to the state of the ecosystem (5, 1). High mortality causes a threat to the survival of a colony and this may force a colony to migrate or colony collapse. A hand held Global Positioning System (GPS) device was used to measure straight line distance between major water sources and the bee hive. Participatory observation and recording approach was used to assess the impact of ants on bee hives.

Data analysis

The relationship between honey bees mortality (i.e measured by the mortality) and the distance to the main water source (as measured by the distance) was investigated using Pearson product moment correlation coefficient. Preliminary analyses were performed to ensure no violation of the assumptions of normality, linearity and homoscedasticity. Data analysis was done in IMB SPSS Version 20.

3. RESULTS AND DISCUSSIONS

There was a strong positive correlation between honey bees mortality (i.e measured by the mortality) and the distance to the main water source (as measured by the distance), \( r = 0.088, n = 8, p<0.005 \) with high levels of honey bees mortality associated with an increase in distance from a major water source. High mortality is recorded as the distance increases as illustrated in (Fig 3). High mortality could be as a result of overworking by honey bees during summer to collect water and limited food to nourish their bodies (3). During the experiments, six sampling sites were established and a total of 123 dead bees were recorded for a period of one month from the six bee hives. A mean mortality of 20.5 bees per week was recorded from the six bee hives. Increased honey bees mortality biologically indicate that the ecosystem may be experiencing some ecological changes (13). The sampled sites have far less risk of colony loss due to honey bee mortality since all sampling sites recorded very low mean mortality which does not give any threat to the colony survival. Honey bees colonies reach a critical stage of survival if threshold mortality of 250 honey bees per week per each bee hive is recorded (5). Mortality below the threshold could have been recorded because the areas have less disturbances from farming activities and the impact of cold weather in winter was not there since the experiments were done in summer. Winter increases honey bees mortality as bees requires more
energy to warm their bodies and there will be limited food due to reduced forage availability (1, 3, 8).

*Fig 3 Bees travelling distances to a water source in the study area*

Besides mortality, ants were noted to trigger bees to abscond their bee hives and this acted as a biotic indication of the state of the environment as shown in *(Fig 4).* The common ants which were noted predating on sampled bees hives were the fire ant *(Solenopsis geminate)* and the wood ant *(Formica rufa).* Ants prove to cause a threat to honey bees colonies in the ecosystem as they predate on bees honey, honey bees larva and pollen. Anthropogenic induced impacts such as veld fires, deforestation and use of environmentally unfriendly pesticides has significant impact on honey bees’ ability to stay on a certain ecosystem. The combined effect of anthropogenic impacts on honey bees is higher than the natural impacts such as ants, water and forage availability.

*Fig 4 Major causes of bees to abscond the their nests sites*
4. CONCLUSION
The use of honey bees as ecological bio-indicator species proved to be reliable and cost-effective to assess the changes in the environment. High levels of honey bees mortality associated with an increase in distance from a major water source in dry season equally bio- indicated the state of the ecosystem. Due to low mortality which was below the weekly mortality threshold of 250, the studied colonies are not at risk from colony collapse. Anthropogenic activities and ants still pose a threat to honey bees survival in communal areas. We conclude that high levels of honey bees’ mortality associated with an increase in distance from a major water source in dry season could be used as a bio-indicator of the state of an ecosystem.

5. RECOMMENDATIONS
Anthropogenic activities still poses a threat to honey bees conservation, and they have to be managed to ensure sustainable conservation. Control of veld fires and soil erosion goes a long way to ensure honey bees forage and water availability. The future survival of honey bees depend on effective conservation and management practices which ensures sufficient forage resources within agricultural and surrounding natural landscapes.

References
THE SOCIO – ECONOMIC AND BIOPHYSICAL IMPACTS OF BLACK GRANITE MINING IN MUTOKO, ZIMBABWE.

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ABSTRACT
Mining has impacts especially on the people living in communities where minerals are found. Although many researches have been conducted on the impacts of mining on the environment, few researches have focussed on the impacts of black granite mining in Zimbabwe. This paper identifies the socio-economic and biophysical impacts of black granite mining in Mutoko, Zimbabwe. Questionnaires, interviews and observations were used to collect data for this study. The findings from five black granite mines surveyed in the study showed that the main biophysical impacts of black granite mining are loss of biodiversity due to deforestation, siltation, soil erosion and displacement of wildlife. The main socio-economic impacts are employment, infrastructural development, loss of prime agricultural land, destruction of sacred sites; cracking of building structures; dust inhalation; and injuries. The study recommends effective implementation of Environmental Management Plans (EMPs) to enhance or reduce the impacts of black granite mining.

Key words: black granite, mining, socio-economic, biophysical, impacts
1. INTRODUCTION

In recent years, black granite mining has become more pronounced in some parts of Zimbabwe such as Mutoko and Mt Darwin (1) The emerging interests in black granite mining, participation by several players and increase in space and volume of granite rock mined have a bearing on the socioeconomic and biophysical outlook of the mined areas and their neighbourhood (2). As mining continues and demand for black granite products in construction as dimension stones and floor tiles; gravestones and memorials the impact continues to escalate. The situation is compounded by more efficient methods of extraction such as diamond wire cutting thereby raising large quantities of granite blocks within a short period of time and the blocks are often littered on adjacent flat and arable or pasture land (2). Mining in general is regarded as a ‘robber industry’ thus wherever it takes place, there is need for continual assessment for appropriate timely policy intervention and review (3, 4). This study seeks to assess the change brought about by black granite mining at operational sites in Mutoko, Zimbabwe.

Foreign companies invested in black granite mining business ventures in the study area but need to address community, biophysical and socio-economic concerns emanating from their operations. Tools such as Environmental Impact Assessment (EIA) and Environmental Management Systems (EMS) guide compliant companies to contend with impacts of mining on the total environment. The companies are expected to adopt and implement best mining practices, ensure that ecological functions are maintained, any damaged parts of the environment as a result of their operations are restored to a condition it was before mining or better and participate in community development projects wherever they operate (2). Most of the mining companies in Mutoko are EIA certified but their compliance and implementation of environmental management plans need to be assessed.

Black granite extraction entails clearance of overburden, cutting the exposed rocks into rectangular blocks varying in weight from 15 – 30 tonnes as specified by market requirements. Traditionally, black granite mining entailed drilling and blasting that generated noise, rock fly and vibrations; of late it entails a combination of blasting and diamond wire cutting. Diamond wire cutting is noiseless, does not cause any vibrations and enables large quantities of granite to be extracted within a shorter period of time. As the blocks are mined, waste rock is generated from deformed blocks and offcuts as blocks are trimmed to meet market specifications. Thus granite mining companies have to contend with disposal problem of waste rock, space for the large blocks awaiting delivery to the market, loss of aesthetic value and loss of the granitic domes from which the blocks are extracted (5). There is therefore need to determine how the mining methods and the resultant waste rocks activity impact on the socio-economic and biophysical environment.

The expansion of black granite quarrying activities in Motoko, transformed the district into an important black granite mining area associated with resultant impacts (1). The possible several resultant impacts have to be determined to enhance beneficial impacts and propose mitigation for unanticipated impacts. The mining activity in the area has the potential to affect the socio-economic and biophysical components of the environment that include surface and groundwater resources, soils, the natural landscape, vegetation, ecosystems, river flow regimes, atmospheric conditions, housing structures, mortality and safety or health of employees (6,7,8). Mining in general, usually has the highest annual number of traumatic fatalities in industry globally (9). For example in 1972 a mine accident that occurred at the then Wankie Colliery killed 427 workers, (10) measures are employed in modern mining nonetheless there is need to determine the prevailing situation at operational mines – black granite mining is a case in point.
Despite negative impacts, research has shown that mining has several environmental and socio-economic positive impacts. Mobtaker (3) used the Folchi method found out that modern sustainable mining operations improves environment and enhance opportunities for improved societal wellbeing. Formal mining forms an integral part in the economic development of any country as several benefits such as its contribution to the country’s GDP (Gross Domestic Product) accounting for about 60 per cent of foreign exchange earnings, 10 per cent of GDP and five per cent of formal employment in Southern Africa (11, 12). Other impacts of mining include infrastructural development, development in communication, transport, educational system, recreation, commerce and medical facilities. This study therefore sought to assess the impacts of black granite mining in Mutoko since there is limited research that has been conducted on this type of mining in Zimbabwe.

2. RESEARCH OBJECTIVES
The objectives of this research were to:
- Identify the socio-economic and biophysical impacts of black granite mining in Mutoko.
- Determine the extent of socio-economic and biophysical impacts of black granite mining in Mutoko.
- Assess the socioeconomic and biophysical impacts of granite mining in Mutoko.

3. METHODOLOGY
The study was conducted in Mutoko District which is 144.7 kilometers northeast of Harare, Zimbabwe. The district is in Mashonaland East Province. Most parts of the district are within Region Four that receives 450 - 650 mm of rainfall, variably spread during the rainy season (2). The dominant activities in the region include cultivation of drought resistant crops, livestock, and semi-intensive farming. Mining, particularly black granite extraction, is part of some of the off farm economic activities in the district. The major geological formations in the study area are the granite/gneiss rocks. The soils thus are paraferrallitic derived from igneous and metamorphosized igneous parent rock, containing low nutrient value to support intensive crop farming. The study area is shown in Figure 1.

Figure 1: Location map for black granite mines in Mutoko
Data for the study were collected using questionnaires, key informant interviews, and observations. Secondary data were from EIA inspections, EMA audit reports and company records. Five mines were surveyed during the study. These mines are Natural Stone, Manwick, ZIQ, Quenya and Illford Services SG3. Permission to conduct the survey on the five mining companies which were operating was sought. Government departments granted permission for their officers to participate in interviews and for access to their reports. Respondents’ consent was sought before questionnaires and interviews were administered. Names of respondents were not revealed in the responses to maintain confidentiality. The respondents were assured that the information they provided was for academic purposes only and they would not be disadvantaged in any way either for voluntary participation or saying their opinions.

Key informant structured interviews were employed to solicit for changes in benefits such as roads, assistance in community projects and infrastructure development and losses of arable land, pasture and impact on houses or community welfare from granite mining. The key informants were representatives from government departments such as Agriculture Extension (AGRITEX), Forestry Commission (FC), Zimbabwe Republic Police (ZRP), Veterinary Services, Mutoko Rural District Council (MRDC), Ministry of Health and Ministry of Education, Sport and Culture; community leadership comprising a councillor, headman and five village heads directly affected by the mining activity, mine management responsible for execution of management plans, school heads as beneficiaries of community support schemes and Environmental Management Agency (EMA) officers. Interviews responses were captured using a voice recorder then transcribed onto an interview schedule for recording and processing.

Random systematic sampling was used to determine participants from local residents and miners. Every fifth household was considered for the survey, thus from 3,688 households in the three wards where mining took place, 200 respondents were identified. The rest were six government departments (AGRITEX, Forestry Commission, Zimbabwe Republic Police, Veterinary Services department, MRDC, Ministry of Health and Ministry of Education, Sport and Culture, five mine managers/supervisors, and twenty-nine mine employees. Questionnaires for households were administered in the vernacular language that was easily understood by the respondents, later translated to English. These questionnaires focused on the problems of and benefits from black granite mining in the area.

Observations were made on impact of black granite mining on infrastructure (schools, houses) along routes to mines and close to mines, bridges and roads as well as mine employees as they worked. The study observed the number of properties that had cracks, the area covered by mined granite blocks and the space that had lost its trees from mining activities.

During data analysis, the questionnaires were coded for identification and recording of variables before editing to check on trends, similarities, differences, exaggerations and recurrences. Completeness check was done to verify whether all questionnaires had been completed. Every questionnaire returned was considered in the analysis. Responses were grouped and frequency calculations were done to determine occurrence of events in granite mining. Responses were grouped into themes so as to cater for results from interviews.
4. RESULTS AND DISCUSSION
Granite mining resulted in both positive and negative socio-economic and biophysical impacts. The positive impacts were revealed by employment opportunities, revenue generation, road construction, contribution to community projects. The negative impacts that include loss of pasture, displacement of people, loss of vegetation, loss of sacred sites and diversion of water channels were identified in the study area.

4.1. Socio-economic impacts of black granite mining
Granite mining in Mutoko takes place in communities that had established livelihoods and lie within conditions meant to improve their welfare. This section outlines the several socioeconomic changes resulting from granite mining activities in the study area.

4.1.1. Employment opportunities
Black granite mining generates off – farm employment for Mutoko communities. As shown in Table 1.

Table 1: Employment opportunities at Black Granite mines (%)

<table>
<thead>
<tr>
<th>Mine Name</th>
<th>Artisan</th>
<th>Secretary</th>
<th>Manager</th>
<th>Security</th>
<th>General hand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Stone</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>18</td>
<td>178</td>
</tr>
<tr>
<td>Manwick</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>10</td>
<td>64</td>
</tr>
<tr>
<td>ZIQ</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>12</td>
<td>41</td>
</tr>
<tr>
<td>Quenya</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>15</td>
<td>75</td>
</tr>
<tr>
<td>Ilford Service SG3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>26</td>
<td>92</td>
</tr>
</tbody>
</table>

Source: Field Survey, 2017
The results show that most of the employment opportunities are for security and general labour constituting over 90% put together at all the five companies. The highest such opportunities are offered by Natural stone (96%). The two labour categories are low income and are given to people of low levels of income. Overall the five companies created 560 opportunities in the district, a mere 5% of these opportunities are taken up by outsiders (managers, artisans and secretaries).

The companies beyond any doubt conformed to the requirement for companies that invest had to engage the locals as first priority. The outsiders have specialist skills and earned high incomes – locals lack the requisite skill, however the companies have the capacity to sponsor empowerment of their employees to attain the requisite qualifications.
4.1.2 Gender and Employment

The study sought for gender variations in the employment structure at the five granite mining companies. The gender employment composition is shown in Figure 2.

![Figure 2: Employment by gender in black granite mines](source: Field survey, 2017)

The results show that three of the mines, Ilford Services SG3, Quenya and ZIQ did not have female employees. Manwick had less female workforce (1%), while Natural Stone had the highest number of females (3%). There was thus no gender balance at the mines. Mine managers said that women were not suitable for the type of work done at the mines – the managers claimed that women who were earlier employed, faced difficulties executing the duties they were employed for. Thus women were not significantly directly benefiting from mining activities in the area. They had to rely on their husbands who were employed by the mines. Gender bias towards men was also witnessed at Ngoyla Mintom, Cameroon where out of 95 miners interviewed, only 3 were women or 3.2% of the sample size (13). Most of the women in the neighbourhood would supply the mining community with basic food items and other commodities through petty trading.

4.1.3 Remuneration for employees

Unskilled labourers are lowly paid in the mining industry as noted by the results of a survey of black granite mines in Mutoko. Salaries of more than 70% of the twenty-five unskilled respondents were below the Poverty Datum Line (PDL) and ranged from US$150 to US$250. The PDL for an average of five persons stood at US$502.90 in May 2017 (14). The economic benefits from employment cannot be overvalued, most of the employees at the mines had to supplement their meagre earnings with agricultural activities in order to meet their basic living requirements. The skilled and semi-skilled workers (supervisors, section leaders and managers who were mostly from outside the local community) were better paid but declined to divulge their salaries.

4.1.4 Revenue generation for the local authority

Miners are expected to pay development levies for the stones to MRDC. The mining levy is used for developmental purposes for example construction and maintenance of roads. During an interview, the CEO for MRDC pointed out that miners were being levied US$1 per tonne of stone. The CEO claimed that miners swindle the council of money by under – estimating tonnage of dimensions stones. The council had no weigh bridge to verify the tonnages. In January 2001, MRDC temporarily stopped all mining operations in order to force miners to pay outstanding levies. Some mines that include Quenya and ZIQ said that they paid levies to MRDC but they did not produce evidence of having made such
payments. Apart from Rural District Councils, the Ministry of Mines benefit from the activity through mining licenses and royalties which are paid by the miners.

4.1.5 Infrastructure development

The study reveals that black granite mines helped influence development in the study area as shown in Table 2.

Table 2: **Infrastructure development from black granite mines**

<table>
<thead>
<tr>
<th>Mine</th>
<th>Road (Km)</th>
<th>Dip tank</th>
<th>Borehole</th>
<th>School</th>
<th>Clinic</th>
<th>Electrification Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Stone</td>
<td>8</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Manwick</td>
<td>7</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ZIQ</td>
<td>15</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Quenya</td>
<td>7</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Illford Services SG3</td>
<td>16</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: Field survey, 2017

The results show that all the mines took part in the rehabilitation or construction of roads, which they used to ferry their blocks of granite to the market. Illford Services SG3 did the largest stretch of 16 km while Quenya and Manwick did the least at 7 km each. The roads are critical for access to the mines and the outer world. The mining companies also took part in dip tank services as each company did one dip tank except ZIQ. The results also reveal that all the companies took part in drilling boreholes for the community at Gurure, Kadiki and Charehwa: each company did an average of two boreholes. The borehole drilling exercise ensured that the community could have access to clean and safe water. The mining companies also constructed at least a classroom block each at Makochera, Gurure, Utonga and Kowo schools as revealed in the results. Quenya and Natural Stone assisted in the construction of a maternity ward at Nyamuzuwe Clinic. Natural Stone Export Company assisted in the electrification of Chief Mutoko homestead thus making it easier for nearby homesteads to draw power to their homes in future. Although the community expected a lot more, the mining companies played a critical part by improving service and community welfare. The community services offered as outlined would make the community and miners work together for a common and effective goal of enhancing the living standards of communities where mining operations take place.

The study revealed that blasting carried out during mining operations had a negative impact on infrastructure. Buildings have developed cracks which are allegedly as a result of the shaking effect of blasting. As observed and reported by residents, at least 50 housing units were reported having developed cracks. Frequent blasting at the mines which produces reverberations that can be felt 20-30 kilometres away, has also been reported to have caused the cracking of houses and other infrastructure in mining areas (13). In another research conducted in Gwalior, India respondents reported that blasting causes shaking of the houses and other buildings and cause disturbance among the inhabitants (15). Schools such as Kowo, Nyamuzuwe, Chirindi, Nyamakope, Gurure, Utongachira, Chiutsi, Kagonde, Chindenga, Gwariwa and Chimukapa are situated close to mines. Cracks were observed on classroom blocks at Kowo (Plate 1). and Nyamuzuwe schools. Nyamuzuwe School is within 200 – 500 m of Quenya mine.
Villagers’ houses in Makochera village near Natural Stone mine have developed also cracks. Cracks also develop as a result of the shaking effect of heavy vehicles passing nearby. It must however be noted that although cracks occur as a result of blasting, it is difficult to attribute all the cracks to mining alone. However it was found that the cracks were more pronounced on houses near the mines. Some factors such as natural ones and human error in the construction of structures also lead to the development of cracks.

4.1.6 State of transport routes
MRDC blames the bad state of gravel roads on the miners’ heavy rock bearing vehicles. During the survey, some roads such as Nyadire road were in a deplorable state. Nyadire and Kanhemba roads that lead to Ilford Services SG3 were full of potholes and in some cases were impassable to small vehicles. In most cases, roads had no mechanical conservation works such as mitre drains. This resulted in the formation of roadside gullies as was noticed along the Kanhemba road. This road poses access problems to trucks that ferry garden produce in the area. All the visited mines claimed that they maintained roads once every month. MRDC argued that in most cases the miners go for more than three months before grading roads. When they repaired the roads, they did not consult MRDC and Ministry of Roads thereby fail to pull critical resources to ensure that joint effort and lasting measures are put in place to tackle the road maintenance challenges. Miners however argued that they did not have a mandate to maintain roads since they paid road taxes that were supposed to be channelled towards road maintenance. MRDC however could not confirm receipt of such funds. Miners were accused of converting scotch carts routes into their access roads thus reducing the extent of crop fields or even displacing people. The conversion of access routes however improved access for farmers to ferry garden produce from one area to the other although it was claimed that miners only maintained roads for their convenience.

Rock bearing trucks were also a threat to bridges. Bridges such as Kanhemba were sagging and cracking possibly due to pressure exerted on them by heavy trucks as shown in Plate 2.
Interview respondents revealed that rocks sometimes fell along transport routes thus blocking the roads or damaging them. The rocks increase the risk of accidents as they usually fall on the bends. Rocks are usually not removed because of high costs hence becoming a permanent risk along transport routes. Although miners are blamed for damaging roads, they also play a part in their maintenance. During the research, it was observed that miners maintained Loti and Katsukunya roads.

It was however difficult to wholly attribute mining activities to the state of transport routes without considering aging infrastructure. However mining activities i.e. constant use of heavy rock bearing trucks definitely has an impact on road infrastructure. It was evident that tracks and falling boulders on the roads had a damaging impact on the roads. The council civil engineer confirmed and attributed damage to the roads to frequent use by heavy trucks and lack of frequent maintenance.

4.1.7 Loss of arable and grazing land

Locals within the vicinity of mines complained of shortages of arable and grazing land. Land lost to mining activities is shown on Table 3.

Table 3: **Arable and grazing land lost to mining activities**

<table>
<thead>
<tr>
<th>Mine Name</th>
<th>Grazing land (Ha)</th>
<th>Arable land (Ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Stone</td>
<td>6.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Manwick</td>
<td>4.5</td>
<td>2.5</td>
</tr>
<tr>
<td>ZIQ</td>
<td>2.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Quenya</td>
<td>3.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Ilford Services SG3</td>
<td>3.5</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Source: EMA (16)
Results show that an estimated 32 ha of land was lost to mining. This comprised 19 ha for grazing and 13 ha for arable land. Natural Stone mine took up most of the land - 10 ha. The rest of the mines each had less than 10 ha of land directly affected by mining. Grazing land was lost at the actual mining sites which are all situated in hills used as grazing areas. Former grazing areas could no longer be accessed because of open pits and rock dumps that were left by miners. Arable land was lost due to dumping of rocks in crop fields and gardens. Sections of fields and gardens were rendered useless to cultivation. This resulted in a reduction of agricultural production levels although AGRITEX officers could not quantify the levels. Villagers from Makochera, Chibanda and Mukoneka pointed out that the dumping of rock rubble reduced the extent of their grazing areas.

Loss of land has occurred in some instances with people's land being taken over to pave way for the mining operations or road construction. This has a negative impact on agricultural activities since rural economies are mainly agro-based. It is unfortunate that communal farmers do not have title deeds rights to land and this makes it difficult for them to claim compensation for lost land. In some instances, some of the land that is lost to mining is among the most fertile in an area thus threatening food security. No one was reportedly compensated by the miners for the loss of agricultural land and or grazing land.

4.1.8 Displacement of people

When mines are pegged, some of the claims are inhabited by people. Mine managers refused that present day locations of their mines were inhabited before the commencement of mining. Evidence on the ground showed that areas within the mine claims were still inhabited. More than 10 homes that have become derelict are evidence that some people had moved away. The settlers were allegedly threatened by flying rocks, noise, dust and blasting tremors which cracked their structures. It was alleged that miners had promised to construct houses for affected people. There was no record for compensation or displacement, nonetheless, evidence reveals there was once settled areas near the mines that have since moved.

4.1.9. Occupational health and safety of mine employees

The health of miners in black granite mines is at stake due to the physical nature of the work involved and exposure to hazardous conditions such as dust. Miners reported that five accidents were recorded over a seven year period. They depicted a picture that the mines are very safe and rarely have accidents. Mine employees however painted a different picture from that of their employers on the issue of their safety and health.

Figure 3 shows that about 20% of mine employees questioned in the questionnaire surveys claimed to have had accidents whilst 50% had witnessed accidents taking place. Approximately 30% had never witnessed or were involved in an accident.
Questionnaires and observations revealed that employees’ safety was at risk. Although all mining companies claimed that they provided adequate protective clothing and or equipment some employees were observed working in dusty and noise conditions with no dust masks and ear plugs. This exposed them to safety and health risk. Approximately 65% of the employees complained that protective clothing or equipment was not adequate. About 30% of the employees said that they had no protective clothing or equipment. A smaller proportion of the mine workforce (5%) claimed to have been issued out with adequate protective clothing or equipment although some had nothing on during mining operations. Mine employees also complained that there were not compensated for injuries sustained at work though this was disputed by mines management.

More than 50% of the employees were worried with the dust they were inhaling. Continued exposure to dust as feared by some of them would result in respiratory complications. In a research conducted in Gwalior, India, interviews revealed that a significant number of the respondents were affected by the air pollution generated from the mining area (15). High noise levels were also a threat to the health of mine employees. At least 10% of the employees complained of ear problems and had difficulties in hearing. Goswami (17) support the findings made by stating that mining noise is now being recognized as a major health hazard; resulting in annoyance. Partial hearing loss and even permanent damage to the inner ear is noticed after prolonged exposure.

It must however be noted that no measurements of dust emissions and noise levels were done due to lack of proper equipment. Some employees complained of backaches as a result of heavy back breaking work. Mine employees in Cameroon also reported a series of health problems notably body pains during a research conducted by Funoh (13).

It was also claimed that some employees had died of injuries sustained in mine accidents. Statistics could not be obtained to verify these claims. Mine managers/supervisors dispelled such reports and actually claimed that the very few accidents that occurred in the past were ‘minor’ in nature.

Mining is a hazardous activity which sometimes threatens lives. Eaton (10) supports this with evidence of the 1972 Wankie Colliery mine disaster when 427 workers were killed in an underground explosion. It must however be noted that no accident of such a magnitude has been recorded in black granite mining. Poor workplace health and safety standards in some of the black granite mines in Mutoko have resulted in illness, injuries and even deaths to some workers. This has impacted
negatively on the lives of the workers and their families with the injured and ill workers failing to fend for their families.

4.1.10 Safety and health of school children and local communities

Research findings show that communities and school children’s health and safety were also threatened by black granite mining activities. Transport routes act as sources of dust which has become a health hazard especially to school children. The acting head of Kowo Secondary school and the Headmaster of Kanhemba Primary School complained of dust emanating from the roads used by the miners when the heavy vehicles pass by their schools. The deafening noises made during the passage of heavy vehicles play a role in disturbing lessons hence the learning process.

Open pits left open by miners are a threat to human life especially children. About 5% of the injuries sustained by children were linked to the open pits although this could not be verified. Open pits that are breeding grounds for mosquitoes that cause the deadly malaria disease were blamed by health officials for the high prevalence of the disease during the wet season. Some locals complained that they were exposed to flying rocks and tremors during blasting at the mines. This complaint was raised mainly by people with homesteads within the proximity of the mines.

On the more positive side, villagers admitted that they were sometimes assisted by miners to ferry their sick to Mutoko Hospital by the miners. Some villagers however expressed anger at the miners’ refusal to assist them with transport to help ferry their sick to hospital. Quenya mine manager said that they also assisted at funerals although without specifying the form of assistance.

4.1.11 Crime trends

The presence of miners in Mutoko has a negative impact on crime. A police officer with the Mutoko ZRP argued that the presence of miners has generally increased criminal activities. He however could not give supporting statistics since he claimed that it was confidential information. However mines reported that they experience theft of equipment by both mine employees and villagers. Mine employees steal equipment such as jack hammers from mines. Mine employees steal possibly to supplement their meagre salaries. Villagers also have a tendency of stealing from the mines in some instances as a way of registering their dissatisfaction with mines authorities. Extortion cases are also reported when the local leadership demands money from the miners. ZRP has been called to intervene in wrangles between politicians and miners.

4.1.12 Disturbances of sacred sites

Miners were blamed for disregarding cultural values and norms. A village head from Nyerenyere village bitterly complained of the miners’ disregard of cultural sites. Without giving specific examples, the village head said that there were no proper consultation of spirit mediums and chiefs before commencement of mining activities. A headman from Kabasa ward admitted that miners did not respect sacred sites. At some point they are said to have planned to mine a hill in Charehwa village that housed Nehoreka’s artefacts. The production manager for ZIQ denied the allegations maintaining that there was proper consultation before mining.

Sacred shrines were alleged to have been destroyed by miners although they (miners) professed ignorance to this. Graves have also not been spared by the miners. Locals claimed that some of their ancestral graves in caves were decimated with the miners refusing to hold traditional ceremonies to appease the spirits of the dead. Although no evidence of desecrated graves was found during the research, a research conducted by Chigonda (1) found out that mining activities in the Kawazva area uncovered human remains and this resulted in conflicts between villagers and a miner.
4.2 Biophysical impacts of black granite mining

Mining of black granite had associated biophysical impacts identified and assessed in this section. No biophysical positive impact was identified in the study area.

4.2.1 Loss of vegetation

During mining processes trees and other vegetation are cleared to access the rock, to construct mining compounds and offices as well access roads. Removal of trees without replacement (deforestation and other vegetation was observed at all mining sites (Plate 3).

![Plate 3: Hill cleared of vegetation](image)

Source: Field survey, 2017

Deforestation levels on the five mining sites were severe to very severe (above 50% of a hectare affected). Mine employees were also responsible for cutting down trees as they used wood for fuel. A study on environmental impacts of mining conducted in Ghana also revealed loss of vegetation in mined areas in Nankaba, Asoampa, Ashtown, Bondaye, Ankobra and Anfegya (9). A research carried out in Cameroon also revealed that miners clear trees at mined areas to have larger mining surfaces and for safety purposes (13). Deforestation in Atiwa, Ghana has resulted in serious land and forest degradation (18).

4.2.2: Displacement of wildlife

Wild animals usually prefer peaceful and undisturbed environments. Disturbances of their habitats and niches due to noise and loss of vegetation result in migration to other more favourable sites. Locals pointed out that there used to be abundant rock rabbits in their areas before the commencement of mining but these had since become ‘extinct’. Mine employees and locals could also have contributed extent to the loss of wildlife through hunting. Locals point out that most of the quarry sites were habitats for wild animals such as leopards, hyenas, baboons, and monkeys. Whilst baboons and monkeys are still found within mining areas maybe because of highly adaptive capacities, leopards and hyenas have completely disappeared. Loss of habitats and high noise levels from blasting beyond thresholds acceptable levels has driven away these animals. Migration of some animal species may trigger ecological imbalances.
4.2.3 Soil erosion

Mutoko is mainly characterised by loose sand to sandy loamy soils which are erodible once vegetation is removed. During the survey, soil erosion was observed along access routes, around and on mine premises and on site works. The use of heavy vehicles leading to intense soil compaction was also to blame for soil erosion. Severe soil erosion due to mining was also observed at one abandoned mined site at Prestea, Ghana (13). Land clearing was a major driver for soil erosion at the mining sites.

Measurements were however not carried out to determine the rate of soil loss in the mining areas. These measurements are important in future to determine how much soil is being lost to the mining activities. The site works located on hilltops devoid of vegetation were found to be prone to soil erosion with gullies beginning to develop within the mines and surrounding areas. Soil erosion on these mines is exacerbated by lack of rehabilitation on mines.

The quarry managers argued that they had plans to reduce soil loss through rehabilitation of mined sites. No evidence of rehabilitation was however found at any of the surveyed mines. Quenya mine however had a project on vertiver grass and the rearing of indigenous trees. They had plans to plant vertiver grass on slopes. ZIQ mine claimed to have assisted communities in establishing plantations although no verifications could be made on this claim.

4.2.4 Siltation and diversion of water ways

Locals accused the miners for siltation of water sources as they critical for their gardening activities. Dukwa River near Natural Stone mine for instance is heavily silted on stretch of over 3 km from the mine. Some of the miner streams have become seasonal and dry during the dry season Mining activities are blamed for causing siltation although many factors such as poor farming methods such as stream/riverbank are also to blame. Some market gardeners claimed that they experienced water shortages during the dry season and blamed mining for worsening the shortages. River diversion was also blamed on the mining activities.

5. CONCLUSIONS

The findings reveal that black granite mining companies play a part in enhancing socio-economic development in the study area as evidenced by support in infrastructure development and assistance delivery. The benefits derived from black granite mining are however voluntary. Communities and the local authority are passive players thus are not the optimum that could be achieved. Although other factors such as the state of infrastructure could be attributed to its deterioration, black granite mining that frequently uses heavy trucks, is predominantly responsible for damage to roads and bridges. There is however potential for synergies between mining and local communities to enhance sustainable development from black granite mining.

6. RECOMMENDATIONS

The mining companies need to employ EMPs to enhance and/or reduce the impacts of black granite mining. EMA should effectively perform its monitoring role to achieve this end.

The mining companies, the local authority, MRDC and the miners need to work together as an integrated team to address community development needs; meant to achieve consolidated development initiatives. Community share ownership trusts established in black granite mining
industry should be strengthened with some benefits accruing to the communities and be channelled towards development and addressing gaps created by black granite mining.

Mining companies need to put in place measures and programmes to tackle workers’ health and safety issues. This can be done through the establishment of Safety and Health sections on mines. The National Social Security Authority (NSSA) should monitor safety and health issues in black granite mines.

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EFFICACY OF EMAMECTIN BENZOATE AGAINST FALL ARMYWORM, SPODOPTERA FRUGIPERDA IN MAIZE
(Zea mays L)

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ABSTRACT

To establish the efficacy of Emamectin benzoate against fall armyworm, (1) in maize foliage, a laboratory experiment was conducted during the summer season of 2017/2018 at Save Valley Experiment Station. Four chemical concentrations of Emamectin benzoate were used. Maize leaf portions without the chemical formed the 5th treatment. The experiment was carried out in a complete randomized design (CRD). Results showed that higher chemical concentration had the shortest time period of 4 to 8 hours to control S. frugiperda. Lower concentrations of 0.2% and 0.1% showed a significant effect against the insect pest 8 to 10 hours. All concentration levels completely controlled fall armyworm after 12 hours of exposure to Emamectin benzoate. Emamectin benzoate had unprecedented potency against S. frugiperda after being ingested as a foliar spray. Emamectin benzoate can be successfully used in controlling the devastating (S. frugiperda) in maize at four different concentrations.

Key words: Spodoptera frugiperda, Zea mays, Emamectin benzoate, efficacy, concentration

1. INTRODUCTION

Maize, (Zea mays L), is one of the most crucial cereal grains in the world as it has various uses. It can be consumed by humans as porridge, snacks, as green mealies, in brewery industries and as animal feed. The production of maize is mainly affected by different abiotic and biotic factors such as mineral nutrition and attack by defoliating insects (2) like the fall armyworm (FAW), Spodoptera frugiperda (1) respectively. S. frugiperda is one of the most studied insect pest among the most economic pests which ever lived. The pest is considered a severe maize pest in Florida, United States of America. However the pest has found its way into Southern African countries (3) in 2016 and has caused severe damage in countries like Zambia and Zimbabwe in the 2016/17 farming season. The 2017/2018 farming season was again severely attacked by the pest especially the late crop which was established between January-March 2018 (FAO, 2018).

It is worth to note that it is the first time in Zimbabwe to face the devastating fall armyworm. Initially most farmers identified it as the African maize stalk borer (Busseola fusc) and used chemicals specifically for the control of stalk borers. Chemicals like Carbaryl 85 and Malathion were used at high doses (4) to control the pest but often fail to reach the insect, especially the late larvae instars, which are located between the young leaves inside the stalk of the plant (8). Various other insecticides like Belt, Ecoterex, Chlopyriphos, Thiodan granules, Lambda, karate among others are being used on
a trial and error basis by smallholder farmers in Zimbabwe. The pest crop damage is most during its last larvae instars.

(6) highlighted that different chemicals like Chlorantraniliprole and Diflubenzuron were used to control the pest in maize, rice and pastures in other countries like South Africa. However, such chemicals fairly reduce its population and did not give a desired mortality of *S. frugiperda*.

*S. frugiperda* feeds on more than 80 species of plants; however it prefers the grass family to other plant families (7). A number of fruit trees, ornamental plants and weed species are also hosts to the pest. Its polyphagous nature presents challenges in management due to the presence of numerous alternative hosts outside the production season of main crops. That is why it is difficult to provide a complete control in the quickest time. It can easily habitats and multiplies in alternate hosts in preparation to attack the farmers’ preferred maize and sorghum crops.

Most lepidoptera family pest can be effectively controlled by use of Emamectin benzoate 20g-l in crops like tomatoes on fruits, cereals, vegetables, tree nuts, oilseeds, herbs, pasture and tea (8); and (9). (10) added that the use of Emamectin benzoate can be of a solution in controlling *S. frugiperda* especially in Zea mays since the chemical was successfully used in other crops like pastures and hayfields. Emamectin benzoate as protector of plants is recommended to be used, especially for biting and chewing lepidoptera insects. It is a foliar insecticide derivative of abamectin in avermectin family (7). It acts by disrupting the nerve impulses by a unique mode of action. The larvae stops feeding shortly after ingestion of the chemical and became paralysed and die in 1-4 days (11).

However, studies that use Emamectin benzoate to control defoliating caterpillars (*S. frugiperda*) particularly in maize have not been significantly explored in Zimbabwe. Therefore it is important to find the best concentration of the Emamectin benzoate which would provide an effective control particularly in *Zea mays* foliage since the chemical has been providing an effective control of other lepidoptera pests in other crops.

2. OJECTIVES

To assess the efficacy of Emamectin benzoate against fall armyworm (*Spodoptera frugiperda*) in maize (*Zea mays*) foliage.

3. METHODOLOGY

3.1 Experimental site

The experiment was conducted in 2018 at the Save Valley Experiment Station in Chipinge District, Manicaland Province in Zimbabwe during the summer farming season. The experiment was carried out from January to February 2018. The station is found at a Latitude of 20°20'26.84" and Longitude of 32°18'31.21" on the map. The laboratory had a mean temperature of 28.6 and a mean relative humidity of 51.0.

3.2 Experimental design and procedure

A small field of maize measuring 0.1 ha was planted on the 8th January 2018 to provide breeding site of the *S. frugiperda* caterpillars which were used in the laboratory experiment. Collected 5 day old caterpillars were placed in modified petri dishes whose volumes were 4 litre at random. Maize leaf
portions were collected from the last two leaves adjacent the funnel. The dishes were numbered and each dish contained three caterpillars. A total of 30 sample dishes were used. A Completely Randomised Design (CRD) was used.

The concentration of Emamectin benzoate 20g-l treatments were (1) 0.1%, (2) 0.2%, (3) 0.3% and (4) 0.4%. The 5th treatment comprised of maize leaf portions without the chemical was used as the control. Calculation of concentration was for example 1ml of Emamectin benzoate mixed in 1 litre of water to give a 0.1% concentration. The other concentrations followed the same formula. The six portions of maize leaf (3 cm wide x 6 cm long were immersed for three seconds in the solution corresponding to each concentration mixture, and dried on paper for eight minutes. These leaf portions were the diet of three caterpillars in one dish, with a replacement of the portions every 6 hours.

3.3 Data collection

Total numbers of dead caterpillars were recorded at 2 hour interval against the chemical concentrations. The insect was considered dead when gently probed with a sharp object and no response was given.

3.4 Data analysis

Data was subjected to analysis of variance (ANOVA) using GenStat Release 16.1 Copyright 2013, VSN International Ltd, computer software package for statistical analyses. Means were separated using the Least Significant Differences (LSD) at 5% level of significance. The data was transformed to log 10 before subjected to Genstat statistical package before analysed.

4. RESULTS

4.1.1 Effect of Emamectin benzoate concentration on the mortality of FAW at different durations
Table 1 below summarises the effects of Emamectin benzoate concentration on the mortality of FAW after twenty four hour exposure. There was a significant difference p<0.001) at 4th, 6th, 8th and 10th hour. Highest mean mortalities (0.36) in the 4th hr, (0.489) in the 6th hr, (0.410) in the 8th hour and 0.1 in the 10th hour were recorded at concentration levels of 0.4, 0.3, 0.2 and 0.1 respectively. No deaths were recorded in the first 2hours and after 12 hours in all treatment

<table>
<thead>
<tr>
<th>Concentration level (%)</th>
<th>Means mortality at 2 hours</th>
<th>Means mortality at 4 hours</th>
<th>Means mortality at 6 hours</th>
<th>Means mortality at 8 hours</th>
<th>Means mortality at 10 hours</th>
<th>Means mortality at 12 hours</th>
<th>Means mortality at 24 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>0.000</td>
<td>0.000a</td>
<td>0.100a</td>
<td>0.201b</td>
<td>0.448c</td>
<td>0.050a</td>
<td>0.000</td>
</tr>
<tr>
<td>0.2</td>
<td>0.000</td>
<td>0.000a</td>
<td>0.280b</td>
<td>0.410c</td>
<td>0.100b</td>
<td>0.000a</td>
<td>0.000</td>
</tr>
<tr>
<td>0.3</td>
<td>0.000</td>
<td>0.230b</td>
<td>0.489c</td>
<td>0.000a</td>
<td>0.000a</td>
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<td>0.000</td>
</tr>
<tr>
<td>0.4</td>
<td>0.000</td>
<td>0.360b</td>
<td>0.360bc</td>
<td>0.000a</td>
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<td>0.000a</td>
<td>0.000</td>
</tr>
<tr>
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<td>0.000</td>
<td>0.000a</td>
<td>0.000a</td>
<td>0.000a</td>
<td>0.000a</td>
<td>0.000a</td>
<td>0.000</td>
</tr>
</tbody>
</table>
Means in the same column followed by the same letter are not significantly different (p<0.05).

4.1.2 Effect of Emamectin benzoate concentrations on FAW mortality at 2 hours.

No Deaths were recorded in the first two hours of the experiment as shown in table 1 above.

4.1.3 Effect of Emamectin benzoate concentrations on FAW mortality at 4 hours

The results indicated significant effects on the efficacy of Emamectin benzoate concentration levels on *S. frugiperda* 4 hours after ingestion (p<0.001). The 0.3% and 0.4% concentration levels had significantly higher mortalities (p<0.001) than the untreated control while 0.1% and 0.2% and the control had no FAW mortalities 4 hours after ingestion of the chemical (Table 1, Fig 4).

![Fig 4. Efficacy of Emamectin benzoate concentrations on FAW mortality at 4 hours](image-url)
4.1.4 Effect of Emamectin benzoate concentrations on FAW mortality at 6 hours

Emamectin benzoate concentration levels showed significant difference on fall armyworm deaths after 6 hours of chemical ingestion (p<0.001). The results indicated that there were no significant difference between 0.1% concentration level and no chemical treatment (Table 1 and Fig. 13). However, high significant differences were observed between 0.1% and 0.2% and 0.3% concentrations. The 0.2% treatment concentration recorded a significantly higher mortality (p<0.0010 than the 0.1% and control treatments. The 0.3% treatment concentration recorded significantly higher mortalities than lower concentrations, but the FAW mortality was not significantly different from that for the highest concentration of 0.4%. (Table 1, Fig. 5)

Fig 5. Efficacy of Emamectin benzoate concentrations at 6 hours

4.1.5 Effect of Emamectin benzoate concentrations on FAW mortality at 8 hours

At 8 hours after insecticide ingestion by FAW, mortality was only recorded in treatments with lower insecticide concentrations (0.1% and 0.2%). FAW in higher concentrations (0.3% and 0.4%) had all died by the 6th hour (Table 1, Figure 6). After 8 hours the 0.1% concentration recorded FAW mortalities which were significantly higher than the no treatment control (p<0.001). The 0.2% concentration also recorded a significantly higher FAW mortality than both the control and 0.1% concentrations (p<0.001) (Table 1, Fig.6).
Fig 6. Efficacy of Emamectin benzoate concentrations at 8 hours

Fig 7. Efficacy of Emamectin benzoate 20g-l concentrations at 10 hours

Fig 7. Efficacy of Emamectin benzoate concentrations on FAW mortality at 10 hours
4.1.6 Emamectin benzoate concentrations on FAW mortality at 10 hours

Results showed that lower treatment concentrations of 0.1% and 0.2% started to be lethal on FAW after 10 hours. In higher treatment concentrations of 0.3% and 0.4%, all the FAW had died by the 6th hour. FAW mortality in the 0.1% treatment concentration was significantly higher than the 0.2% treatment concentration (p<0.0010).

4.1.7 Effect of Emamectin benzoate concentrations on FAW mortality at 12 hours

Emamectin concentration levels showed no significant difference on mortality after 12 hours of chemical ingestion (p>0.426) (Table 2). Most of the larvae had already died in all treatments.

Table 2. Efficacy of Emamectin benzoate at 12 hour

<table>
<thead>
<tr>
<th>Concentration level %</th>
<th>Mean deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>0.050a</td>
</tr>
<tr>
<td>0.2</td>
<td>0.000a</td>
</tr>
<tr>
<td>0.3</td>
<td>0.000a</td>
</tr>
<tr>
<td>0.4</td>
<td>0.000a</td>
</tr>
<tr>
<td>No chemical</td>
<td>0.000a</td>
</tr>
</tbody>
</table>

4.1.8 Effect of Emamectin benzoate concentrations on FAW mortality at 24 hours

No deaths were recorded as all the larvae in the treatments had died except those in no chemical treatment (Table 1).

4.1.9 Grand FAW mortality mean comparisons

The grand FAW mortality mean results showed that most of *S. frugiperda* died from the 4th hr after ingestion of the insecticide. The highest death occurred in the 6th hr after ingestion of the insecticide. No deaths were recorded in the first 2hrs and at 24hrs (Fig 16) after insecticide ingestion. Generally higher treatment concentrations of 0.3% and 0.4% had their highest effects in terms of FAW mortality at 6 hours whilst that for 0.2% was at 8 hours and that for 0.1% had the highest effect on FAW mortality at 10 hours (Fig. 8, Fig. 9)
Fig 8. Grand FAW mortality mean comparisons

Fig 9. Efficacy of Emamectin benzoate concentrations on FAW mortality at different time intervals.
5. DISCUSSION

5.1 Efficacy of Emamectin benzoate on FAW mortality at 2 hours

There were no deaths recorded in the first 2 hours after the *S. frugiperda* ingested the chemical. The larvae in different chemical levels showed high level of feeding activity. Their survival was due to smaller doses within the pest’s body system as the larvae had not ingested a lot of foliage within that period. Similar results were also coined by (14) who observed that Emamectin benzoate caused minimum mortality of *Spodoptera litura* larvae 2-3 hours after ingesting the chemical.

5.2 Efficacy of Emamectin benzoate on FAW mortality at 4 and 6 hours

Higher Emamectin benzoate concentrations indicated significant effect in knocking down *S. frugiperda*. The study showed that 0.3% and 0.4% concentration levels knocked down the pest significantly because the chemical was more concentrated and hence more toxic. Similarly, (10) reported that higher concentrations were effective and superior in reducing fruit borer (*Melalgus confertus*) larvae population in grapes.

(7) pointed out that Emamectin benzoate increased in its efficacy 5-7 hours after being ingested and its efficacy made it an excellent insecticide in the control of a wide spectrum of lepidoptera pest species on several crops. The results of this study showed significant effects in knocking down *S.frugiperda* 6 hours after being ingested. (15) indicated that the chemical affected the pest’s nervous system and stops feeding and later dies within 1-4 days depending on the concentration ingested. High larvae deaths rates were attributed to assumptions that there was high chemical concentration within the pests’ bodies due to the chemically treated maize leaves which were ingested. (16) also reported that efficacy of Emamectin benzoate on other pests of different crops like in cotton where it controlled effectively *Spodoptera littiralis* and *Helicoverpa zea* in maize was excellent.

5.3 Efficacy of Emamectin benzoate on FAW mortality at 8-10 hours

The larvae which were exposed to lower doses of 1-2% were mainly affected during this time interval. In this study lower doses had a notable effect on *S. frugiperda* after 8 hours of chemical ingestion. The results were in collaboration with the findings of (5) who reported that lower Emamectin benzoate concentrations found to be superior in reducing grape leaf and fruit damage by fruit borers after 9-24 hours.

5.4 Efficacy of Emamectin benzoate on FAW mortality at 12-24 hours

The remaining *S. frugiperda* larvae all in 0.1% concentration level died after the 12th hour. (17), pointed out that accumulation of Emamectin benzoate in the pest’s body system is low at low concentrations and resulted in low mortality of arthropods. This implies that the lower the insecticide concentration the longer it takes to kill the insect. Similarly (18) also reported that the Emamectin benzoate provided a significant control of lepidoptera pests in foliage and fruit vegetables at lower rates and frequently applied.

6. CONCLUSIONS AND RECOMENDATIONS

6.1 Conclusion

Emamectin benzoate concentrations had an effect on controlling *S. frugiperda* on maize foliage. Results of this experiment proved the efficacy of the chemical under different concentrations at different time intervals.
It has been shown that higher concentration had a quicker knock down effect as compared to lower concentrations. All the concentrations provided a complete control of the *S. frugiperda* within 24 hours. Finally, the efficacy of the chemical under study had shown to be superb against the devastating fall armyworm at Save Valley Experiment Station.

### 6.2 Recommendations

The study showed that in order to safeguard the maize crop against fall armyworm, Emamectin benzoate 20g-l can be applied as foliar spray. Farmers are recommended to use 0.3 % Emamectin benzoate concentration as it has similar effect with 0.4%. Lower dosages can also be considered for use when fall armyworm infestation is still low and in its emerging instars. Emamectin benzoate is quick in knocking down the insect pest, paralysing it thereby prohibiting it from feeding which result in death. However further experiments should be done to assess Emamectin benzoate efficacy against *S. frugiperda* to validate the results and to assess its residual effects in maize grain after its use. Also there is need for further research to understand the most appropriate timing for applications of insecticide in order to maximise effectiveness in various cropping systems.

### REFERENCE

EFFECTION OF PLANTING DATES ON THE PERFORMANCE OF FOUR SUGAR BEAN (PHASEOLUS VULGARIS L.) VARIETIES
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ABSTRACT
In an effort to establish the effects of planting dates on the performance of different sugar bean varieties (Sweet violet, Natal sugar, Cherry(MG38) and Gloria), an experiment was conducted during the winter season of 2017 at Save Valley Experiment Station Four planting dates; 1st April, 25 April, 14 May and 05 June were used. The experiment was arranged in a 4*4*3 factorial in a completely randomized block design. Results showed no significant interaction between planting date and variety on yield. Sowing date however had a significant difference (p<.001). 1st April plantings had the highest yield of 4.312t/ha followed by 25th April and 14th May plantings whose yields were not significantly different from each other though different from 1st April plantings and 5th June plantings. 5th June plantings had the lowest yield of 1.865t/ha. A delay in planting exposes bean varieties to varying levels of black aphid attack (p<0.027).

Key words: planting date, sugarbean, performance, Lowveld, potential yield

1. INTRODUCTION
Sugar bean (Phaseolus vulgaris L.) is an annual herbaceous legume crop that can be classified as either bush or vine type. According to (1) sugar beans are native to Mesoamerica, with Central Mexico the most likely center of origin. Sugar beans were taken to Europe by the Spaniards and Portuguese who as well took them to Africa and other parts of the World in the 16th and 17th centuries (2). Sugar beans are now cultivated in the tropics, subtropics and temperate regions.

Sugar beans are highly nutritive, relatively low-cost protein food. The leaves, green pods, young and mature seeds are edible (3). Sugar bean seeds contain 22% protein, 2% fat, 61% carbohydrate and including 5% fiber (4). In low-income countries including Zimbabwe, sugar beans supply a large portion of the protein needs of low and middle class families. After sugar beans are harvested, the straw and residues can be used as fodder. The crop residues can also be composted into manure (3).

Beans are traditionally a subtropical or temperate crop that tolerates most environmental conditions in tropical zones. Beans do poorly in very wet tropics where rain promotes diseases and flower drop. Frost kills plants and pods. There are both short-day and day-neutral cultivars. Excessive water will injure plants in a few hours. Beans grow best in well-drained, sandy loam, silt loam or clay loam soils that are rich in organic content, but are sensitive to high concentrations of aluminium (Al), boron (B), manganese (Mn), and sodium (Na) (5). (6) reported that temperature during the growing season of sugar beans should be between 15 and 30°C. Temperature below or above that range has negative effects on plant performance. Seeds either do not germinate or may decay at temperature below 10°C. Hot dry or wet weather results in flower and pod shedding.
Bean production can therefore be improved by planting at the proper date as changing climatic factors on different planting dates can affect both the quantity and quality of beans.

In Zimbabwe, bean production is characterized by low yields and instability, mainly due to the use of poor quality seed and untimely plantings. The speckled beans are most popular and the red speckled beans had high soluble fibre content. The soluble fibre absorbs water in the stomach forming a gel which slows down the absorption of bean carbohydrates. This helps in balancing blood sugar levels while providing steady, slow burning energy which makes them good choice for people with diabetes. Apart from that, sugar beans can help to restore more iron which is an integral component of haemoglobin necessary in oxygen transportation from the lungs to all body cells (7).

The popular bean variety that has been grown by farmers for the past decade in the Save Valley farming area is Natal Sugar. The Crop Breeding Institute of the Department of Research and Specialist Services has recommended other bean varieties whose performance is perceived to be better than Natal Sugar. However, yield and quality of these are still as low as Natal sugar mainly due to poor cultural practices. (6) believed that testing of some cultural practices such as planting dates and varieties are paramount for improved yield and quality of sugar beans.

(5) recommended the planting of sugar beans between March and May in the lowveld. However, there was a research gap as these were meant for traditionally planted varieties. Accordingly, this study was undertaken to investigate the effect of planting dates on the performance of four bean varieties; three new varieties and Natal sugar a traditional variety as a control.

2. OBJECTIVES

1.4 Aims
To investigate the effect of planting dates on performance of four bean varieties.

1.3: Specific objectives
1) To investigate the effect of planting dates on pest and disease incidence on different bean varieties
2) To investigate the effect of planting dates on days to flowering of different bean varieties
3) To investigate if newly released varieties give better yields compared to Natal sugar in Save Valley farming area.

3. MATERIALS AND METHODS

3.1 Description of the experimental Site
The experiment was conducted in 2015 at the Save Valley Experiment Station in Chipinge District, Manicaland Province in Zimbabwe during the winter season (March – September). The site is located in agro-ecological region V. The soils fall under Calcimorphic order, Siallitic group – Sabi 4U. 2 series. These are deep, well-drained and unleached, high base saturated soils. The texture is sandy clay loam to sandy loam (alluvial) with clay content of 34% (8). Rainfall is erratic, characterized by frequent dry spells. The area receives an average of 250-450mm rainfall per annum (9). Most of the rain comes in heavy storms between October and February. Mean annual temperatures range from 15 to 25°C (Save Valley Experiment Station meteorology station).

3.2 Experimental Design and Treatment
Four sugar bean varieties obtained from the Crop Breeding Institute by Save Valley Experiment Station, were used for the research. The experiment consisted of two factors, planting date and variety. There were four levels
of planting dates (1 April, 25 April, 14 May, 5 June 2015) and four sugar bean varieties (Cherry, Sweet Violet, Natal Sugar and Gloria) replicated three times arranged in 4*4*3 factorial in randomized complete block design. Each plot had 4 rows that were 6m long, 0.5m inter-row and 0.07m in-row. The net plot had 2 rows that were 4m long, 0.5m inter-row and 0.07m in-row. There were 1m pathways between blocks and plots.

3.2.1 Agronomic practices
3.2.1.1 Land preparation, Fertiliser application and planting
The land was prepared in late summer by deep ploughing and discing. These brought about a deep, relatively level and firm seedbed that ensured good seed-soil contact, and increased moisture absorption. Up to 56mm of irrigation water was applied to the field two days prior to planting using overhead sprinkler irrigation. Six metre furrows of approximately 0.03m depth were created at 0.5m intervals in experimental plots using hand hoes. In each plot four planting rows were created. A basal fertilizer compound D (7:14:7) was applied at the rate of 300kg per hectare and covered by a thin film of soil. Eventually, the seeds were sown at a spacing of 0.07m guided by marked reeds to give a plant population of 285700 plants per hectare and covered with soil independent of obstacles. Ammonium nitrate (34.5% N) was then applied at first flowering at the rate of 100kg/ha.

3.2.1.2 Weed control
Hand hoeing was done when the crop was at second trifoliate stage and the weeds were small followed by subsequent hand pulling in the plots throughout the growing period depending on need. Pathways were also kept clean of weeds by hoeing.

3.2.1.3 Pest and disease management
A mixture of Dithane M45, 40g/10litres of water and Diazinon 12ml/10litres of water were applied on the 2nd week of emergence against blights and bean stem maggot respectively. The spray was followed with routine sprays of a mixture of copperoxychloride and diazinon applied after every seven days for 3 weeks. Any sprays thereafter were as a response to a detected pest or disease after scouting. Carbaryl 85WP was first used in PD 2 in the 7th week against Hilda bug at the rate of 80g/10litres of water. It was again used at the same rate in the 5th week in PD 3 against the same pest mixed with 50ml/10litre Dimethoate 40EC for aphid control. Dimethoate 40 EC was then sprayed in the 5th week of crop establishment at the same rate in PD 4 followed by Acetamark in the 7th week at a rate of 55g/15litres of water against the black aphid.

3.2.1.4 Irrigation management
Irrigation activities were instituted following needs as determined by a class A evaporation pan from which evaporation records were noted; cumulative evaporation calculated and booked on a daily bases. The reference crop evapotranspiration (Open pan evaporation * Pan Coefficient) was then multiplied by a predetermined crop coefficient to come up with an estimate of moisture that could have been lost through evapotranspiration in the crop field at a specific time. That was the amount of water that would then be applied on to the field through sprinkler irrigation. The nozzles had an output of 5.6mm per hour.

3.2.1.5 Harvesting
After physiological maturity and browning of more than 80% of the pods in all plots, the side rows of each plot were eliminated as the marginal effect, and also 1 meter from the top and bottom of each plot was removed from two middle rows. Plants from the four square metre net plot were then hand-pulled early in the morning and carried in distinct bags to drying shade. Plants from each plot were dried separately. Threshing was hand done by beating with sticks and wind used to separate the seed from the chaff. The grain from each plot was weighed on a digital scale, weight recorded and grain stored in separate bags.
3.2.2 Data collection
Data on days to flowering, pest and disease incidence, yield and the yield components were recorded from the net plot.

3.2.2.1 Days to flowering
Number of days from planting to first flowering was recorded. Days to first flowering were signified by the emergence of the first visible blooming flower(s) on any plant(s) within the net plot.

3.2.2.2 Determination of pest infestation
Field inspections to determine the incidence of pests were conducted four weeks after bean emergence and after every seven days thereafter until the plants reached physiological maturity. From each plot, bean plants were examined for presence of pests. Large and easily visible pests like Heliothis were counted and recorded. Minute pests and those that live in clusters were recorded using scores. Symptoms of pest presents (ants making holes on plant bases for *Hilda* bug) and symptoms of pest damage, such as yellowing of leaves, stunted seedlings, swellings, mines or cracked stems were also used to determine the number of infested plants. The percentage number of plants showing the pest was considered the percentage incidence of the plot. Pest identification was also done. Bean stem maggot incidence was determined after plants with symptoms such as hypocotyl swellings and cracking wilt and die. The dead plants were dissected using a scapel blade from hypocotyls to the root to expose the pupae and larvae. The cumulative percentage number of plants showing the pest was considered the percentage incidence of bean stem maggot within a plot. Black aphid, *Hilda* bug and bean stem maggot were scored using a score card below.

<table>
<thead>
<tr>
<th>Percentage range</th>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>No insect pest</td>
</tr>
<tr>
<td>1-20</td>
<td>2</td>
<td>Slight incidence of insects presence</td>
</tr>
<tr>
<td>21-30</td>
<td>3</td>
<td>Moderate incidence of insect presence</td>
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<tr>
<td>31-40</td>
<td>4</td>
<td>Slightly severe incidence of insect present</td>
</tr>
<tr>
<td>41-50</td>
<td>5</td>
<td>Severe incidence of pests</td>
</tr>
<tr>
<td>51&amp; above</td>
<td>6</td>
<td>Very severe incidence of insects</td>
</tr>
</tbody>
</table>

Table 3.1: Pest infestation score card: Source CPR- Save Valley Experiment Station

3.2.2.3 Determination of disease incidence
The plants were assessed for disease incidence in the seventh week after planting and thereafter weekly until the plants reached physiological maturity. From each plot, all the plants were also closely examined for presents
of disease symptoms. Disease identified and the percentage number of plants showing the symptoms associated with that disease was considered the percentage incidence of the plot.

\[
\text{Disease incidence} = \frac{\text{number of diseased plants}}{\text{total number of plants examined}} \times 100
\]

<table>
<thead>
<tr>
<th>Percentage range</th>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>Health plants</td>
</tr>
<tr>
<td>1-10</td>
<td>2</td>
<td>Slight disease incidence</td>
</tr>
<tr>
<td>11-20</td>
<td>3</td>
<td>Severe disease incidence</td>
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<tr>
<td>21 &amp; above</td>
<td>4</td>
<td>Very severe disease incidence</td>
</tr>
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</table>

Table 3.2: Disease incidence score card: Source CPR- Save Valley Experiment Station

3.2.2.4 Yield measurement
After maturity, prior to uprooting, 10 plants were selected from the net plot of each plot. The average number of pods per plant was obtained by adding all pods from the ten plants and divide by 10. Average number of grains per pod was also determined by counting number of grains in 10 pods then divide by 10. After threshing and cleaning 100 grains were counted from each lot and weighed on a digital scale to find their weight. Finally, yield from each plot was measured and converted to tones per hectare by simple proportion.

3.2.3 Data analysis
Data was subjected to analysis of variance (ANOVA) using GenStat Release 14.1 (PC/Windows) Copyright 2011, VSN International Ltd, computer software package for statistical analyses. Means were separated using the Least Significant Differences (LSD) at 5% level of significance.

4. RESULTS

4.1 Incidence of Damping off
There was no significant interaction (p>0.05) on damping off disease between sowing date and variety. Sowing date and sugar bean variety did exhibit any significant difference (p>0.05) on incidence of Damping off disease.

4.2 Incidence of Common Blight
There was no interaction p>0.05) on common blight disease between sowing date and variety. Even the individual factors showed no significant difference

4.3 Incidence of Mosaics
There was no interaction between planting date and sugar bean variety (p>0.0.05) on the incidence of mosaic disease. Variety had no significant difference (p>0.05). However, sowing date had a significant difference (p<0.009) on mosaic incidence. The 5\textsuperscript{th} of June plantings had mosaic disease incidence whilst the other 3 planting dates were free of any mosaic disease.
4.4 Hilda bug infestation
There was no interaction between sowing date and sugar bean variety (p>0.563). There was also no significance difference on Hilda bug infestation exhibited on planting dates. Sowing date however, had significant difference (p<.001). PD 2 and PD3 had slightly severe infestation of Hilda bug while PD 1 and PD 4 had no Hilda bug infestation or its damage on any part.

![Figure 4.1: Effect of planting dates on Hilda bug infestation](image)

4.5 Black aphid infestation
There was an interaction on sowing date and variety in terms of black aphid infestation. (p<0.02) Variety and sowing showed significant difference on black aphid infestation. Mean scores of three varieties; SV, Cherry and GL in PD 4 were significantly higher than means of the other three planting dates. Black aphid infestation in Natal sugar was also significantly higher than other three varieties in PD 4.

4.6 Days to flowering
There was an interaction between planting date and variety PD1 and PD 2 showed significant difference in days to flowering to PD 3 and PD 4. All varieties also significantly varied their number of days to flowering across the four planting dates. On all planting dates, MG38 had significant difference to the other varieties on its number of days to first flowering.
4.7 Days to maturity

There was no interaction of sowing date and sugar bean varieties (p>0.056). Planting date showed significant difference (p<0.001) on number of days to maturity. PD 1 and PD 2 were significantly different from PD 3 and also from PD 4. 14th May plantings had the highest number of days to maturity and 5th June plantings had the least number of days to maturity whilst the 1st and 25th April plantings together were intermediate.

Figure 4.2: Interaction effects of planting dates and variety on number of days to flowering

Figure 4.3: Effect of planting dates on number of days to maturity
4.8: Number of pods per plant
There was no significant interaction between sowing date and variety. Sowing date showed significant difference (p<0.001) on number of pods per plant. PD 1 had significantly high number of pods per plant followed by PD 3. There was no significant difference in number of pods per plant between PD 2 and PD 4 and these had the least number of pods per plant. Sugar bean variety had a significant difference (p<0.015) on the number of pods per plant. There was significant difference in number of pods per plant between Gloria and MG38, and also between Gloria and Sweet Violet. However, there was no significant difference between Natal sugar and all other varieties in number of pods per plant.

Figure 4.4: Effect of planting date on number of pods per plant
Sugar bean variety had a significant difference (p<0.015) on the number of pods per plant. There was significant difference in number of pods per plant between Gloria and MG38, and also between Gloria and Sweet Violet. However, there was no significant difference between Natal sugar and all other varieties in number of pods per plant.

4.9: Number of seeds per pod
Sugar bean variety significantly affected (p<.001) number of seeds per pod. Natal sugar had the highest number of seeds per pod followed by Gloria. Sweet Violet and MG38 had no significant difference between them in number of seeds per pod. Sowing date (p=0.723), and interaction of sowing date and variety on the other hand showed no effect on number of seeds per pod (0.900).

4.10: 100-grain weight
There was no interaction of sowing date and variety on weight of 100 seeds (p>0.251). However, sowing date showed significant difference (p<.001) on weight of 100 seeds. Weight of 100 seeds from 1st April plantings had significant difference from the rest. The weight of 100 seeds for the other three planting dates had no significant difference among them. Sugar bean variety has a significant difference (p<.001) on weight of 100
seeds. All varieties had different 100 – grain weight from each other. Sweet violet had the leading weight of 100 seeds while Natal sugar had the least weight per 100 seeds.

4.11: Yield

There was no interaction between sowing date and variety (p>0.897). Sowing date however had a significant difference (p<.001). 1st April plantings had the highest yield of 4.312t/ha followed by 25th April and 14th May plantings whose yields were not significantly different from each other though different from 1st April plantings and 5th June plantings. 5th June plantings had the lowest yield of 1.865t/ha.

\[\text{Figure 4.5: Effect of planting date of yield of sugar beans}\]
5. DISCUSSION

5.1 Pest and disease incidence

On first sowing date all varieties showed no signs of Black aphid infestation. In PD 4, all the newly introduced varieties were severely infested with black aphid whilst Natal sugar was moderately infested. This might be attributed to varietal adaptability as the Natal sugar was planted in the area for long time. Aphids are not very active in winter. According to temperature records obtained from the meteorological department at Save Valley Experiment station, temperatures started to increase in the third week of June and the pest became active. June plantings were still tender hence favored the pest to all other planting dates. The incidence of Mosaic virus disease in PD 4 is also a result of heavy presence of the disease vector that proliferates in warm weather.

Planting date showed a significant difference (p<.001) on Hilda bug infestation. The main host plant for Hilda bug is groundnuts. The crop was uprooted mid-May at Save Valley Experiment station. The destruction of the pest’s main host at this period may have caused a temporary infestation in beans as an alternative host. It however failed to persist after control as its reproduction slows in winter.

The results indicated a significant difference in Heliothis infestation (p=0.010) due to sowing date. Only 1st April plantings had slight incidence of Heliothis. Heliothis is a summer pest and is very active in warm temperatures. It stops feeding when temperatures fall below 12°C (10). It survives winter as pupae in the soil. All sugar bean varieties planted early were attacked by Heliothis and all the subsequent planting dates were free of the pest.

5.2 Flowering of bean varieties

Interaction of sowing date and sugar bean variety showed a significant difference on number of days to flowering. The difference in days to flowering among the four planting dates and four varieties can be attributed to difference in temperatures, day lengths and genetic makeup of the varieties. (11) proclaimed that genotype sensitivity to photoperiod is directly related to the effect of day length and temperature on days to flowering in sugar beans. He revealed higher temperatures as causing reduction in days to node development hence reduction in days to flowering. April plantings received higher temperatures at early vegetative stages hence had fast growth leading to reduced number of days to flowering. (12) attached the difference in flowering among common bean varieties as a result of difference in genotype. As such, MG38 flowered earlier than all other varieties in all cases.

5.3 Yield and yield parameters of sugar bean varieties

The results indicated that number of pods per plant was significantly affected by planting date. (13) claimed that the total number of pods per plant depends on number of nodes on the plant. A delay in planting cause a reduction in stem height hence reduced number of nodes per plant. (12) attributed the reduction in pod numbers to abscission of flowers and small pods as well as failure of fertilization due to production of unviable pollen. (14) sited wind and high temperature stress as main causes of flower and young pod abscission. June plantings flowered in August when wind and temperature were on the higher side in Save Valley. Because of their difference in genetic makeup Gloria was superior to Sweet Violet and cherry but not different to Natal sugar in number of pods per plant.

Sugar bean variety significantly affected the number of seeds per pod. Natal sugar had the highest average number of seeds per pod. It has shown great genetic potential and adaptability as the number of seeds per pod is also said to be influenced by specific environmental stresses and genotype (13).
Planting date showed significant effect on the weight of 100 seeds. 1st April plantings had the uppermost weight of 51.67g per 100 seeds and 5th June plantings had the least weight of 41.67g per 100 seeds. (15) believed that temperatures above the optimum after flowering reduce the grain filling period and the reduction is not compensated by increase in rate of assimilate accumulation. (13) assumed overheating during grain filling as the main cause of a decrease in stored metabolic materials due to increased respiration. 5th June plantings coincided with rising temperatures of August. Genetic makeup of the varieties also contributed to difference in 100 seed weight among varieties. Each variety had its own 100-grain weight.

Results of interaction between sowing date and variety showed no significant effect on the yield of sugar beans while sowing date showed significant difference on yield of sugar beans per plot. 1st April plantings had the highest yield of 4.312t/ha while 5th June plantings had the lowest yield of 1.865t/ha. Late plantings produced low yields as a result of pest attack. Black aphids suck sap thereby reducing amount of carbohydrates destined for storage in the seeds. It also spread mosaic virus diseases to the plants reducing their leaf photosynthetic area. Reduced number of pods per plant and reduced seed weight also affected the final yields of sugar beans as discussed above. (14) obtained similar results.

6. RECOMMENDATION AND CONCLUSION

6.1 Conclusion
Planting date had an effect on pest and disease incidence of bean varieties. Planting date also had an effect on sugar bean flowering. Its interaction with bean varieties was significant on sugar bean flowering and pest incidence (Black aphid). Results of this experiment also proved early planting as better compared to late planting. Pest incidence was low in 1st April plantings and was of pests of low economic importance in the area. Finally, the performance of Natal sugar equated the performance of the newly released varieties under Save Valley conditions.

6.2 Recommendation
Farmers in Save Valley can plant sugar beans early April to make use of the favorable growing conditions. Farmers should as well consider Natal sugar as it is still competent enough to remain in use in their region. It has low weight per 100 seeds but its yield is augmented by increased number of pods per plant as well as increased number of seeds per pod. The variety is also no favored by black aphids compared to the new varieties.

REFERENCES


ABSTRACT

Spiders are macro-arthropods that are important as predators of insect pests. In this study, we investigated the effect tillage system, fertilizer application rate and weeding intensity on spider communities in soybean. The study was conducted at Chinhoyi University of Technology farm during the 2017/18 cropping season using an experiment that was arranged as a split-split plot replicated three times. Abundances of total spiders and those in the family Saltisidae were higher in conservation agriculture (CA) compared to conventional tillage (CT) during flowering and physiological maturity of soybean. The abundance of spiders in the family Lycosidae was 16% higher in CA relative to CT. At flowering, spider evenness ranged from 0.47 (rip lines) to 0.77 (CT). Fertiliser application rate and weeding intensity had no effect on spiders. It is recommended that CA should be practiced to enhance biological pest control through enriched spider abundance.

Keywords: biological control; Chinhoyi; Tillage; Lycosidae; Saltisidae

1. INTRODUCTION

Diversity of natural enemies in cropping systems is important for pest control and is considered to be of economic significance in crop production (1). Spiders are arthropods which, as an order (Araneae), represent one of the most abundant and diverse groups of predators in agricultural crops. Their potential attributes like number of insects killed per unit time, good searching ability and wide host range are correlated with specific vegetation characteristics, suggesting that habitat availability is important for spider colonization and establishment (2). Spiders constitute an important natural biological control group in agroecosystems. In countries like Zimbabwe, spiders have received relatively little attention as natural enemies of insect pests despite their almost unique predatory habits.

For agroecosystems involving crops such as soyabean (Glycine max), the fields are usually disturbed by frequent cultivation of land (3). It is important to note that these disturbed habitats are usually inhabited by various and abundant invertebrate fauna. Mechanical tillage, fertilizer application and weed destruction are some agricultural management practices that potentially influence the activity, abundance and diversity of spiders in agro-ecosystems. As a whole, the population density and species diversity of invertebrate species such as spiders are adversely affected by intensive tillage, fertilizer use and weed management (4). Spiders are fundamental predators whose species richness is associated with reduction
in pest densities (5). In conventionally farmed monoculture, growers tend to till their fields and totally eliminate vegetation. This results in the reduction of predator population densities and an increase of pest occurrences (6). Generally, spiders prefer complex ecosystems with semi-natural conditions suggesting that they will probably colonize conservation agriculture (CA) cropping systems. Conservation tillage systems coupled with tolerating certain levels of weed density in a cropping system diversification appear to create more favourable microhabitats for spiders. Conservation tillage based systems such as CA incorporate legume-based rotation as one of the key principles with soybean being one of the popular legume crops under these systems.

Fertilizer application has a strong impact on the soil-plant interface through the rhizosphere boundary, which subsequently impacts the productivity and sustainability of agricultural crops. Organic and inorganic fertilizers may have beneficial or harmful effects on the interactions among plants, soil biota, and the soil environment. However, few studies have examined the effects of fertilizers on generalist predators like spiders in managed cropping systems in sub-Saharan Africa in general, and Zimbabwe in particular. The application of chemical and organic fertilisers provides nutrients for plant growth, providing food resources for herbivorous prey and subsequently increasing the populations and diversity of associated predatory arthropods (7). However, some negative effects of fertilizer application, particularly decreased abundance and diversity of beneficial arthropods, are inevitable. Therefore, there remains much uncertainty as to the impacts of fertilizer application on the abundance and diversity of spiders especially in Zimbabwe.

Weed control is one of the most crucial crop protection practices in crop production. Weed management programs should promote a balance between crop and non-crop vegetation. Marín (9) and Štokmane and Spuņģis (8) found that the abundance of natural enemies like spiders in agriculture is directly related to complexity of the microhabitat. Weeds promote vegetation diversity thereby increasing natural enemies like spiders. Weeds also provide secondary food resources to the community as well as substrate for overwintering of natural enemies in agroecosystems. Thus evaluation of weed intensity can be an ideal technology to improve vegetation structure of cropping systems that may promote occurrence, abundance and diversity of spiders whilst sustaining livelihoods as relish and/ or medicinal herbs.

The overall aim of the study was to identify agronomic practices that drive the existence of spiders in agroecosystems. More specifically, this study investigated how tillage system, fertilizer application rate and weeding intensity affect beneficial spider population abundance and diversity during the growth cycle of soybean in a sub-humid environment in Zimbabwe.

MATERIALS AND METHODS

2.1. Study site

A field experiment was conducted at Chinhoyi University of Technology (CUT) farm in Zvimba district, in Mashonaland West Province in Central Northern Zimbabwe (17°20'S, 30°14'E). The experiment was established in the 2012/2013 summer cropping season and treatments repeatedly applied on the same plots since then. Maize was grown in rotation with soybean. This study was conducted between December 2017 and April 2018 when the plots were under soybean production. The research site has an
altitude of 1140 m and receives 700-1000 mm of rainfall per annum and annual average temperature of 19.8 °C in winter and 27.0 °C in summer (11). Soils are granite-derived fine-textured Cambisols. Natural vegetation is dominated by miombo woodland and *Hyparrhenia* grasslands.

### 2.1 Experimental design and treatments

The field experiment was laid out in a split-split-plot randomised complete block design. Main-plot factors were tillage system whilst fertilizer rate and weeding intensity were sub-plot and sub-sub plot factors, respectively (Table 1). The total number of treatments used in this study was 36. Each treatment was replicated three times to give a total of 108 plots.

| Table 1: Treatments used in the experiment at Chinhoyi University of Technology farm during the 2017/2018 cropping season |
|---|---|---|
| Factor                          | Levels                                    | Description                                                                 |
| Tillage system                  | Shallow planting furrows (SPF)             | Shallow planting furrows were prepared manually using a hand held hoe to a depth of about 10 cm. |
|                                 | Rip line seeding (RIP)                    | Rip lines were prepared using a tractor mounted ripper to a depth of 10-15 cm. For both SPF and RIP, about 30% plant residue cover was left on the soil surface these two treatments represented CA. |
|                                 | Conventional tillage (CT)                | Plots were ploughed using a disc plough followed by a disc harrow to produce a fine tilth. All plant residues from the previous crop were removed before ploughing. |
| Fertilizer application rate     | Zero fertilizer (NF)                     | No fertiliser was applied.                                                                 |
|                                 | Low rate (LF)                            | One handful manure (about 100 g) + 80 g/ha compound fertilizer (8 % N: 14 % P<sub>2</sub>O<sub>5</sub>: 7 % K<sub>2</sub>O) + 80 kg/ha ammonium nitrate (34.5 % N), 100 kg/ha compound fertilizer (8 % N: 14 % P<sub>2</sub>O<sub>5</sub>: 7 % K<sub>2</sub>O) + 100 kg/ha ammonium nitrate (34.5 % N). 200 kg/ha compound fertilizer (8 % N: 14 % P<sub>2</sub>O<sub>5</sub>: 7 % K<sub>2</sub>O) + 200 kg/ha ammonium nitrate (34.5 % N). |
|                                 | Medium rate (MF)                         |                                                                                   |
|                                 | High rate (HF)                           |                                                                                   |
| Weeding intensity               | Weeding two times (TWI)                  | Weeding was done two times at two and four weeks after crop emergence (WAE).        |
|                                 | Weeding four times (FOU)                 | Weeding was done four times at two, four, six and eight WAE.                      |
|                                 | Clean weeding throughout (CLE)           | No weeds were allowed to grow in the plots through the cropping season.          |
2.2. Sampling procedure
In this experiment, sampling for spiders in the field was done using pitfall trapping, a method that is frequently used for sampling ground surface dwelling arthropods (12). The pitfall sampling procedure involved placement of two pitfall traps per plot, each trap measuring 13 cm in diameter and 1,000 cm$^3$ volume. The pitfall traps were placed in the soil such that their brims were flush with the ground surface. The traps were located 1 m from the edges of the plot and in the eight central rows of the plot and traps within each plot were spaced at a distance of 2 m. Each trap container was half filled with a 15% liquid detergent: 85% water solution. The liquid detergent was put as an initial preservative in the field and prevented the spiders from escaping once they fell into traps. These traps were left in place over a sampling period of seven days and then rested for two weeks before the next sampling occasion. Spider sampling was done at the vegetative (six WAE), flowering (13 WAE) and physiological maturity (15 WAE) stages of the crop. During each sampling period, the traps were checked and spider catches were collected after every 48 hours to minimize deterioration. Spider catches were collected from the pitfall traps by filtering the contents through a strainer. Spider specimens were immediately placed in vials that were filled with a 70% alcohol: 30% water solution to preserve them for identification in the laboratory. At the end of each seven day sampling period, the traps were covered for two weeks with polyethylene plastics. This was done to avoid continuous sampling and probable depletion of spiders in the plots.

2.3. Spider identification
Spider identification work was carried out in the postharvest laboratory at Chinhoyi University of Technology main campus. The specimens were identified using keys by Dippenaar-Schoeman and Jocqué (1997). Spiders were identified into different families and the number of spiders found per family was recorded for each plot. The most distinct morphological characteristic used in this study as an identification tool was the arrangement of eyes which differs among families. The eyes were viewed using a Stereo light microscope.

2.4. Data analysis
Shapiro-Wilk’s test for normality and Bartlett’s test for homogeneity of variances showed that spider count data required transformation. Spider count data were therefore transformed using log10(x + 2.5) to normalise the variance. Spider community diversity measures i.e. richness, evenness and Shannon-Weaver index were computed using Paleontological Statistics (PAST) package version 3.14 (12). Spider abundance and diversity data was subjected to analysis of variance using GenStat Release for Windows Version 10 (22). Where significant differences were detected, means were separated using the standard error of difference (s.e.d) at 5% probability level. Tables and bar graphs were used to give a visual presentation of analysed data.
3. RESULTS

2.2 Treatment effects on spider abundance and diversity

There was a significant (P < 0.05) effect of tillage system on the total abundance of total spiders and those in the family Saltisidae. The main and interaction effects of fertilizer rate and weeding intensity on both spider abundance and diversity were not significant (P > 0.05). Sampling time point also had a significant (P < 0.05) effect on all spider families, total spider abundance and spider diversity. The main effects of tillage were, therefore, confounded by the significant (P < 0.05) interaction effects of tillage and sampling time point that were observed on abundance of total spiders, Lycosidae and Saltisidae as well as spider diversity measures i.e. evenness and richness.

Treatment effects on intra-seasonal dynamics of spiders

The effect of tillage system on abundance of total spiders and those in the families, Lycosidae and Saltisidae differed (P < 0.05) across the soybean growth stages. However, fertiliser application rate and weeding intensity had no effect on spider communities. In general, total spider and Saltisidae abundance was least during the reproductive (13 WAE) compared to the vegetative (six WAE) and physiological maturity stages of the crop (15 WAE (Figures 2 and 2, respectively). For total spider abundance, conservation agriculture (CA) treatments had the highest abundance at vegetative and physiological stages of soyabean growth. However, tillage had no effect on total spiders during the flowering stage. Saltisidae abundance was significantly (P < 0.05) higher in SPF than CT at both vegetative and physiological maturity of soybean. Reduced abundance of Lycosidae was observed during flowering and physiological compared to vegetative stages of growth (Figure 3). However, significant (P < 0.05) differences among tillage treatments on Lycosidae were only evident during the vegetative stage when the two CA treatments had higher abundances compared to CT. Tillage effects on spider family evenness varied across soybean growth stages with a generally low evenness during the flowering stage of the crop (Figure 4). During this growth stage, CA had a significantly (P < 0.05) lower evenness than CT.
Figure 1: Effect of tillage systems and sampling time point on total abundance of spiders in a soybean field at CUT farm between February 2018 and April 2018.

Error bars are ± standard error of difference for the comparison of tillage means within and across sampling time points. Tillage system treatments are shallow planting furrows (SPF), rip line seeding (RIP) and conventional tillage (CONV). Total spider abundance was transformed using Log10 (x + 2.5).

Figure 2: Effect of tillage system and sampling time point on the abundance of Saltisidae spider family in a soybean field at CUT farm between February 2018 and April 2018.

Error bars are ± standard error of difference for the comparison of tillage means within and across sampling time points. Tillage system treatments are shallow planting furrows (SPF), rip line seeding (RIP) and conventional tillage (CONV). Saltisidae spider abundance was transformed using Log10 (x + 2.5).
Figure 3: Effect of tillage systems and sampling time point on the abundance Lycosidae spider family in a soybean field at CUT farm between February 2018 and April 2018.

Error bars are ± standard error of difference for the comparison of tillage means within and across sampling time points. Tillage system treatments are shallow planting furrows (SPF), rip line seeding (RIP) and conventional tillage (CONV). Lycosidae spider abundance was transformed using Log10 (x + 2.5).

Figure 4 Effects of tillage systems and sampling time points on evenness of spider diversity in a soyabean field at CUT farm between February 2018 and April 2018.

Error bars are ± standard error of difference for the comparison of tillage means within and across sampling time points. Tillage system treatments are shallow planting furrows (SPF), rip line seeding (RIP) and conventional tillage (CONV).
4. Discussion

This study focused on spider abundance and diversity response to tillage system, fertilizer application rate and weeding intensity during the different growth stages of soybean. The results of this study provide evidence that the effects of tillage on spider abundance and evenness vary across the different growth stages of soybean. This confirms the findings of Bao et al. (13) who observed that recently tilled fields had low vegetation complexity and represent a critical period for predator’s establishment. Therefore the recovery of spider populations after disturbances in the field is achieved by reproduction. During the vegetative stage (six WAE) of soybean growth, the spider community abundance in CA was relatively higher than in CT possibly because plant residues that were retained in CA plots served as a reservoir of spiders during the dry season.

Results observed in the study also showed that abundance of total spiders Lycosidae and Saltisidae were enhanced by SPF and rip line seeding during the vegetative and physiological maturity stage of soybean. This agrees with Pfingstmann et al. (14) who observed that overall arthropod and spider faunae are increased by reduced tillage and a complex underground sub-system. The observed effects of CA on the total abundance of spiders and spiders in the families, Lycosidae and Saltisidae are perhaps associated with its influence on the physical structure of the soil habitat and accumulation of crop residues. In CA where crop residues are retained on the soil surface and act as overwintering sites for spider faunae, spiders set in earlier than in CT. On the other hand, in CT, crop residues are removed and as such there are limited overwintering sites hence spiders migrate into the habitats with the establishment of vegetation at the onset of the rainy season. In addition, CT breaks the soil and buries plant residues, destroying suitable habitats for reproduction, shelter and refuge of agroecosystem spider assemblages (11). In contrast, lack of disturbance in reduced tillage cropping systems, particularly SPF, reduces spider mortality probably due to the presence of alternative prey and residues to hide from natural enemies. This enables the maintenance of a stable spider population (15). Spiders also decrease with increasing intensity of soil disturbance possibly because tillage destroys the vegetative food resources of herbivorous and soil fauna which are alternative prey of spiders (16). Previous studies showed that Lycosidae play an important density-dependent role in controlling agricultural pests that include Helicoverpa spp., aphids (Aphididae), Trichoplusia spp. and Plutella spp. (17).

There is no evidence from this study to show that fertilizer application rate and weeding intensity influence the abundance and diversity of spiders in agroecosystems. These results contradict the findings of Patrick et al. (18) who demonstrated that spider abundance increased with increasing fertilizer application rate. The contradiction between the results of this study and Patrick et al. (18) may be due to the differences in climatic conditions between the study sites. Our results were also contrary to the findings of Amalin and Peña (19) who, in a study conducted in Florida, observed increased abundance of hunting spiders in non-weeded compared to weeded plots for all sampling periods. The results in this study do not agree with the claims probably due to the differences in the weed species, climate and spider species found in Florida and Zimbabwe.

The research findings also show that during the reproductive phase of soyabean, spider community evenness was relatively higher in CT systems compared to CA plots. This agrees with Whitmore et al. (20) who also observed that spider families showed varying degrees of affinity for different microhabitats
with some being widespread and abundant while others were restricted to a single habitat and were locally rare. This implies that in CA some spider families were more dominant than others resulting in less even spider communities compared to CT. Thus, under the specific environmental and experimental conditions of this study, CT provided suitable conditions for spider species in even numbers than in CA where other species totally colonize the habitat than others which go extinct during this growth period (21).

Conclusion and recommendations
This study showed that the effects of tillage on spider abundance and diversity varied across the three growth stages of the soybean crop. In particular, increased abundances of spiders were observed in CA plots during the vegetative and physiological maturity stage. We therefore conclude that tillage influences abundance of total spiders and those in the Lycosidae and Saltisidae families. Based on the results of this study, it is further concluded that fertilizer application rate and weeding intensity do not influence the abundance and diversity of spiders in soyabean.

Based on the results of this study, it is recommended that farmers should practice CA in order to enhance spider abundance and diversity particularly during the vegetative stage of soybean. This would have the potential benefits of enhanced biological insect pest control in soybean cropping systems. Future research should focus on the effects of fertilizer rates and weeding intensity under different experimental conditions and evaluate the effects of management strategies on spiders.

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THE ROLE OF HONEYBEES (*APIS MELLIFERA*) IN ENSURING FOOD SECURITY FOR RURAL COMMUNITIES

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ABSTRACT

Globally, concerns of a serious decline in insect pollinator abundance have been raised. Honeybees (*Apis mellifera*) are facing critical species threatening risks ranging from a variety of diseases, climate and environmental changes as well as anthropogenic impacts. Honey bees are key pollinators of food crops and the study investigated the key roles of bees in ensuring food security to communal areas. Qualitative and quantitative research design was used in a case study approach during dry season from (September to October 2018) in 3 villages within Nyamakate communal lands. Participatory observation method was used with fifty questionnaires targeted to households in communal villages. About 61.81\% households surveyed in 3 villages had ventured into apiculture to ensure food security in the event of a disaster. There was a positive correlation between apiculture farming and number of bee hives per household \(r=0.430, n=55, p<0.005\). Most of the farmers are realizing the importance of honey bee conservation in ensuring food security and income generation. About 34.5\% of the households managed to harvest 16-20 kgs of honey annually. Honey bees conservation ensures food security to communal farmers in a variety of ways which ranges from harvested honey as sources of food, income generations from sales and reduction of several environmental degradations through creation of favorable honey bees conservation methods.

Key words: Apiculture, food security, honey bees, pollinator, subsistence farming.
1. INTRODUCTION

Apiculture has proved to be effective in improving farmers’ resilience to both climatic and economic shocks. Besides improving different crops and livestock to ensure food security to communal farmers, bees and trees production plays a pivotal role in improving the livelihoods of the local communities as they complement production of agricultural crops and enhancing the agro-ecosystem (1, 2). Farming in most of Zimbabwe’s communal lands depends largely on seasonal rains thus depends on nature and its extremes and as such farmers have no control of their efforts (10). In this regard, apiculture can guarantee farmers food, nutrition and income if they can adopt environmentally friendly farming practices.

Crop production alone cannot provide adequate food security as this is affected by several factors and some are beyond control such as natural disasters (3). Apiculture provides a feasible diversification option to farmers thus helping to improve communities’ livelihoods since it has low cost, low risk and requires minimal labour and land, making it viable for old and young and disadvantaged societies (1, 3). Apart from that, apiculture does not compete for resources with other types of agriculture, it is self-sufficient and do not need constant attention. Most farmers practice a mix of activities that is combining apiculture with raising crops and cattle and this help to improve the food base for a family and communities at large (1).

The demand for honey and other bee products is high in Southern African Development Committee (SADC) and in Zimbabwe (1). Honey from honeybees is a good source of carbohydrates beside that it is used in making confectioneries and pharmaceuticals and as a natural medicine. Besides employment creation in rural communities, bees conservation play a significant role by pollinating crops, contributing to increased food production thus enhancing food security to communal areas. Bees pollination services to wild plants, including forest trees, which gives them a vital ecological role in biodiversity conservation and the maintenance of ecosystem helps to reduce the effects of climate change which can threaten the food security (4). Apiculture as an agro-business has a strong market for beeswax needed in making cosmetics, antiseptics, floor and furniture as well as shoe polish and this generate money for subsistence farmers (4). Besides that, apiculture enables farmers to make their own candles, wax, soap and skin lotions thus improving their lifestyles (4, 5). Honey is an effective detoxifier, and contains vitamins C, D, E and K, which help strengthen the body’s immune system thus reducing cost for medication which can threaten the food security of a community or a nation (5). Ethiopian economy thrives very well on
honey and by products export such as bee venom, propolis and royal jelly and this makes a significant role to the country at large and the local communities in ensuring food security (6).

The intensification of agro-business, especially tobacco farming in Hurungwe district has resulted in dwindling of both wild and commercial bees kept in apiaries (1, 7). Intensive production of flue cured tobacco has resulted in massive clearance of forest thus destroying bee habitats and forage ground for honey bees and this threatens the food security (1, 8). Low agricultural productivity due to unreliable rains and drought has resulted in severe problems such as food shortages and lack of capacity to access basic food. Apiculture has become a feasible option to ensure food security to communities and this option is hindered by unsustainable agricultural practices such as deforestation and the use of lethal agro-chemicals (9). Carbon Green, Environmental Management Agency (EMA) and Forestry Commission have made efforts to convince subsistence farmers to resort to apiculture to ensure food security to their families and communities (7).

1.1 Objectives
The study seeks to examine the role of Honeybees in ensuring food security for rural communities. Specifically, the objectives of the study were to: (1) quantify communal farmers involved in apiculture, (2) assess the relationship between apiculture and the need to ensure food security in communal area, (3) investigate the major reasons why communal farmers ventured into apiculture and (4) assess the intensity of honey production and the types of bee hives used by communal farmers.

1.2 The role of bees in ensuring food security to subsistence farmers.
Zimbabwe has been battling to ensure food security since 1980 and this has been worsened by most of its population living under the poverty datum line (1). Zimbabwe was once a bread basket of the SADC but the situation started to deteriorate since 1992 following recurring droughts. Zimbabwe implemented the Economic Structural Adjustment Programme (ESAP) in 1992 following a drought that hard hit the country in 1991 and the idea to ensure food security thorough apiculture was conceived (1). The first apiculture project for subsistence farmers was introduced in Hurungwe district of Mashonaland West province by Zimbabwe Farmers Development Trust (ZFDT) (1). Local farmers who have 5 or more bee hives occupied by bees feel secured in the event of food shortage than families without bee hives (1, 7). Good stock of honey for a family and for a community gives a great assurance of low risk of starvation. Some local communities go into local protected National parks to hunt honey to secure food for their families and sell the surplus. Bees play a pivotal role in pollination of flowering crops such as pumpkins,
watermelons, sunflowers (8) among others and this can be invisible to local communities as they may sometimes not be able to quantify or value the importance of pollination to food security. Apart from that marketing and selling locally produced honey is profitable and plays a significant role in creating employment and increasing rural income thus helping rural communities to ensure food security through poverty alleviation (7, 10).

RESEARCH METHODOLOGY

Study area

Hurungwe district lies within farming regions II, III and IV as shown in Fig 1 with rainfall amounts ranging from 500-1000mm. The district has an estimated population of 329,197 and covers about 19,200 km² (11, 12). Periodic seasonal droughts, prolonged mid-season dry spells and unreliable starts of the rainy season are experienced within the district. Anthropogenic impacts to the environment are noticeable through farming of maize (Zea mays), tobacco, cotton, beans (Phaseolus vulgaris), sorghum (Sorghum bicolor) and groundnuts (Arachis hypogaea) (12). The major vegetation type comprises of mopane and miombo woodland (12)

Fig 1 Location of study area in the context of protected and subsistence areas. Source: (13) unpublished

Quantitative and qualitative methods were used to capture and analyze data. Combining these methods helped to strengthen the data collection and analysis and remove data gaps. Random sampling technique was used in this study and three villages that is Village 28, Village 31 and Village November were studied. The research worked with 55 households which were randomly selected from the randomly selected 3 village. Questionnaires (55) which were translated into local vernacular language were used to interview the households directly. The quantity of communal farmers involved in apiculture, annual
honey produced by each farmer and major challenges which these farmers encounter in apiculture were captured and recorded on spread sheet for data analysis. The relationship between apiculture farming (i.e. measured by the number of bee farmers) and the need to ensure food security in communal areas (as measured by the number of bee hive per each household) was investigated using Pearson product moment correlation coefficient. Preliminary analyses were performed to ensure no violation of the assumptions of normality, linearity and homoscedasticity. Data analysis was done in IBM SPSS Version 20. In-depth information was gathered from Republic of Zimbabwe Bees’ Act, reports, books, journal articles etc on the roles bees plays in ensuring food security and possible solutions which can be adopted to ensure sustainable utilisation of bees. The structured interviews provided quick access to prior history of the situation and helped to identify other sources of evidence on the factors under study. Secondary data was also gathered from the Agricultural Extension Services and incorporated to show the livelihoods of communities in relation to benefits obtained from apiculture. Graphs, pie charts and tables were used to present data obtained from interviews and secondary data.

RESULTS AND DISCUSSION

About 61.81% of the sampled households had a farmer who had ventured into apiculture to ensure family food security in the event of mishaps. These farmers had at least 1 or more bee hives in their field or state land as a measure to ensure their food security. Apiculture is gradually becoming more of a renewed rural occupation (10). Only 5.5% of the farmers had ventured into apiculture as a hobby. The relationship between apiculture farming (as measured by the number of households involved in apiculture) and the need to ensure food security in communal areas (as measured by the number of bee hives per household) was investigated using Person product-moment correlation co-efficient. There was a positive correlation between the two variables (number of household and number bees hives set as means to ensure food security, \( r=0.430, n=55, p<0.005 \),

About 58% of the households in the study area had at least 1-5 bee hives as illustrated in fig 2. These bee hives were either in the farmers property or shared common resources like rivers, mountains and state land areas. In this regard, communal farmers are making use of the land which may not be suitable for cultivations which enables them to ensure food security.
About 53% of the bee hives used by the farmers were Kenyan Top Bar Hive (KTBH) as illustrated in fig 1.3. KTBH type of bee hive is environmentally friendly as it does not allow destruction of trees since most of the wood used is obtained from commercial farms which grow exotic trees (7). Farmers view the need to avoid deforestation which can be caused by use of traditional bee hives which involves de-barking live trees and cutting down trees with halos (10). About 13% as illustrated in fig 3 of farmers used the Langstroth type of bee hive. This type of bee hive is expensive, difficult to make and not very popular to communal farmers (7, 10).

About 34.5% of the households manage to harvest between 16-20 kgs of honey per year
CONCLUSION

High numbers of households had ventured into apiculture to ensure food security to their families in the event of uncertainties such as droughts. A positive correlation between the households involved in apiculture and number of bee hives per household indicates a significant role of honey bees in improving the communal farmers livelihoods. We conclude that honey bees conservation ensures food security to communal farmers in a variety of ways which ranges from harvested honey as a sources of carbohydrates, income generations from sales and reduction of several environmental degradations through creation of favorable honey bees conservation methods. Apiculture help to maintain tree cover by promoting the protection of woodlands and planting more trees and helps to ensure a regular and ample supply of bee forage.

Data availability.

The data used in this manuscript can be publicly assessed for other studies without restrictions. The data can be accessed from the Zimbabwe Parks and Wildlife Management Authority Library and Chinhoyi University of Technology library.

Competing Interests

The authors declare that there is no competing interest regarding the publication of this paper.

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REFERENCE


9. Republic of Zimbabwe, Bees Act Chapter (19:02) 2002


EVALUATION OF VARIOUS PROCESSING METHODS ON COWPEAS (VIGNA UNGUICULATA) USED AS A PROTEIN SOURCE FOR FEEDING GROWING FINISHING PIGS
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ABSTRACT
An experiment was carried out to determine the growth performance of pigs fed rations with cowpeas subjected to various processing techniques. Forty crossbred pigs at five weeks of age were used in randomized complete block design. Blocking was on breed (Large White, Landrace and Duroc crosses) and sex class (barrows and gilts) with five treatments presented as a 3 x 2 x 5 factorial experiment with four replicates. Forty pigs were randomly allotted to five treatment groups: germinated cowpeas (A); cowpeas soaked in 0.03% sodium bicarbonate then boiled for two hours (B); cowpeas soaked in 0.03% sodium bicarbonate for 16 hours (C); raw cowpeas (D) and the soya bean meal based diet (E). Pigs were fed for nine weeks. Pigs on diets with soaked and boiled cowpeas had significantly (P<0.05) higher live weight gains (LWG) than those on the other treatment groups. Feed intake was higher among growers fed diets with soaked cowpeas. Pigs on the diet with unprocessed cowpeas had the lowest feed intake and live weight gain. There were no significant differences in feed conversion ratio (FCR) among the treatment groups (P>0.05). In terms of cost per live-weight gain, soya bean meal based diet was cheapest. It is recommended that smallholder farmers that have challenges accessing soya bean meal but have access to cowpeas to use boiled instead of raw cowpeas in their pig diets to enhance production.

Keywords: cost, cowpeas, feed intake, live weight gain, processing method
INTRODUCTION
Cowpea (*Vigna unguiculata*) is one of the most important food and forage legumes in the semi-arid tropics (Timko *et al.*, 2007). It is a multifunctional crop, providing food for man and livestock and serving as a valuable and dependable revenue-generating commodity for farmers and grain traders (Singh, 2002). In addition to mixed cropping with pigs, the smallholder farmers can formulate diets using the cow peas as the protein source. The nutritional profile of cowpea grain is similar to that of other pulses with a relatively low fat content and a total protein content that is two- to fourfold higher than cereal and tuber crops. Similar to other legumes, the storage proteins in cowpea seeds are rich in the amino acids lysine and tryptophan when compared to cereal grains. Total seed protein content ranges from 23% to 32% of seed weight (Nielson *et al.* 1993; Hall *et al.* 2003). Cowpea seeds are also a rich source of minerals and vitamins and among plants have one of the highest contents of folic acid, a B vitamin necessary during pregnancy to prevent birth defects in the brain and spine (Hall *et al.* 2003). Although cow peas are a good source of nutrients, they also contain antinutritional factors (ANFs). It has also been shown that feeding raw cowpeas reduced growth and causes histomorphometric changes in various segments of the intestines (Makinde *et al.*, 1997) attributed to ANFs. The major ANF in the cowpea are trypsin inhibitors, tannins and phytates (Aletor and Aladetimi 1989) which have growth inhibiting effects. Compared to other legumes, cowpea is known to have good adaptation to high temperatures and resistance to drought stress (Hall *et al.* 2002; Hall 2004) which are the prevailing climatic conditions in arid and semi-arid areas. For example, Hall and Patel (1985) reported cowpea grain yields of as much as 1t/ha of dry grain in a Sahelian environment with low humidity and only 181 mm of rainfall. At present, few other legume crop species are capable of producing significant quantities of grain under these conditions. Cowpea is also a valuable component of farming systems in areas where soil fertility is limiting. This is because cowpea has a high rate of nitrogen fixation (Elawad and Hall 1987), forms effective symbiosis with mycorrhizae (Kwapata and Hall 1985), and has the ability to tolerate a wide range of soil pH when compared to other grain
legumes (Fery 1990). Cowpea is also well recognized as a key component in crop rotation schemes because of its ability to help restore soil fertility for succeeding cereal crops (Carsky et al. 2002; Tarawali et al. 2002; Sanginga et al. 2003). Smallholder farmers will improve their livelihoods from mixed farming. Small holder farmers face huge challenges in meeting the pig nutritional requirements especially essential amino acids mainly because of the high cost of feed concentrates which are not easily accessed by the farmer. The smallholder farmers are unable to use conventional feeds to feed their pigs due to cash flow challenges. The resource constraints are further worsened by the recurring droughts. The use of protein sources that are readily available in the smallholder sector to feed pigs is therefore considering. The use of cowpeas in pig diets is one of the options available for the farmer to improve the nutritional composition of the pig diets. In order to succeed, there is need to develop alternative pig production systems for the smallholder farmers based on the use of locally available feed resources and avoiding as much as possible any processing that will increase the costs of production. However, in order to make an efficient use of those resources, it is necessary to understand the principles that govern pig nutrition, as well as the impact of using feed resources with antinutritional factors. The use of cowpeas in pig diets has the potential to improve pig production and productivity in the smallholder sector, a development that will result in improved nutritional security.
OBJECTIVE

The objective of the study is to evaluate the effect of various processing methods on cowpeas (*Vigna unguiculata*) used as a protein source for feeding growing finishing pigs.

METHODOLOGY

Study Area

The study was conducted at the Pig Industry Board Zimbabwe Arcturus station. The station has a 300 sow unit comprising of Large White, Landrace, Duroc, Dalland and Mukota breeds and their crosses. The farm is located at 17°48´ South and 31°20´ East. It is 30 km to the North-east of Harare in Zimbabwe, an intensive mixed crop farming area in Zimbabwe natural region IIA (Mugandani et al., 2012). The site lies approximately 1500m above sea level. Mean temperatures during the warm humid months (October to March) averages 21°C, while the cool dry months average 16°C. The mean annual rainfall is 800mm.

Experimental design and animal management

Forty crossbred pigs at five weeks of age were used in a randomized complete block design. Blocking was on breed (Large White, Landrace and Duroc crosses) and sex class (barrows and gilts) with five treatments presented as a 3 x 2 x 5 factorial experiment with four replicates. Forty pigs were randomly allotted to five treatment groups: germinated cowpeas (A); cowpeas soaked in 0.03% sodium bicarbonate then boiled for two hours (B); cowpeas soaked in 0.03% sodium bicarbonate for 16 hours (C); raw cowpeas (D) and the soya bean meal based diet (E).

The variety of the cowpeas was CBC2. The experimental weaners were selected from those weighing between 14 - 16kg. The allocation of weaners to treatments was such that each treatment had the same number of pigs, breeds and sexes. An experimental unit comprised of a pen with two pigs. A total of 20 pens were used in the study. The trial pigs were on *ad libitum* feeding system during the trial period.
Experimental treatments

Five treatments comprising of a control diet and experimental diets with cowpeas subjected to different treatments were used. The CBC2 cowpeas variety were processed and included in the diet in place of soya bean meal. The processing methods of the cowpeas are listed and described in Table 1.

Table 1. Processing methods

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Processing method</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Cowpea seed was germinated for 36 hours on trays after soaking them in 0.03% sodium bicarbonate for 16 hours. The cowpeas were then dried in a solar drier, ground and added to the diet.</td>
</tr>
<tr>
<td>B</td>
<td>The cowpea seed was soaked in the 0.03% sodium bicarbonate solution for 16 hours then boiled for two hour and dried in a solar drier, grinding and added to the diet</td>
</tr>
<tr>
<td>C</td>
<td>Cowpea seed was soaked in a 0.03% sodium bicarbonate solution at room temperature for 16 hours then dried in a solar drier and before adding to the diet.</td>
</tr>
<tr>
<td>D</td>
<td>Conventional soya bean meal based diet (Control)</td>
</tr>
<tr>
<td>E</td>
<td>Unprocessed cow peas</td>
</tr>
</tbody>
</table>
The compositions for the grower and finisher rations are as shown in Table 2.

### Table 2. Compositions of the grower and finisher rations (kg)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Ingredients</th>
<th>Grower ration (control)</th>
<th>Grower cowpea ration</th>
<th>Finisher ration (control)</th>
<th>Finisher cowpea ration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td></td>
<td>484.5</td>
<td>230</td>
<td>511.0</td>
<td>306.6</td>
</tr>
<tr>
<td>Wheat Bran</td>
<td></td>
<td>85.5</td>
<td>40.5</td>
<td>90.0</td>
<td>54.1</td>
</tr>
<tr>
<td>Soya Bean Meal</td>
<td></td>
<td>157.5</td>
<td>0.00</td>
<td>126.5</td>
<td>0.00</td>
</tr>
<tr>
<td>Cowpea Meal</td>
<td></td>
<td>0.00</td>
<td>457.0</td>
<td>0.00</td>
<td>366.8</td>
</tr>
<tr>
<td>Pig Grower Premix</td>
<td></td>
<td>22.5</td>
<td>22.5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pig Finisher Premix</td>
<td></td>
<td>-</td>
<td>22.5</td>
<td>22.5</td>
<td></td>
</tr>
<tr>
<td>TOTAL (kg)</td>
<td></td>
<td>750.00</td>
<td>750.00</td>
<td>750.00</td>
<td>750.00</td>
</tr>
<tr>
<td>Total cost/kg</td>
<td></td>
<td>$0.47</td>
<td>$0.45</td>
<td>$0.45</td>
<td>$0.43</td>
</tr>
<tr>
<td>CP %</td>
<td></td>
<td>16</td>
<td>16</td>
<td>14.5</td>
<td>14.5</td>
</tr>
</tbody>
</table>

### Data analysis

The effect of the processing technique of cowpeas on the growth rate was analyzed using the general linear model procedure (PROC GLM) of SAS with diet treatment as the variable. Where significant, the means were separated using Tukey’s method. The following model was used;

\[
y_{ijkl} = \mu + B_i + T_j + P_k + (B*T)_{ij} + (T*P)_{ik} + e_{ijkl}
\]

Where:

- \(y_{ijkl}\) is the response variable (LWG)
- \(\mu\) is the overall mean common to all observation
- \(B_i\) is the effect of initial weight as the blocking factor

$T_j$ is effect of the treatment (jth treatment 1, 2 and 3)

$P_k$ is the effect of breed

$(B*T)_{ij}$ is the interaction between initial weight and treatment

$(T*P)_{jk}$ is the interaction between treatment and piglet breed

$e_{ijkl}$ is residual error

RESULTS AND DISCUSSION

All treatment diets had a significant effect ($P < 0.05$) on the live weight gain and total feed intake (Table 3). However, type of diet did not affect the feed conversion ratio (FCR)

**Table 3: Least Square Means of effect of diet on feed conversion ratio (FCR) live weight gain feed intake and their standard errors in parentheses.**

<table>
<thead>
<tr>
<th>Protein source</th>
<th>Live weight gain (kg)</th>
<th>Total feed intake (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cowpea seed soaked in 0.03% sodium bicarbonate, germinated and dried (Diet A)</td>
<td>61.75bc (0.32)</td>
<td>182.20b (5.71)</td>
</tr>
<tr>
<td>The cowpea seed soaked in the 0.03% sodium bicarbonate, boiled and dried (Diet B)</td>
<td>82.125a (0.43)</td>
<td>219.7a (5.71)</td>
</tr>
<tr>
<td>Cowpea seed soaked in a 0.03% sodium bicarbonate solution at room temperature and dried (Diet C)</td>
<td>72.75b (0.24)</td>
<td>214.5a (5.71)</td>
</tr>
<tr>
<td>Conventional soya bean meal based diet (Control) (Diet D)</td>
<td>76.25b (0.27)</td>
<td>186.95b (5.71)</td>
</tr>
<tr>
<td>Unprocessed cow peas (Diet E)</td>
<td>54.5c (0.29)</td>
<td>171.00c (5.71)</td>
</tr>
</tbody>
</table>

abc Means with different superscripts within columns differ significantly ($P < 0.05$) according to Tukey’s test
Pigs fed diet with soaked, boiled and dried cowpeas had significantly higher weight gains than the other treatment groups whilst pigs fed diets with unprocessed cow peas had the lowest weight gains. Differences in growth rate, as indicated by the differences in weight gain among the treatment groups, were observed despite the fact that the diets were formulated with similar nutritional composition. The differences in growth rate of the pigs fed with diets containing cowpeas subjected to different treatments methods could be attributed to the effect of the processing technique on animal performance. Feed intake was highest for boiled and soaked cowpeas than for the other three treatments although all animals were on *ad lib* feeding. It is conceivable that processing of the cowpeas had an effect on the final taste of the diet hence the difference in intake. Raw cow peas had the lowest intake confirming that the processing technique affects taste and consequently intake. The control diet with soya bean meal as the protein source was moderately consumed. Although feed intake was different (P<0.05), diet did not affect feed conversion ratio (P=0.2544).

**Table 4: Feed Conversion Ratio (FCR) Least Square Means and the cost implications**

<table>
<thead>
<tr>
<th>Diet</th>
<th>FCR</th>
<th>Feed cost of producing a kg pork (grower and finisher feed only)</th>
<th>Feed cost of producing a 60kg carcass (grower and finisher feed only)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3.14</td>
<td>$1.38</td>
<td>$82.80</td>
</tr>
<tr>
<td>B</td>
<td>2.69</td>
<td>$1.18</td>
<td>$70.80</td>
</tr>
<tr>
<td>C</td>
<td>2.95</td>
<td>$1.30</td>
<td>$78.00</td>
</tr>
<tr>
<td>D</td>
<td>2.46</td>
<td>$1.13</td>
<td>$67.80</td>
</tr>
<tr>
<td>E</td>
<td>3.19</td>
<td>$1.40</td>
<td>$84.00</td>
</tr>
</tbody>
</table>
Although diet had no effect on the feed conversion ratio, the cost implications indicate some form of savings on production costs especially on a small scale set up. Soya bean meal based diet had the lowest cost to produce a kg of pork, followed by diet with boiled cowpeas. Unprocessed cowpeas based diet had the highest cost to produce a kg of pork. However, for smallholder pig producers in marginal areas who have limited access to soya bean meal, boiled cowpeas based diets are recommended to meet the nutritional requirements of pigs. Boiling cowpeas before incorporating them in diets is a useful technique to counter the effects of antinutritional factors like trypsin inhibitors, tannins and phytates (Aletor and Aladetimi, 1989) which have growth inhibiting effects. Germinating cowpeas before incorporating them in pig diets reduced the negative effects of the anti-nutritional factors in the raw cowpeas. These findings agree with those by Ibrahim et al., (2002) who noted that increasing the germination time resulted in increased reduction of tannin content. Ibrahim et al., 2002 also noted that duration of soaking had a bearing on tannin and phytic acid content.

CONCLUSIONS AND RECOMMENDATIONS

In conclusion, boiling improved the nutritive value of cowpeas to growing finishing pigs hence can be recommended for marginalized small holder farmers who have limited access to soya bean meal. The inclusion of cowpeas in the diets can be limited to the growing finishing pigs that are fed for a short duration. Inclusion of cowpeas in the diets of the breeding herd can only be recommended after further studies because the pigs will be exposed to the diets for long durations. It is conceivable that the detrimental effects of anti-nutritional factors on body organs, if they are any, are likely to show when the pigs are fed the cowpeas over a prolonged period of time.

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REFERENCES


THE PURPOSE AND APPLICABILITY OF INCLUSION- AN ECCLESIASTICAL APPROACH

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ABSTRACT

The need for inclusion in educational institutions in Zimbabwe is a national policy issue. In Teachers’ Colleges curricula have been amended to incorporate inclusion and this has become the ‘in thing’ for such institutions. At such institutions this has attracted a lot of attention in terms of financial expenditure and policy amendments. Many researches have also been conducted especially on the purpose of inclusion yet little attention has been paid to the applicability of inclusion in varying conditions and circumstances in educational institutions. This study takes a more ecclesiastical approach to inclusion through a situational analysis of a Government owned Primary School Teachers College in Zimbabwe. The main aim was to establish the suitability of the social and physical conditions at the college and how they could promote inclusion practically and realistically hence the ecclesiastical focus of the study. The study adopts a descriptive research design where observation especially of facilities is used to gather information. Important documents like the College policy on inclusion, the College Strategic Plan among others have been analysed to establish the effort done towards adopting inclusion. Interviews also were carried out with selected persons to establish their opinions on the feasibility of adopting inclusion at the College. Interviewees are therefore purposively sampled. The study established that the application of the national policy cannot be uniform. Instead, it is determined by the different circumstances at institutions such that it attains different forms. The paper concludes that there may not be a uniform way of applying the policy of inclusion as demonstrated by the unique circumstances of this college that has been studied. Contexts for the application of inclusion will certainly vary from place to place. This paper therefore suggests three forms of inclusion which are absolute inclusion, contextual inclusion and targeted inclusion from which institutions can chose. For the College under study, this research has proposed contextual inclusion and has tried to justify it.

KEY terms:
Inclusion, context, multi-cultural education, ecclesiastical approach
INTRODUCTION

1.1 The concept of inclusion

In 1994, UNESCO through the Salamanca Declaration made inclusion a primary service option for educational institutions (3). Inclusion was “a policy of addressing and responding to the diverse needs of all (learners) by increasing participation and achievement of all learners” cited in (3). Inclusion involved accommodating in the mainstream learners that operated in both extremes of the ability ladder. According to the Blessinger (2) “Inclusion is about all of us, ... living full lives, about learning to live together, about our abilities and how to share them, sharing tools, resources, capacities so all can live full lives”. Asante (1) viewed inclusion as “oneness” and “interdependence” and there is no exclusion. At a global level, the European Commission also made deliberate efforts to promote social inclusion through offering scholarships and participation of people with fewer opportunities (7).

The concept of inclusion has a set of preconditions which include diversity, plurality, equality and social justice (3). In Zimbabwe the concept of inclusion “… involves the identification and minimisation or elimination of barriers to students’ participation in traditional settings … and the maximisation of resources to support learning and participation”(9). In educational institutions like a teacher education college students under inclusion are all, despite their different abilities expected to participate in the institution’s everyday activities while at the same time meeting their unique needs. Inclusion is strongly related to human rights (2). Blessinger (2) views inclusion as reclaiming and respecting all identities and the need to create a culture of inclusion in higher education. So inclusion is not about accommodating disabilities only but also about exceptional abilities as well at educational institutions (8).

This paper analyses the physical and social context of the College and its implications on inclusion, measures taken by the college to implement inclusion as well as the effects of these measures on the successful implementation of the policy of inclusion at the institution. The paper takes a specific dimension of inclusion and proposes what can be called “contextual inclusion”. In this paper inclusion includes students with physical challenges, those who fell sick, students with ailments, the visually impaired, the not so gifted learners academically, students with special needs, the poor and the gifted ones.
1.2 Inclusive education in Zimbabwe’s educational institutions

The implementation of inclusion in educational institutions in Zimbabwe is not supported by any specific legislation except a number of government policy issues that support inclusive education (9). These include the Zimbabwe Education Act (1996), the Disabled Persons Act (1996), and various Ministry of Education Policy Circulars. However, according to (9) these pieces of legislation do not commit the government in any way to provide inclusive education in its educational institutions. Inclusive education is therefore not supported by a strong legal framework. However, the Ministry of Higher and tertiary Education, Science and Technology Development, like its sister Ministry of Primary and Secondary Education expects educational institutions to provide equal access to education for all students.

Every Teachers’ College, like other educational institutions is expected to practise recruitment policies that are nor discriminatory in any way. This should be supported by appropriate resource mobilisation and infrastructural development for the successful implementation of inclusion. This study however shows some of the inherent weaknesses of the policy of inclusion by showing how the application of the policy cannot be universal hence the focus on an ecclesiastical approach to inclusion.

1.3 The ecclesiastical approach to inclusion

This approach is derived from the ecclesiasticism or pragmatist philosophy which is propounded by prominent philosophers like John Jewey among others (Rosenthal & Thayer: 2000). When applied to education, pragmatism emphasises that children learn by doing things. It emphasise the practical aspect of learning hence its link with ecclesiasticism.

It shows the necessity of considering the different contexts in which any educational policy is applied. In other words it calls for an understanding of the different conditions where educational policies are applied. This defies all arguments for uniform application of educational policies that include inclusion in educational institutions. This has therefore called for different systems of application of the policy of inclusion depending on the circumstances at different institutions. The study analyses the situation at a government owned Primary School Teachers’ College and calls the application strategy an ecclesiastical approach. Infrastructural conditions are the main determinant of this realistic and practical approach to inclusion.
OBJECTIVES OF THE STUDY

The study was guided by the following objectives:

1. To assess the physical and social conditions at the college
2. To assess the measures taken by the college to implement inclusive education
3. To evaluate the effects of these measures on the implementation of the Inclusive Education Policy in the college context.

RESEARCH QUESTIONS

1. What physical and social conditions exist at the college that can promote the implementation of inclusive education?
2. What physical and social conditions exist at the college that can inhibit the implementation of inclusive education?
3. What measures have been taken at the college to promote the implementation of inclusive education?
4. What challenges have been faced in the implementation of inclusive education?
5. How effective have these measures been on the implementation of inclusive education?

MATERIALS AND METHODS

A descriptive research design was used where interviews were the main source of data. Observations were also used to check on students’ participation in various activities like sport and clubs. Documents were also analysed like the College policy document on inclusion. Informants included students and staff who participated in interviews. Students were purposively sampled depending on their physical conditions and needs. Key staff members like the Dean responsible for students’ welfare, Health and Life Skills lecturers including college counsellors were also interviewed. Students who were interviewed came for interviews on a voluntary basis after a public invitation where the researcher indicated the type of students he wanted for the study. Data analysis was descriptive.

5. RESULTS

Participation in the study

After an invitation students with disabilities came for interviews without any problems and provided very rich information. Some of these students had eye sight problems and some had other physical ailments. However, although interviews with clinic and student affairs personnel indicated a high incidence of HIV infections at the College, no single student with this challenge reported for the
interview. This therefore means that some of the students were not free to disclose their health status. This became one weakness of the study in that it could not provide information on such cases for analysis. One interesting category was that of ‘gifted students’ who included those who excelled both in class and extracurricular activities including sports and clubs. Gifted students were quite enthusiastic to participate in the research partly because they saw it as an opportunity to officially communicate their concerns. There was no stigma around such students hence their active participation in the research. This helped to show the broader scope of inclusion to include the gifted and the no so gifted students.

College support for inclusive education

Marymount Teachers College enrols student teachers for both the General and Early Childhood development levels. Teachers are educated to be inclusive by being able to operate in different environments and deal with different situations. Besides this, the College is expected to provide equal opportunities to all people despite their disabilities. This study looks at how possible it is to apply such a policy considering the physical circumstances of the College. The physical outlook of the College, like the terrain and the structure of the buildings, demand a more practical and realistic approach to inclusion. Inclusion was first introduced in 2008 when there was a recruitment drive of qualified lecturers for inclusive education. Before this the college curriculum taught Special Needs Education as a component under Psychology. From 2008 Inclusive Education was introduced an addendum was put to the Professional Studies, Theory of Early Childhood Development Education and Theory of Education syllabuses. However, a number of challenges have continued to be reported during departmental, sectional and general staff meetings and other fora as well as reports by students on challenges related to inclusive education. While most of the gifted and no so gifted students were very happy with the support they got from the College in the provision of educational facilities including sports and clubs, some felt that more still needed to be done in terms of educating students on issues around labelling and stigmatisation. Some complained of being excluded by fellow students in activities at college. Others who were physically handicapped complained of lack of association with fellow students. The incidence of such challenges was however difficult to establish when this study was carried out.

The college was supporting the implementation of inclusive education in many ways which included

Recruitment of qualified staff that students with disabilities were welcome. One physically challenged student reported that;
“I saw the advertisement three for three consecutive times in the paper and was convinced to supplement my Mathematics which I had not passed during my first sitting of ‘O’ Level examinations. I passed Mathematics, applied and got a place at the College to train as a teacher”.

The recruitment policy of the college for students also was encouraging because it specified preference for the physically challenged although this policy compromised on quality of students enrolled.

Infrastructural development like the construction of ramps and pathways for easy movement of those wheelchair chairs and with other disabilities.

Resource procurement like purchase of library books, sport equipment for the disabled though more should be done in this direction.

Affected students were deployed for Attachment Teaching Practice to convenient schools especially of their own choice. At deployment priority was given to such students where they were required to indicate the school of their choice and a note showing their condition.

The college offered support services for counselling which students were happy with. The clinic also provided medical services including a College doctor who visited the College once every week and medication like anti-retroviral drugs for those with HIV/AIDS. Extreme cases of disability certainly will not benefit from entry into the institution.

Support for paralympic games where students participate at local and national levels. Students also participate in clubs like the Nzewe Club for training sign language which is supported by Nzewe Deaf Centre, a sign of networking. The College has also participated at the Disability Forum which was organised by the University of Zimbabwe. However, interviews with students showed that the college was supporting them in doing practice at college during sporting days. They also complained of lack of equipment like wheelchair chairs for volley ball and other games.

Support for research on issues of inclusivity and attendance of related research conferences as delegates and paper presenters like the International Disability Conference at Victoria Falls (2015), The Teacher Education Research Conference (2016), Research and Intellectual Outputs- Science, Engineering and Technology (RIOSET) among others.

Policy development and implementation

The college had participated in the formulation of a national policy on inclusive education by crafting a college policy document which was submitted to Harare for incorporation into the national policy. While the college policy on inclusion was being implemented, there was need for more frequent evaluation of
the implementation of the policy to avoid unnecessary problems especially among students. The physically challenged students were generally happy with the attitude of most lecturers towards them. According to one;

"Some lecturers even mentioned our names when we do well which makes us happy. We feel the same with others".

This shows appreciation of the attitude of lecturers. It was also a College policy and right of physically challenged students to send other students to call lecturers to attend to them wherever they could be in the College. During assessments in Physical Education for example, problems of students considered so as not to disturb one’s health. Staff members were also very cooperative in repairing the gadgets used by the physically challenged. This included such simple repairs like putting rubbers on crutches which often got off because of the some hard surfaces and obstacles. The gate staff was also very conscious of the needs of the physically challenged like allowing them in and out without much delays. Affected students were always given priority to enter the Principal’s office and other offices.

Challenges

Inadequate infrastructure as shown by the high rise building at the college which would be very expensive to adjust to accommodate the disabled. They cannot access the library for example which is in the first floor and would require an electric lift which will be very expensive to procure and install. The Physical environment is discriminatory in many ways such that although even when some candidates may have requisite academic qualifications, they do not come to the college because of such an unsuitable environment. This was related to the issue of lack of financial resources because it will be very expensive to redress these infrastructural imbalances to cater for the physically handicapped. The issue of lack of resources was also observed in Zambia and South Africa (9), (5).

The uneven terrain of the College also inhibited free movement of some students round the College. In many places the terrain however was uneven and was only suitable for those with mild disabilities. They were allocated rooms at the ground floor and could not access the lounge for example to watch television during their free time. Some students complained of the larger number of disabled students in one room which created room for many visitors and therefore disturbances. They actually preferred to be treated in the same manner as other students where the first years lived separately from the third years. The toilets did not have suitable facilities to cater for the disabled. There was need for appropriate handles for example in the toilet to assist them to take appropriate positions when they were helping themselves. The rails installed at the main entrance to the reception had improved the situation.
The clinic did not have adequate medicines to cater for the albinos such that they ended up going to town where the medicines were often excessive to buy.

Interviews with some disabled students showed that some of the disabled students experienced serious problems in accessing resources like books from the library which was located at a higher floor which was not easily reachable by those walking on crutches. One such student who was completing two terms at the College reported that she had visited the library only four (4) times otherwise she relied on using the internet facilities in the hostels which were sometimes disturbed by disruptions of the network. They also could rely on sending others to collect books for them which was sometimes problematic. They would appreciate a situation where they would search for books from the shelves by themselves.

Some complained of being discriminated by the able bodied. Association with other students was sometimes difficult especially if one had outstanding deformity. In class they were sometimes not given the same responsibilities as the able bodied. Moving from one class to another was also problematic since it would also involve scrambling for chairs. Some would need assistance in carrying chairs which could only be done by students who understood such conditions. Some preferred reserved seats for disabled students in lecture rooms including the computer laboratories. One physically challenged student reported that;

“I am often the last person to enter the computer laboratory and will be forced to sit behind others when we share a computer”.

There is also need for a more deliberate policy of talent identification and support for the growth and development of talent especially among students. Some students who had interest in sewing were given an opportunity to participate in garment manufacturing as a mainstream activity in main subject (Home Economics). However, some expressed the need to form a club that would help them develop their talent and help them to become professional tailors.

The College participates in major events like the Zimbabwe International Book Fair (ZIBF), the Zimbabwe International Trade Fair (ZITF), Tertiary Institutions Arts Festival of Zimbabwe (TIFAZ), the Research and Intellectual Outputs-Science, Engineering and Technology (RIO-SET). In these students and staff participate in various ways to show their talent. However, there was need for more concerted deliberate effort to identify talent among students and staff and support it. The College was not doing enough to support the gifted academically, technically and in sport. Talent identification and supporting the development of the talent or nurturing it was not being done systematically.
In a recent sports competition, The Zimbabwe Teachers’ Colleges Sports Association (ZITCOSA) Zone A held in Masvingo-Zimbabwe, the disabled students were quite happy to be part of the College team together with the able bodied although they had their own events. They also appreciated that they were the first to be given awards which they said showed appreciation for their disadvantaged status. Unfortunately, at the same competitions they were not given preferential treatment when on accommodation. They had to scramble with the able bodied for rooms and ended up crowding in one room.

However, they complained of the separation of events at the final competitions where they will play with universities at different times and venues with the able bodied students. This implies that there was no consistency in the manner in which the disadvantaged were treated in sport at different levels. This was quite discouraging and demotivating to some of the para-professionals.

The unavailability of suitable gadgets for the disabled like those with poor vision and hearing impairments which is more serious now where there are very large classes or mass lectures of up to 600 students per class. Such considerations were not made at registration where some students had special requirements. There was no deliberate policy to support such students. There is need to assess the needs of such students before registration and design strategies to assist with them.

Inadequate sporting facilities and equipment affected the sporting activities of the physically challenged. There was only one wheel chair to use for practising wheel chair sport. Many concentrated on field events due to the unavailability of equipment for other sport activities. There was also need for such equipment like stools for use in throws which some students only saw during paralympic competitions. They would therefore have problems in using them and would not perform well. While all sporting “houses” were represented by the physically challenged, they did not get prizes as what happened to the able bodied.

Some students especially those with hidden disabilities and HIV/AIDS do not disclose their condition such that they do not get assistance only until there is a problem with their health.

While lecturers were reportedly not discriminatory, there was need to avail information on the disadvantaged and the nature of disability to all staff so that the students would be given fair treatment at all times.

In the dining hall, some students complained of lack of consideration by some able bodied students who lacked consideration by using tables close to serving points which could be reserved for the physically challenged. However, reserving tables is rather tricky because it could also have undesirable effects like labelling. So, this had to be handled quite carefully. The issue of special diet also needed attention in the dining hall as little attention was being paid to this issue. Some students preferred living out of the College.
because of the unavailability of desired diet for their health. Unfortunately this had other problems like movement for long distances which was unhealthy for some cases.

Some students had problems of disclosing their health problems and go for a long time without being attended to until there is a problem. This is worsened by the absence of any initiation programme for those with HIV although they are often referred to the general hospital for treatment. Common health problems are HIV, Tuberculosis, Sexually Transmitted Diseases (STDs’), Hypertension, Asthma as well as Gastro-intestinal diseases. There are medication facilities for all except tuberculosis and the college gets appropriate medicines. The lack of a nurse aid affects the performance of the single nurse at the institution. Some students however abuse medicines by misrepresenting relatives and friends.

Equal access to education remains a dream in educational institutions because of lack of a more pragmatic and ecclesiastical approach to its implementation. This study has shown that while effort was being made to provide access to all, there was a bias towards the physically challenged students. There was also discrimination even with the physically challenged in that those with observable disabilities were catered for more than those with disabilities which were not easy seen like hearing impairments and others.

The very high cost of adjusting some physical structures also indicated that financially manageable adjustments could be done hence the purpose of a more pragmatic approach to inclusion which is contextual. Some of these physical barriers are not easy to deal with and doing away with exclusion completely may not be possible (8). The physical contexts for the application of inclusion will never be the same as they observed in a study of inclusion ay the University of Seville where does can be closed for students with disability.

**CONCLUSIONS**

The implementation of inclusive education should therefore be contextual depending on the physical and other circumstances at different institutions. This study therefore advocates for contextual or targeted inclusion as opposed absolute I-inclusion. This study, though focusing on a specific Teachers’ College, has shown that a specific context has its own demands on the application of the policy of inclusion. In other words the policyis not universally applicable to educational institutions in Zimbabwe because of the unique conditions that each institution has. The research is a case study of a Government owned Primary School Teachers’ College in Zimbabwe whose unique qualities call for a more pragmatic approach to the implementation of inclusion in educational institutions.
DISCUSSION

The policy of inclusion has very much been popularised in Zimbabwe as shown by efforts by government through the Ministry of Primary and Secondary Education as well as the Ministry of Higher and Tertiary Education, Science and Technology Development. Supportive policies have been established. However, the major weakness of this thrust has the expectation of a rather uniform style of implementation. The differentiation in conditions at different contexts was completely ignored by policy makers. There is therefore need for a revision of the policy of inclusion and encourage more research into strategies for implementing inclusion in different contexts. The issue of encouraging partnerships with the private and public partners needs to be pursued more vigorously in accordance with the requirements of goal number 17 of Sustainable Development Goals. This is closely related to the concept of the Triple Ps (Private – Public Partnerships).

RECOMMENDATIONS

The paper has therefore recommended an ecclesiastical or practical and realistic approach in the implementation of the policy of inclusion.

There is need to change the mind-sets of policy makers at the college to prioritise the implementation of inclusive education and invest more in the area if there is to be equal access to education.

There was need for continues staff development activities involving staff members to enhance their level of consciousness of treating the gifted and not so gifted students and thus promote inclusion in the College.

The policy of inclusion should be made part of the life skills workshops held with all students who are enrolled at the College.

There is need for awareness campaigns for students and staff on caring for the needy and dealing with preventable diseases like STIs. The availability of condoms at convenient places has lessened some problems although some have seen this as encouraging promiscuity among students.

The provision of a direct telephone line or cell phone at the clinic for easy communication especially at night.

Areas for further study cab be other dimensions of inclusion which are absolute Inclusion and Targeted Inclusion or a comparative analysis of the three dimensions of Contextual, Ecclesiastical and Absolute Inclusion.
DETERMINATION OF THE NATURAL HOST STATUS OF AVOCADO FRUIT TO PESTIFEROUS THRIPS (THYSANOPTERA: THRIPIDAE) IN KWAZULU-NATAL, SOUTH AFRICA

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ABSTRACT
The South African avocado industry is export-orientated, with approximately 3.0% of international market share and with a five-year mean annual production of 118 000 tons from 17 500 ha. Feeding by thrips results in fruit scarring and corky tissue development, making the fruit unsuitable for export. The study aimed to identify the spectrum of thrips in avocado flowers and more importantly, to confirm the identity of the thrips species responsible for damaging fruit. Firstly, thrips were collected from flowering panicles and identified using taxonomic keys. Frankliniella occidentalis (Pergande), Scirtothrips aurantii (Faure), Thrips gowdeyi (Bagnall), Thrips pusillus (Bagnall), Thrips tenellus (Trybom), Haplothrips gowdeyi (Franklin), Haplothrips bedfordi (Jacot-Guillarmod) and Megalurothrips sjostedti (Trybom) were consistently collected from May to September 2018. The minute size of thrips warranted a pre-season trial to determine the best netting material to contain thrips. Insect screen (149 µm), nylon netting (250 µm), chiffon (210 µm), voile (250 µm), organza (500 µm), tea filter paper (74 µm) and coffee filter paper (53 µm) were evaluated. The experiment was laid out as a randomized complete block design with 6 replications and the trials repeated twice. Only coffee filter paper and tea filter paper contained at least 85% of the thrips and were therefore chosen for thrips exclusion trials. Lastly, surveillance by fruit sampling was undertaken to determine the natural host status of avocado to thrips. Avocado fruitlets were randomly sampled and incubated under laboratory conditions. Scirtothrips aurantii (Faure) (the South African citrus thrips) emerged from fruitlets and was sustained on that fruit to adulthood. This is the first study to demonstrate that avocado is a natural host to this pest in South Africa.

Key words: Thrips spectrum, exclusion, South Africa, avocado, fruit scarring.
INTRODUCTION

South Africa is Africa’s largest avocado exporter (also 4th in the world) followed by Kenya, Rwanda, Democratic Republic of Congo and Cameroon. The South African avocado industry is export oriented with approximately 40% of the total production volume exported (1). Being an export-oriented industry, there is a commercial impetus to optimise the exportable percentage of avocado fruit. However, thrips pose a significant threat to the industry by scarring fruit resulting in fruits being downgraded. Damage in the U.S.A. by *Scirtothrips perseae* (Nakahara) was estimated to cost the industry US$8.65 million annually (2).

South Africa currently has a five-year mean annual production of 118 000 t, from 17 500 ha of commercial avocado orchards, concentrated mainly in the subtropical areas of Limpopo (60%), Mpumalanga (29%), KwaZulu-Natal (9%) and parts of the Cape Province (2%). Three-hundred and forty commercial growers and 78 emerging growers anchor production with the industry employing 8 200 permanent and 7 300 seasonal workers (3).

Approximately 70% of the trees produced by South African avocado nurseries are ‘Hass’ and the remaining 30% is comprised mostly of ‘Fuerte’, ‘Ryan’ and ‘Pinkerton’ (1).

Thrips are fringe-winged insects in the order Thysanoptera, with most pestiferous thrips belonging to the sub-order Terebrantia. Thrips lay extremely small eggs, about 0.2 mm long, by cutting slits in plant tissue with their ovipositors, and inserting their eggs, one per slit (4). Being hemimetabolous, thrips gradually metamorphose to the adult stage. The first two instars are wingless nymphs, feed on plant tissue, and are devoid of functional genitalia. The third and fourth instars are non-feeding, resting stages and are respectively referred to as propupa and pupa. Individuals of this sub-order pupate in soil or leaves (5) and these resting stages can last three to five days before adults emerge (6). During this pupal stage, the insects’ body organs are reshaped, wing-buds are developed and genitalia formed (4). In warm weather, the adult stage can be attained in three weeks (5) and last about 45 days, with several generations in a single year being possible (6).

A study by Johansen, Mojiica-Guzman, Ascension-Betanzos (7) revealed 38 thrips species on avocado, but only six of them were primary pests. Worldwide some of the thrips recorded on avocados include *Liothrips perseae* (Watson), *Scirtothrips aceri* (Moulton), *Frankliniella cephalica* (Crawford), *Heliothrips haemorrhoidalis* (Bouché) (8) and *Selenothrips rubrocingtus* (Giard) (9). These cosmopolitan, polyphagous species survive on foliage by scraping and sucking the contents of epidermal cells, in the process leaving silver-white discoloured spots, which later darken. Silvering is common, due to air entering cells from which the contents have been removed, and on fruits, this leads to scarring and corky tissue development. Very large populations of thrips can induce premature flower loss, and can reduce
available pollen to below critical levels (10). Damage is mostly observed on leaves and fruits, but thrips can also be found on tender shoots, buds, and flowers. These insects may cause malformation of fruit; premature fruit drop and lesions that become entry points for microorganisms such as *Sphaceloma perseae* (Jenkins) (11). While minor thrips damage can be tolerated, any damage covering an area of more than 2 cm² will result in the fruit being unacceptable for premium export grade (12), and crop losses of up to 50% have been reported by Adame (13).

The climates of southern African countries range from semi-arid and sub-humid in the east, to hyper-arid in the west (14). Global warming is expected to make southern Africa warmer and drier (15). The projected changes in climate provide favourable conditions for the proliferation of thrips species such as the South African citrus thrips *Scirtothrips aurantii* (16). *Scirtothrips aurantii* is a major pest on citrus (17), mangoes (18) and macadamia (19).

Thrips are therefore economically important pests on avocado fruit, and important candidates for pest risk analysis. Surveillance by fruit sampling is the most reliable method of determining the natural host status, and is preferred because it does not interfere with the natural behaviour of thrips. It also has the advantage of taking into account high levels of variability in the fruit, insect behaviour and periods of activity. According to the International Standard for Phytosanitary Measures 37, the status of a host can be determined based on confirmation of natural infestation and development of the pest to adult stages by sampling fruit from the field (20). For this reason, fruit sampling was chosen as the method to determine the host status of avocado to thrips.

The objectives of this study were to determine the spectrum of thrips species found in avocado flowering panicles, to establish the effectiveness of different fruit bagging material as thrips exclusion screens and to identify the thrips species responsible for the scarring damage observed in avocado fruit in KwaZulu-Natal Province, South Africa.
2. MATERIALS AND METHODS

2.1 Determination of thrips species spectrum in avocado flowers of KwaZulu-Natal, South Africa

Study site

This study was carried out in two avocado orchards (Pinkerton variety), at Conlink Trust (-29.453415 30.683398) and Baynesfield Estate (-29.756873 30.314269), in KwaZulu-Natal Province, South Africa. Every fortnight from May to September 2018, 10 early-fruiting trees were randomly selected, from which 10 panicles/tree were gently beaten 10 times using the beat cup method modified from Reisig, Godfrey, Marcum (21). A 2-l water jug was fitted with a funnel, a 2 mm metal sieve, and at the base, ice cubes, to immobilise the thrips that were dislodged from the foliage using the apparatus shown in Fig 1. Thrips were collected and aspirated into vials. Thereafter, the thrips were euthanised and preserved in 70% alcohol before being sent to Plant Health and Protection (Pretoria, South Africa) for taxonomic identification.

![Apparatus used to collect thrips from flowering panicles](image)

**Figure 22: Apparatus used to collect thrips from flowering panicles**

2.2 Pre-season determination of the effectiveness of different fruit bagging material as thrips exclusion screens

The minute size of thrips warranted a pre-season trial to determine the best material to contain thrips. The pore opening sizes (µm) were determined under a stereo microscope (Leica M216 and image processing done using Leica application suite (LAS) 4.2). Thrips netting (149 µm), nylon netting (250 µm), chiffon (210 µm), voile (250 µm), organza (500 µm), tea filter paper (74 µm) and coffee filter paper (53 µm) were then evaluated against two thrips species *Scirtothrips aurantii* and *Haplothrips bedfordi*, for their ability to contain the thrips - 10 thrips per species were introduced into each of 7 x 50 ml tubes. The tubes were then sealed off with the test material. From one tree, six flowering panicles were selected and from these flowering panicles, experimental tubes were suspended 5 cm below the flowering panicles. The tubes were incubated in the field for 72 h, after which the tubes were assessed to see whether they successfully contained the thrips. The trial was repeated twice. The trial was laid out as a randomised complete block design with six replications.
and 42 sampling units. The results were analysed using the Bartlett test for homogeneity, Kruskal-Wallis non-parametric test and pairwise Wilcoxon test (for post hoc treatment separation).

2.3 Host status determination by means of fruit sampling

Pinkerton avocado fruitlets were collected from Conlink Trust and Baynesfield Estate from July to October 2018 and brought to the laboratory for incubation or ‘rearing’. The actual selection of fruits was done using random sampling (probability based unbiased surveying technique) where the only basis of fruit selection was size (length ≤40 mm). Fruitlets were acquired for incubation trials every two weeks, with the target sample size for each sampling occasion being 80 fruitlets per sampling activity.

In the laboratory, individual fruits were washed in 0.035% sodium hypochlorite solution and rinsed several times with tap water before being air-dried, measured (mm) and placed in clearly labelled incubation units (one fruit/unit) following the method modified from Ekesi, Billah (22). An incubation unit consisted of a 25-ml transparent glass tube. The incubation tube was then sealed with coffee filter paper using tightly strung rubber bands. Incubation units were then held at 25 – 28 °C, 75 ± 5 % relative humidity and 12L:12D photoperiod.

Eggs are laid just below the skin and larvae emerge from the eggs. The tubes were inspected and monitored daily for larval emergence (22). After a few days, the larvae pupate to adults. All the larvae and pupae were held for two weeks to ensure maximum adult eclosure. After two weeks of incubation, the fruitlets were inspected once more before being discarded (by this time the fruits had dried).

The adults were kept alive for four days after adult eclosion to enable them to develop their full body colour and normal shape because morphological features were the main identification tools. After four days, when adult body colour had fully developed, the adults were euthanised and identified using morphological keys provided by (23). Adults were identified to species level and preserved in 70% alcohol. The identity of the thrips as *S. aurantii* was also confirmed by ITS gene amplification and sequencing using the primers ITS1-F: TCGTAACAAGGTTTCCG and ITS1-R: GCTGCGTTCTTCATCGATGC at Inqaba Biotechnology Industries (Pretoria, South Africa). A fruit infestation index was calculated as the ratio of number of larvae and adults per fruit collected (24).
3. RESULTS

Frankliniella occidentalis (Pergande), Scirtothrips aurantii (Faure), Thrips gowdeyi (Bagnall), Thrips pusillus (Bagnall), Thrips tenellus (Trybom), Haplothrips gowdeyi (Franklin), Haplothrips bedfordi (Jacot-Guillarmod), and Megalurothrips sjostedti (Trybom) were consistently collected from avocado flower panicles during the May–September 2018 survey period from two avocado farms in Pietermaritzburg (Figs 2 and 3). Scirtothrips aurantii and H. bedfordi recovered from flower panicles at the end of winter/ beginning of spring were used to test the effectiveness of various thrips screening material.

Fig. 23. Thrips recovered from flower panicles, 1 = Scirtothrips aurantii; 2 = Frankliniella occidentalis; 3 = Thrips gowdeyi; 4 = Thrips pusillus

Fig. 24. Thrips recovered from flower panicles, 1 = Megalurothrips sjostedti;
2 = *M. sjostedti*; 3 = *Haplothrips gowdeyi*; 4 = *Thrips gowdeyi*; 5 = *H. bedfordi*

Identification photos courtesy of Michael Stiller, ARC-PH&P, Biosystematics, Pretoria, South Africa.

The fruit bagging material were scrutinised under a stereomicroscope (X 57.5) (Fig. 4) and their effective pore size was determined (Table 1).

**Fig. 25.** Test screening material: a – Thrips netting, b – Voile, c – chiffon, d – Nylon netting, e – organza, f – tea filter paper, g – coffee filter paper

**Table 23.** Properties of bagging material used in the experiments

<table>
<thead>
<tr>
<th>Material</th>
<th>Mesh No.</th>
<th>Pore size (μm)</th>
<th>Hole size</th>
<th>Thread diameter, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coffee filter</td>
<td>270</td>
<td>53</td>
<td>0.052</td>
<td>0.005</td>
</tr>
<tr>
<td>Tea filter</td>
<td>200</td>
<td>74</td>
<td>0.074</td>
<td>0.0108</td>
</tr>
<tr>
<td>Chiffon</td>
<td>70</td>
<td>21</td>
<td>0.179</td>
<td>0.023</td>
</tr>
<tr>
<td>Thrips netting</td>
<td>100</td>
<td>14</td>
<td>0.052</td>
<td>0.1446</td>
</tr>
<tr>
<td>Nylon netting</td>
<td>60</td>
<td>25</td>
<td>0.046</td>
<td>0.2134</td>
</tr>
</tbody>
</table>
Voile & 60 & 25 & 0.218 & 0.00 & 0.11 \\
& & 0 & 6 & 7 & \\
Organza & 35 & 50 & 0.472 & 0.02 & 0.0484 \\
& & 0 & 2 & 2 & 

The mesh number represents the number of openings per linear 25 mm of material. The bigger the mesh number, the greater the number of pores, and the smaller the pore size. The opening pore size can however vary slightly due to wear and distortion. The pore sizes determine the maximum size of particles and/or insects that can pass through. The average length-width (l;w) of \textit{S. aurantii} and \textit{H. bedfordi} were measured to be 0.57 mm; 0.18 mm and 1.29 mm; 0.21 mm respectively. Containment of thrips after the 72-h evaluation period was statistically analysed using R version 3.5.1 and the results summarised in Table 2.
<table>
<thead>
<tr>
<th></th>
<th>Trial 1</th>
<th>Trial 2</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Thrips 1</td>
<td>Thrips 2</td>
<td>Thrips 1</td>
<td>Thrips 2</td>
</tr>
<tr>
<td>Bartlett's</td>
<td>Bartlett's K² = 5.983</td>
<td>Bartlett's K² = 1.7088</td>
<td>Bartlett's</td>
<td>Bartlett's</td>
</tr>
<tr>
<td>test for</td>
<td>df = 6, P-value = 0.4251</td>
<td>df = 6, P-value = 0.244</td>
<td>K² = 3.5681</td>
<td>K² = 0.7349</td>
</tr>
<tr>
<td>homogeneity</td>
<td></td>
<td></td>
<td>df = 6, P-value = 0.09782</td>
<td>df = 6, P-value = 0.9444</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kruskal-Wallis rank sum test</td>
<td>Kruskal-Wallis χ² = 31.085, df = 6, P-value = 0.00001921</td>
<td>Kruskal-Wallis χ² = 34.328, df = 6, P-value = 0.000005813</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pairwise comparisons of treatments using Wilcoxon rank sum test</td>
<td>Thrips netting a,d,e,f</td>
<td>Thrips netting a,d,e,f</td>
<td>Thrips netting b</td>
<td>Thrips netting b,c,e,f</td>
</tr>
<tr>
<td></td>
<td>Thrips netting a,d,e,f</td>
<td>Thrips netting a,d,e,f</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nylon netting a,d,e,f</td>
<td>Nylon netting a,d,e,f</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Organza b,d,f</td>
<td>Organza c,e,f</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chiffon b,c,d</td>
<td>Chiffon b,d,f</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatments with at least 85% thrips containment</td>
<td>Voile&lt;sup&gt;b,c,d&lt;/sup&gt;</td>
<td>Voile&lt;sup&gt;c,d,e&lt;/sup&gt;</td>
<td>Voile&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Voile&lt;sup&gt;b,c,d,e,f&lt;/sup&gt;</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>----------------</td>
<td>----------------</td>
<td>----------------</td>
<td>----------------</td>
</tr>
<tr>
<td>Tea filter&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Coffee filter&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Coffee filter&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Coffee filter&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Coffee filter&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Coffee filter&lt;sup&gt;a&lt;/sup&gt; (96.67%); Tea filter&lt;sup&gt;a&lt;/sup&gt; (91.67%)</td>
<td>Coffee filter (93.33%); Tea filter (91.67%)</td>
<td>Coffee filter (96.67%); Tea filter (91.67%)</td>
<td>Coffee filter (88.33%); Tea filter (85.00%)</td>
<td></td>
</tr>
</tbody>
</table>

**Note.** Treatments sharing a letter in their superscript are not significantly different at the 0.05 level according to Benjamini-Hochberg (BH) procedure, $P < 0.05$.

487 Thrips netting, nylon netting, chiffon, organza and voile were ineffective at containing the thrips. Tea filter paper and coffee filter paper retained both thrips species (> 85%).
Scirtothrips aurantii larvae emerged from young avocado fruit and were sustained on the fruitlets to adulthood (Fig. 5). During feeding, the thrips punch a hole by extruding a solid needle-like mandible. This is then withdrawn, and the maxillary stylets are inserted into the food source through the hole, with saliva being pumped into the tissues and the resultant fluid pumped back into the thrips’ crop. Larvae and adults use a similar punch and suck feeding technique and individuals tend to feed in localised patches on foliage, flowers and fruit, gradually moving out over undamaged areas of the fruit (25).

From random sampling of 643 young avocado fruitlets, 70 S. aurantii larvae emerged from 31 fruitlets. Of these 70 larva (51.43%), successfully eclosed to 36 adults (Table 3).

Figure 26: Scirtothrips aurantii feeding on young avocado fruitlets

Table 25: Summary of Scirtothrips aurantii emergence from avocado fruitlets

<table>
<thead>
<tr>
<th>Site</th>
<th>Total no. of fruitlets</th>
<th>No. of infested fruitlets</th>
<th>No. of emerging larvae</th>
<th>No. of adults eclosed</th>
<th>% Adult eclosure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baynesfield</td>
<td>30</td>
<td>3</td>
<td>7</td>
<td>4</td>
<td>1.06</td>
</tr>
<tr>
<td>Conlink</td>
<td>43</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>2.17</td>
</tr>
<tr>
<td>Pooled</td>
<td>643</td>
<td>31</td>
<td>70</td>
<td>36</td>
<td>51.43</td>
</tr>
</tbody>
</table>

Thrips emerged from fruitlets of length 12 mm to 34 mm, with a mean of 20.74 mm. No thrips emerged from smaller fruitlets (Table 4). Of the 643 fruitlets surveyed, 31 fruitlets (4.82%) were infested. On average, up to five larvae emerged from an infested fruit. The thrips larvae were observed feeding on the epidermal layer, leaving behind characteristic necrotic damage and were sustained on the fruitlets until adult thrips eclosed from pupae. Adult thrips survived on the drying fruitlet for several days until the fruit had either completely dried out or saprophytic fungi had completely covered the fruitlet.
4. DISCUSSION

During spring, various species of thrips are attracted to avocado blossoms and this is reflected in the catches of various thrips species. *Frankliniella occidentalis*, *S. aurantii*, *T. gowdeyi*, *T. pusillus*, *T. tenellus*, *H. gowdeyi*, *H. bedfordi* and *M. sjostedti* were consistently collected during the survey. Of these species, only *S. aurantii* is known as a pest in citrus, responsible for much of the scarring damage caused on South African citrus (17).

Of the possible thrips screening material tested, coffee filter paper out-performed the other test materials (greater than 85% thrips containment) (Kruskal-Wallis $\chi^2 = 31.63; df = 6; P < 0.001$); however, it is not very malleable and would be difficult to fit around avocado fruitlets. Tea filter paper is flexible, and was not significantly less effective than coffee filter paper (Kruskal-Wallis $\chi^2 = 31.09; df = 6; P < 0.001$) and can thus be used to contain the thrips. Thrips netting did not perform as well as expected, and thrips used in the test were observed to breach the screen within minutes of being introduced into the test tubes. This could possibly be because thrips netting was designed to exclude much larger thrips such as *F. occidentalis*. In this study, *F. occidentalis* was measured to be 1.04 mm; 0.27 mm, compared to 0.57 mm; 0.18 mm (l;w) of *S. aurantii*.

Fruit sampling revealed that the South African citrus thrips, *S. aurantii*, is a pest of concern in avocado. Studies in the 1990s by Steyn, Du Toit, De Beer (9) revealed two thrips species, the greenhouse thrips, *Heliothrips haemorrhoidales* (Bouche), and the redbanded thrips, *Selenothrips rubrocinctus* (Giard) as the only thrips species attacking avocado fruit, accounting for a loss of 2.1% of the fruits (26). Just a few years prior to this, De Villiers, Van den Berg (27), reported that avocado orchards were relatively free from serious insect pests owing to good control by natural enemies. However, as a consequence of growth in production, there is an increase in the number and severity of insect pests and their impact on the avocado industry.

Milne (28) noted that over 300 pests had been recorded on avocado worldwide and, of these, 76 occurred in southern Africa. Erichsen, Schoeman (29) forecasted an increasing abundance and diversity of avocado insect pests. Prior to this study, *S. aurantii* was not considered as an economic pest of avocado in South Africa (30), however, this study showed a thrips infestation index of 4.82% comparable to the 4.5% infestation index found in another study conducted in Mexico (31). *Scirtothrips aurantii*, though polyphagous, is an established pest of citrus, where it is known to cause quality losses of up to 50% in export fruit. In this study, *S. aurantii* was observed to emerge and feed on young avocado fruit < 4 cm long. Similarly, in the U.S.A., oranges are reported to be most susceptible to scarring by a related citrus
thrips, *Scirtothrips citri* (Moulton), from petal fall until they are 4 cm in diameter. Fruit larger than 4 cm are rarely scarred (32).

It was observed from this study that avocado fruit are particularly vulnerable to attack by *S. aurantii* for a short period between fruiting and spring flush (new growth). The fruit are most susceptible to infestation when the young fruit are the only new growth available to the thrips. Yee, Phillips, Faber (33) reported that as the foliage matures, it becomes less attractive to the thrips and the insects begin to feed on immature fruit. The sporadic nature of thrips attack on avocado fruit, coupled with the complex interaction with the avocado tree phenology, makes it difficult to accurately predict and forecast infestations. As thrips dwell in many microhabitats, they are consequently subject to host plant phenological changes. These changes are driven by the environment, since weather imposes conditions that determine when a plant will produce flowers, fruits and leaves (34). Weather influences host plant phenology by directly affecting production of flowers and leaves, which in turn attracts and maintain thrips in a given host.

5. CONCLUSION

The study confirms that *F. occidentalis, S. aurantii, T. gowdeyi, T. pusillus, T. tenellus, H. gowdeyi, H. bedfordi* and *M. sjostedti* constitute the spectrum of thrips associated with avocado flowers. Due to the minute size of *S. aurantii*, coffee and tea filter papers can be used in thrips exclusion experiments. Thrips netting proved to be ineffective as a shield against penetration by this species.

*Scirtothrips aurantii* emerged from avocado fruitlets, and were observed to be feeding on young fruit, causing visible scarring damage. The fruitlets sustained the thrips to adulthood, confirming the host status of avocado as a natural host to *S. aurantii*.

6. ACKNOWLEDGEMENTS

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ABSTRACT (word count: 150)

Introduction
Blood transfusion is a life-saving medical intervention despite the inherent risk of transfusion transmissible infections (TTIs). Zero-risk is not achievable because of the residual risk. The lack of data is challenging in performing risk modelling of TTIs in sub-Saharan Africa (SSA).

Objective
Sharing the results of the blood safety risk modelling studies conducted in SSA.

Methodology
Various cross-sectional and analytical studies were undertaken.

Results
HIV changes have been shown in general to blood donor populations. The use of donor management factor for blood safety was demonstrated. TTIs residual risk estimates for Zimbabwe were determined. Applicable residual risk models and impact of blood donor subpopulations on residual risk estimates was assessed. The travellers’ TTIs risk model was developed. The results of cost-effectiveness analysis of introducing NAT testing in Zimbabwe were unfavourable due to cost constraints.

Conclusion
Risk modelling can inform blood safety decision-making in SSA and should be promoted and supported.

INTRODUCTION

Whilst blood transfusion is now an integral part of medical practice there remains inherent risks associated with it.(1) The World Health Organization recognizes the threats presented by transfusion transmitted infections (TTIs) and recommends universal testing of all donated blood for viral TTIs, human immunodeficiency virus (HIV), hepatitis B virus (HBV) and hepatitis C (HCV).(2) It is also recommended by World Health Organization that other TTIs tests could be introduced based on the epidemiological context and emerging diseases agents for different blood services.(1,2) Several blood services implement various blood safety strategies(3) and World Health Organization helps to highlight the success and challenges of these through published reports from regular surveys on Global Database on Blood Safety programme.(4) The Global Database on Blood Safety reports highlight the disparities between different countries on their blood safety achievements. It is important to note that not all blood services have managed to comply with the World Health Organization recommendations on testing of all donated blood.(4) There is also a variation on the testing technologies and approaches that are used and these range from no testing at all, rapid diagnostic test, enzyme-linked immunosorbent assay based tests, and nucleic acid testing (NAT) technologies.(4) These varying testing technologies present window period risk to transfused patients and this remains a major challenge for blood services.(5) There is also growing number of pathogen reduction technologies that are being introduced by blood transfusion centres throughout the world. All these TTIs risk management and modelling in transfusion medicine need to be fully appreciated and B. Custer gave a comprehensive review of the methods, strengths and limitation of such risk modelling in blood safety.(8) The need to optimise blood safety remains a central theme within transfusion medicine but this comes with related costs, as health budget is not infinite.(9) The need to balance safety and cost take a central stage in transfusion medicine.(10) This has broadened the scope and complexity of making evidence based decision making for blood safety. This debate has resulted in the initiatives of establishing and promoting risk-based decision-making in blood safety.(10) These continual blood safety and costs considerations becomes even complicated for blood services in resource constrained settings which are often characterised by high diseases burden of these TTIs, inadequate blood supply, limited resources, and conflicts which compromise blood provision.(11)

1.1 Risk modelling in blood safety

Risk modelling is defined as a set of techniques that can be used to inform and support decision-making at all levels in transfusion medicine as there is need to quantify and contrast risks and benefits.(8) This informs policy development and intervention decision-making. There are various types of questions that can be answered through risk modelling including the identification of effective strategies for risk management. Despite risk mitigation strategies that may be introduced it should be appreciated that zero risk is an unattainable goal.(9) It is common practice to combine these analyses with economic information to assess the feasibility of risk interventions based on budgetary constraints. The concept of risk modelling in blood safety gained momentum following the publication in 1996 by Schreiber and co-workers(12) on the risk of transfusion transmitted viral infections. They developed an algorithm of quantifying this risk based on the incidence and window period of the testing technologies. These and the variations of the model are generally classified as incidence-window period risk assessment model.(5) Accurate estimates of the residual risk is essential for monitoring the safety of the blood supply and evaluating the potential effect of new blood safety interventions. One of the current challenges in risk modelling is the need for proactive assessment of risk posed to the domestic blood supplies by travelling donors.
1.2 Cost effectiveness analysis of blood safety

Nucleic acid testing of donated blood is widely recognized as an essential activity required for improving the safety of the blood supply. However, it has been associated with low returns at high costs resulting in unfavourable cost-effectiveness ratios in most developed countries where economic evaluations were performed.\(^{(13)}\) However, in sub-Saharan Africa, the risks of TTIs are relatively high and transfusion recipients are much younger. This subsequently enhances the benefits of introducing NAT in these settings.

1.3 Study focus

Recently a within-gender analysis of HIV prevalence changes between 2005/06 and 2010/11 Zimbabwe Demography and Health Surveys (ZDHS) was conducted.\(^{(14)}\) It was noted that whilst Zimbabwe has reported a significant decline among both men and women, there are important differentials across provinces and demographic characteristics. It was concluded that the results tend to suggest that the epidemic in Zimbabwe is heterogeneous and therefore interventions must be targeted in order to achieve epidemic control. In order to assess this heterogeneity effect on blood safety programme, blood donor data analysis over the same study period was conducted and changes and patterns were examined and compared with ZDHS results.

National Blood Service Zimbabwe (NBSZ) human immunodeficiency virus (HIV) risk management strategy includes screening and discarding of first-time donations, which are collected in blood packs without an anticoagulant (dry pack). To evaluate the impact of discarding first-time donations on blood safety the HIV prevalence, incidence, and residual risk in first-time and repeat donations (wet packs) were compared.

The NBSZ adapted a published incidence-window period (IWP) model, which has less demanding data requirements. We assessed the impact of various definitions of blood donor subpopulations and models on residual risk (RR) estimates. We compared the outcomes of two published models and an adapted NBSZ model.

The EUFRAT (European Up-Front Risk Assessment Tool) was developed as an online risk assessment tool (http://eufrattool.ecdc.europa.eu) to help decision-makers assess the transmission risk of emerging infectious diseases (EID) through blood transfusion. Our study extended the methodology developed in the EUFRAT project to quantify the transfusion transmission (TT) risk from travelling donors.

We also assessed the cost-effectiveness of introducing individual-donation nucleic acid testing (ID-NAT), in addition to serologic tests, compared with only using serologic tests for the identification of hepatitis B surface antigen (HBV), hepatitis C antibody (HCV), and human immunodeficiency virus I and II (HIV) among blood donors in Zimbabwe.

OBJECTIVES

1.4 To assess the general and donor population HIV data and implications on blood safety
1.5 To assess the effectiveness of first-time blood donors risk management strategies
1.6 To estimate the residual risk of HIV, HBV and HCV
1.7 To model the risk of infection transmission by travelling donors
1.8 To assess the cost-effectiveness of NAT introduction addition in Zimbabwe
METHODOLOGY

We analysed within gender changes in HIV prevalence for 276,720 women and 352,080 men who donated blood nationally for the combined periods of 2002-2006 and 2007-2011 being corresponding periods for ZDHS 2005/6 and 2010/11 respectively. The proportional changes (%) in HIV prevalence were determined and statistical significance using chi-square test was performed over the two periods. Sub-analysis by donation provinces and age categories was done and results compared with corresponding analysed ZDHS data. A blood safety indicator, the Donor Management Factor (DMF) was obtained by dividing the ZDHS’s HIV prevalence’s by the corresponding blood donor HIV prevalence. Donor data from 2002 to 2010 were retrieved from centralized national electronic donor database and retrospectively analysed. Chi-square test was used to compare HIV prevalence with relative risk (RR), and the RR point estimates and 95% confidence interval (CI) are reported. Trend analysis was done using Cochran-Armitage trend test. HIV residual risk estimates were determined using published residual risk estimation models.

The Schreiber IWP model (Model 1), an amended version (Model 2) and an adapted NBSZ model (Model 3) were applied. Variably the three models include prevalence, incidence, preseroconversion intervals, mean lifetime risk and person-years at risk. Annual mean RR estimates and 95% confidence intervals for each of the three models for human immunodeficiency virus (HIV), hepatitis B virus (HBV) and hepatitis C virus (HCV) were determined using NBSZ blood donor data from 2002 through 2011.

A generic model for estimating the TT risk from a group of travelling donors that visited an EID risk area was developed. In addition, the new model distinguishes projected future transmissions from those that have already occurred. As an illustration, the model was applied to the outbreaks of chikungunya in Italy in 2007 and Q fever in the Netherlands in 2007-2009.

The costs, health consequences and cost-effectiveness of adding ID-NAT to serologic tests, compared to serologic testing alone, were estimated, from a healthcare perspective, using a decision-analytic model for Zimbabwe.

RESULTS / FINDINGS

Although there were similar proportional declines in ZDHS HIV prevalence at national level for males (15%, p=0.011*) and females (16%, p=0.008*) in the overall blood donors there was a 4% increase in females (p=0.376) and no change in males (0%; p=0.929) (see Figure 1 and Figure 2). Sub-analysis for new blood donors showed increases of 10% in females (p=0.09) and 3% in males (p=0.573). In repeat blood donors there was no change in females (0%; p=0.907) and a decline of 3% in males (p=0.645). There were variations in changes and patterns overall (Figure 2) and also by provincial setting and age groups. The DMF decreased over the two periods in males from 28 (14.5/0.51) to 24 (12.3/0.51) and woman from 29 (21.1/0.72) to 24 (17.7/0.75). Variations in changes in DMF were also observed across provinces and age strata.
Figure 1: HIV in general (ZDHS 2005/6 & 2010/11) and new blood donor (2002/06 & 2007/11)

Figure 2: Overall proportional change (%) in HIV prevalence among men and women (general and blood donors populations) between two periods 2002-6 (ZDHS 2005/6) and 2007-11 (ZDHS 2010/11).

Over the 9 years the overall HIV prevalence estimates are 1.29% (n = 116,058) and 0.42% (n = 434,695) for first-time and repeat donations, respectively. The overall RR was 3.1 (95% CI; 2.9 - 3.3, p < 0.0001). The overall mean residual transmission risk of HIV window phase donations in first-time was 1:7384 (range, 1:11,308–1:5356) and in repeat donors it was 1:5496 (range, 1:9943–1:3347).
The annual mean RR estimates for Models 1 through 3 were 1 in 6542, 5805 and 6418 respectively for HIV (Figure 3, trend); 1 in 1978, 2027 and 1628 for HBV; and 1 in 9588; 15,126 and 7750 for HCV.

**Figure 3: RR estimates for HIV in Zimbabwe per year (2002 – 2011) for the three models.** NB: Model 1 – Schreiber and co-workers (12); Model 2 – Shang and colleagues (15); Model 3 - adapted NBSZ model

Formulas for calculating the travelling donors’ TT risk were derived (see Figure 4). For the chikungunya outbreak in Italy an early intervention (at the end of week 7 after the start of the outbreak, so after only 19% of all cases) would have been required to prevent only 41% of all expected transmissions at that time. For Q fever, in which the transmission of chronic Q fever is considered, even at the end of the third annual outbreak’s peak 47% of all (chronic) Q fever transmissions could still be prevented.

**Figure 4: Modelling travellers’ risk when visiting a risk area.**

*The key features to note are that travellers’ exposure varies depending on the time of entry \( t_e \) in relation to the start and end of the observation \( t = 0, t = t_{obs} = D_o \). Transmission risk is further affected by the time of getting infected \( t_i \), and the time of donating \( t_x \) after the travellers’ return to their home country. Transmission will only occur if donation takes place within the remaining infectious period \( D_x \). Other factors considered are the duration of the visit \( D_v \), the duration of infectivity \( D_l \), and the duration of the observation \( D_o \). Returning donors who have already donated at the end of observation \( t_{obs} \) (past transmissions) can obviously not be prevented. Transmissions that are yet to occur (future transmissions) can be prevented by implementing additional safety interventions.*
It was established that the introduction of ID-NAT in addition to serologic tests would lower HBV, HCV and HIV transmission risks to 46.9, 0.3 and 2.7 per 100,000 donations, respectively. ID-NAT would also prevent additional 25, 7 and 9 HBV, HCV and HIV transfusion transmitted infections (TTIs) per 100,000 donations, respectively. The introduction of this intervention would save an estimated 217 quality-adjusted life years (QALYs). The incremental cost-effectiveness ratio is estimated at US$12,252/QALY, a value far more than three times the GNI per capita for Zimbabwe.

DISCUSSION

The general themes of this paper are several fold. Firstly, the assessment of HIV burden in general and blood populations, and its implications on the blood safety programme, especially on the blood donor management. Secondly, the studies focused on the TTIs residual risk and travellers’ risk modelling focusing mainly on resource limited setting. Lastly, we examined the implications of our studies transfusion patients (cost effectiveness) with focus on sub-Saharan Africa settings.

1.9 HIV in general and blood donor populations – implications on blood safety

Our studies looked at these two populations (general and blood donor) HIV changes over two periods and examined the possible impact on blood safety in Zimbabwe. There is need to understand the epidemiological context of TTIs in both populations as it is critical to ensure safer blood donations. Past studies have shown that Zimbabwe is categorized as a country with a generalized epidemic of HIV.\(^{(16,17)}\) Comparison of HIV data in general and donor populations can be key in responding to HIV burden\(^{(18)}\) especially in Zimbabwe, which does have a generalised HIV epidemic.\(^{(19)}\) The variations in the change in HIV prevalence support studies that have shown that national trends mask the real differences hence the need of disaggregated analysis of data.\(^{(20,21)}\) The findings further support the view that the HIV epidemic in Zimbabwe is heterogeneous and these variations warrant a data driven focused approach in HIV programming. A donor management factor was determined to indicate progress or challenges in blood safety programme management. We note that there have been limited studies in literature to utilise this ratio especially for blood safety management whereas this would greatly assist in blood donor management. The donor management factor decline that was observed for the Zimbabwe blood safety programme may be a reflection of increasing difficulties encountered in attracting safer blood donations. This would point to the need for more blood safety budgetary support in Zimbabwe for further public (donor) education, intensified donor selection and introduction of contemporary blood donation testing technologies such as ID-NAT and pathogen reduction. There is speculation (personal communications within NBSZ) that the generation born in an environment with HIV (those born from 1985) is now contributing to blood donations, hence this may be contributing to HIV cases in the age group 16-20 years which is not driven primarily by risky behaviour exposure of the blood donor. This may represent a new dimension for the blood safety programme to deal with, given that 70% of blood donations in Zimbabwe are from this age group. This finding would not only have blood safety implications for Zimbabwe, but also for other settings with high proportions of young donors and with generalized HIV epidemic which is the actual situation for most sub-Saharan Africa countries. There is a need for a global multi-centre centre study to determine the generalizability of donor management factor in different settings and context. We were not able to extend our studies for similar analysis to include other key viral TTIs of HBV and HCV as the general population level data of these is not readily available in Zimbabwe. This should though be priority for future studies.
1.10 Blood donor risk management of TTIs

The NBSZ HIV risk management strategy, which includes screening, and discarding of first-time donations, which are collected in blood packs without an anticoagulant (dry pack).(22) The Zimbabwean strategy deviates from other settings, especially from developed settings, which do not make use of new donations but only take a sample for testing. The concept of sample collection only for presenting higher risky blood donors is currently being investigated in Zimbabwe by assessing the views of donors (especially potential stigmatization in school settings) and the potential risk that the NBSZ might be used as an HIV voluntary counselling and testing centre. There is early evidence of such test-seeking behaviour among some of the blood donors and thereby compromising blood safety. In both first-time and repeat blood donations, the HIV seroprevalence is lower than in the general population,(23) which indicates the efficacy of donor motivation and selection procedures by NBSZ. The overall residual risk estimates in first time and repeat donations were comparable and this finding is consistent with the findings of Shang and co-workers (15) who found a lower residual risk among Shenzhen first-time blood donors. This is in contrast with Western blood donor populations. They speculated that this might be due to differing donor demographics and donation motivations in the population they studied. In high HIV prevalence settings, such as Zimbabwe the use of appropriate donor selection methods complemented with advanced testing technologies will improve blood safety. In South Africa where the HIV prevalence in the general population is 11.4%, (24) the South Africa National Blood Service reported their residual risks in first-time and repeat donors as 1:25,641 (3.9/100,000 donations) and 1: 40,000 (2.5/100,000 donations), respectively based on the study by Heyns and co-workers. (24) After ID-NAT introduction in 2005, the South Africa National Blood Service reported (25) that the residual transmission risk of window phase donations was estimated at 1:479,000, which indicates enhanced blood safety through implementation of an advanced testing technology. In another residual transmission risk of TTIs study in sub-Saharan Africa by Jayaraman and colleagues(26) it was estimated that the risk of HIV transmission is 1:1,000 donations (1 infection per 1,000 units), which is high compared to the Zimbabwean data. This may be indicative of different risk management strategies required in the sub-Saharan Africa blood services, depending on variations in prevalence and also related differences in cost-effectiveness.

1.11 Risk modelling of TTIs

The residual risk estimates for Zimbabwe are low (1:10,000 – 1:1000), when compared to the majority of blood services in sub-Saharan African countries, which have moderate levels of residual risk estimates (1:1000–1:100) to high (1≥1:100). (26,27) However, residual risk estimates for sub-Saharan Africa vary greatly as residual risk estimates for HIV have been estimated and ranges from 1 in 90,200 donations to 1 in 25,600 donations in a multinational collaborative study. (28) The variation found in various studies estimates may be a reflection of the application of different residual risk models, data quality, or differences in study coverage (facility / regional / national). All these factors will ultimately compromise the full understanding of the actual status and attempts to monitor and evaluate the effectiveness of blood safety measures in sub-Saharan African countries. Our study has provided a justification for the use of comparable residual risk models for use by regional health authorities, policy makers and decision markers. (26) Blood Safety projects should include residual risk estimates as an indicator tool for monitoring and evaluation in the programme management, to complement current measures for tracking seroprevalence trends. The Africa Society for Blood Transfusion has commendably included residual risk assessment for blood transfusion services as part of its stepwise accreditation programme (29) and research initiatives (30) to promote and standardize the residual risk estimation in blood services in the region. We note that there is no universally accepted residual risk classification and there is a risk classification proposed by Calman,(27) which could be considered for adoption. This residual risk
classification was adopted by the Australian Red Cross Blood Service, which uses four published risk models, to determine residual risk estimates. The use of three models in this study identifies the challenges inherent in residual risk modelling. This is an opportune time for blood services to agree on a generic model(s), which can be used for estimating residual risk. Van Hulst and colleagues and the online EUFRAT tool (for emerging infectious diseases) have demonstrated the importance of such tools.

We have demonstrated that it is feasible to estimate for any setting (developed and developing countries) the number of transmissions from travelling donors using the novel method we developed. We applied the travellers’ risk model to the chikungunya outbreak in Italy and the Q fever outbreak in the Netherlands as these have previously been analysed using EUFRAT for the transfusion transmissible risk among the local residents. For chikungunya outbreak, we estimated the traveller’s risk for a one week visit as 0.1 per million (0.1 infections in 1,000,000 donations made by travellers to the outbreak region). Liumbruno and colleagues reported that during this outbreak, a 21-day deferral policy was implemented nationally for all donors who had visited the risk area even for a few hours, although their acceptable cut-off risk is 1 in 380,000, which is much higher than our model’s estimate. Had the travellers’ risk model been available at that time, the policy might have been different. Chikungunya has only a short infectious period of 8 days, therefore, only a limited number of future infections are anticipated. The ability of the travellers’ risk model to generate the expected number of future infections allows decision makers to quantify the potential immediate impact of (in)action on transfusion safety. Application of the travellers’ risk model may assist blood establishments in harmonising risks posed by travelling donors.

Several studies have shown that travellers do pose a risk which requires blood authorities in both the developed and developing settings to have mechanisms in place to manage such risks. The limited number of generic model parameters required permits the model to be applied in very diverse settings including sub-Saharan Africa. This not only empowers public health decision-makers with an appropriate tool to objectively quantify the risk from traveling donors, but also provides a sound proactive basis for enhanced management and response to outbreak situations. In addition to our risk modelling efforts, there is need to enhance the risk modelling based on the developed framework for risk-based decision-making to assess utility in resource-limited settings in sub-Saharan Africa.

1.12 Implications for blood services and transfusion patients

We examined the implications of our studies especially for the sub-Saharan Africa. One key aspect is for the blood services to be able to make evidence based decisions for the blood safety programme. As presented in the this paper, one such safety measure is to consider and implement new testing technologies. However, this comes at an additional cost. We investigated the cost-effectiveness implication of adding ID-NAT testing to the serologic testing of HIV, HBV and HCV in Zimbabwe as have been done elsewhere for such interventions. It was shown that the introduction of ID-NAT in addition to serologic tests would lower HBV, HCV and HIV transmission risks and save an estimated 217 quality adjusted life years (QALYs). The incremental cost-effectiveness ratio was estimated at US$12,252/QALY, a value far more than three times the gross national income (GNI) per capita for Zimbabwe. However, the use of this WHO threshold and its applicability in settings such as Zimbabwe warrants further attention, as this value in other settings would result in favourable decision. Although desirable, the implementation of ID-NAT in Zimbabwe will result in a significant increase in the unit cost of blood (fee-for-service), which is already considered expensive and unaffordable by the public sector hospitals. This would adversely affect the patient’s receiving transfusion services in Zimbabwe. Thus, although the introduction of NAT could further improve the safety of the blood supply, current evidence suggests that it cannot be considered cost-effective. It was noted that reducing the test
costs for NAT will improve cost-effectiveness and NBSZ would need to pursue this route with NAT vendors and funders.

CONCLUSION AND FUTURE PROSPECTS

In conclusion, overall this paper has demonstrated that the risk modelling of TTIs can be equally and gainfully applied in sub-Saharan Africa and this momentum needs be maintained. The HIV changes and patterns linkages have been established from general to blood donor populations. The use of donor management factor as a risk assessment and management ratio for blood safety has been demonstrated and can be potentially transferred to other settings. The viral TTIs (HIV, HBV, and HCV) residual risk estimates for Zimbabwe were determined and used to assess the blood safety implications, and these were generally low risk though there was demonstrated high HBV burden, which requires further attention. Applicable residual risk models and impact of blood donor subpopulations on residual risk estimates for sub-Saharan Africa were assessed and it was demonstrated that sub-Saharan Africa adapted model performed comparatively well with other published models. These viral TTIs residual risk estimates needs to be further monitored and compared across sub-Saharan Africa based on comparable data sets and similar models applications. The travellers’ risk model we developed can be applied globally, including sub-Saharan Africa. However, there is need to have this model applied prospectively in realtime emerging infections diseases outbreaks in sub-Saharan Africa and other settings. This will enable further review and validation of the model. The review and validation outcomes will be used to inform further refinements of the travellers’ risk model. The cost-effectiveness analysis of ID-NAT introduction in addition to serologic testing in Zimbabwe was presented. Although our findings indicated that it was not cost-effective to implement ID-NAT there is need for comparative studies across sub-Saharan African blood services involving current (implementing) and prospective centres on NAT technology implementation. This will allow an assessment and applicability of the current thresholds for cost-effectiveness of health interventions for the sub-Saharan Africa as questioned in our study.

REFERENCES


DEVELOPMENT OF AN ONLINE MEDICAL DIAGNOSTIC AND CONSULTATION SYSTEM
CASE OF GWERU PROVINCIAL HOSPITAL
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ABSTRACT

Gweru provincial hospital as the largest hospital in the province and also the referral hospital it is faced with a great number of patients daily. The introduction of the online medical diagnostic and consultation system will vastly improve the operations of the hospital as not all of the patients will have to come to the hospital but be easily assisted online to reduce congestion and queues at the hospital out-patient department. Another major advantage of the medical diagnosis system is the fact that you can gain online access to general doctors, specialists otherwise not is available to you. The system will allow users to get expert medical advice in the comfort of their houses. Interviews, questionnaires and observations were used in gathering information relevant to the study. The system was developed using PHP software package (web development and MySQL (database development). It has a centralized architecture that also implies a central database server. All computer terminals then access data using the later architecture. The medical diagnosis system had a variety of modules to facilitate the different users of the system within the hospital. The study also involved analysis of usage of such kind of system and its advantages to the patients.

Keywords: Diagnosis, Outpatient, Disease surveillance, System, DHIS2

HOSPITAL (House Of Sick People Including Treatment And Labour)
INTRODUCTION

Online Medical Diagnostic and consultation System is meant for the Outpatient department (OPD) to provide health services to patients in the comfort of their homes and beyond. With the emergence of new technology there is need to invest in systems that assist in saving lives and help in improving the efficiency of hospitals by adopting systems that quickly assist patients and reduce the manual process at low cost that benefits both the patients and the hospital. Gweru Provincial Online Medical diagnostic and consultation system will complement the manual process in assisting doctors and patients for immediate diagnosis in the Outpatients Department. This system will be used to quickly find out the disease from given signs and symptoms from patients online and the expert doctors system will state the diagnosis and give recommendations to the patient online. The system will also track patients’ information on diagnosis and medical reports as well as analysis of disease trends and pattern as part of disease surveillance.

I. LITERATURE REVIEW

Computer-based methods are increasingly used to improve the quality of medical services. Mostly the remote areas, the population are deprived of the facilities of having experts to diagnose disease. So it is the need of the day to store the expertise of specialists in computers through using ES technology [1]. After that they can consult the specialist doctor if it is necessary or serious. Rule based expert system includes both conventional techniques, such as database management systems (DBMSs), and artificial intelligence (AI) techniques, such as knowledge-based systems (KBSs) or expert systems (ESs) [2]. In this paper, an intelligent medical system for diagnosis of diseases that uses the above methods is presented. A Medical Diagnosis System is developed with the purpose of assisting the Physician in diagnosing several diseases. It retrieves data from previous records to improve the accuracy of current
diagnosis, indicates and analyses laboratory exams and lists all the possible diseases that the patient may have [3].

Quite often one or more diagnostics procedures such as diagnostic tests are also done during the process. [6] In most developed such kinds of systems are being widely used as a replacement to physical doctor-to-patient consultations. Hence most people tend to depend on such system such that we have seen development of the systems as online application as well as those to be used on android operating system. Common systems that are currently being usually mine the Local database with the goal of deriving diagnoses that had been made over the past few days, weeks, months etc. Data is usually mined locally unless the system is to be used over wide geographical area [6]. Such systems include the Coronary Artery diagnosis system that uses production rules for its diagnosis and it’s widely used in the US [6]. The proposed system is implementing the same concept when it comes to the aspect of the data mining.

As much as the systems are beneficial some people are hesitant to adopt them due to issues of data protection and confidentiality when using such kind of system. Medical records are treated as confidential information hence use of appropriate information security techniques is necessary to maintain integrity of the data. Such techniques include use of passwords, firewalls and data encryption. The proposed system shall also incorporate some of these techniques as protection of data is of major importance.

III. OBJECTIVES

To develop an online diagnostic system that will be able to conduct the following:

- To diagnose a disease from given signs and symptoms.
- To prescribe drugs based on diagnosis.
- To recommend a doctor or specialist who has expertise in the patient’s disease from the given database of doctors.
- To recommend a lifestyle on diet or exercise etcetera or to either visit the doctor based on diagnosis.
• To track information on diagnosis and medical reports

• To allow patients to pay consultation fees online using ecocash or paynow and thereafter be granted access to the system

IV. METHODOLOGY

Methodology for development of the online medical consultation and diagnosis system is given as under.

SCOPE & LIMITATIONS

The diagnosis deals with following diseases:

Malaria, Chicken pox, Diarrhoea, Diabetes, Jaundice, Hepatitis, Typhoid, Alzheimer’s Disease, Bronchitis, Migraine, Influenza, Cholera, Pneumonia, Asthma among others.

KNOWLEDGE ACQUISITION

• Searching for relevant books, World Wide Web (WWW).

• Meetings with ophthalmologists’ students and patients.

• Personnel observations and getting data from various ophthalmology clinics and wards in hospital, and medical colleges.

SYSTEM OVERVIEW

The main objective of this system is to produce relevant data and information for consultations, and with the results obtained at this stage, produce possible diagnoses. In the definition of this process, 3 modules were created, to be used by specialists.

In the first module,

• It is possible for a specialist or any medical committee to define which symptoms, clinical exams or laboratory exams are relative to one or more illnesses and, thereby, attribute the values (statistical
weights) or results that define the illness. This means, for instance, that blood pressure can be associated to the Diagnosis of High Blood Pressure, Diabetes, Pregnancy Risk, or renal failure, among others. It also indicates, in some cases, whether this symptom result provides the certainty of diagnosis or not. Information from previous consultations and examinations are automatically linked and analysed under temporal logic reasoning.

In the second module,

- The system allows consultations whereby the relevant data for the patient is recorded and related to other correlated exams. Data not considered are discarded. During the stage of diagnosis, the system may suggest other tests or procedures to then decide whether there are other risks or diseases to be further investigated.

In the third module,

- A diagnosis is made whereby the system removes refutes diagnosis, redefines the remaining ones (if necessary). Also, this system searches out levels of illnesses according to exam results. It may also suggest further investigation whenever data is not enough to ensure a precise diagnosis; If no further information exists, it can reason under incomplete information relaying on current data. Finally, the system asks what results will be considered for the formation of the diagnoses, and then asks the doctor which diagnoses are confirmed.

**KNOWLEDGE REPRESENTATION**

- Using production rules facilitated by programming language used [4]

- Storing additional information from external databases.

**SOFTWARE DEVELOPMENT**

Different software modules, like: Xammp server, Php, were integrated to software. Validity of software was checked for sample data being acquired through various sources
V. IMPLEMENTATION & MAINTENANCE

Expanding scope of the system by giving it inputs from different sources like World Wide Web, recent research conducted in the field of medicine [5]. Implementation of software in different healthcare departments: e.g. hospitals, clinics medical colleges etc.

VI. RESULTS AND DISCUSSION

The system was tested to determine how accurate it could diagnose some symptoms to detect the disease, the results of the test are shown below.

Figure 1 Level of accuracy
The results show the distribution of questionnaires between the hospital staff, patients and other stakeholders.

Table 1 Questionnaire distribution

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staff</td>
<td>31</td>
</tr>
<tr>
<td>Patients</td>
<td>32</td>
</tr>
<tr>
<td>Others</td>
<td>17</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>80</strong></td>
</tr>
</tbody>
</table>

Table 2 Respondent Rate

Questionnaires from staff were 87% in response. From patients there was a 66% response rate and others 71%. The total overall response rate was 75% and this high return might be due to the fact that the topic was of great interest to the various stakeholders. Staff were asked their working experience with the current system. Overly this 75% is of satisfactory to the researcher. The high return rate from staff can also be attributed to the fact that they were given a chance to respond while in their working environment. Moreover, the staff were willing to see their work computerized reducing the burden of the current manual system.

<table>
<thead>
<tr>
<th></th>
<th>Total distributed Questionnaires</th>
<th>Returned Questionnaires</th>
<th>Response Rate %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staff</td>
<td>31</td>
<td>27</td>
<td>87</td>
</tr>
<tr>
<td>Patients</td>
<td>32</td>
<td>21</td>
<td>66</td>
</tr>
<tr>
<td>Others</td>
<td>17</td>
<td>12</td>
<td>71</td>
</tr>
</tbody>
</table>

The results were also represented graphically below,
The researcher is employed by the Ministry of health and child care as Health Information Officer and her duty is to collect, analyse, verify and submit hospital statistics via DHIS2. The statistical information of OPD data is an estimate from DHIS2. Monthly Data collection tools used included T1, T2, T3, T5, T12 and HS3/5 Forms.
Figure 4 nurse patient ratio and doctor patient ratio

OPD attendances were used to determine the visits to the department in relation to nurse patient ratio to show that the ratio was not ideal.
Doctor Patient Ratio
VII. CONCLUSION

In this paper, a case-based medical expert system prototype that supports diagnosis of Common diseases was developed. Several properties of this model remain to be investigated. It should be tested on several more databases. Unfortunately databases are typically proprietary and difficult to obtain. Future prospects for medical databases should be good since some hospitals are now using computerized record systems instead of traditional paper-based. It should be fairly easy to generate data for machine diagnosis. One important aspect of automated diagnosis is the accompanying explanation for the conclusion, a factor that is important for user acceptance. A trained expert would evaluate the quality of the diagnosis performed by the system, followed by adjustment of the utilities. For future work, more cases will be added to the case memory and it will be clinically tested.

VIII. REFERENCES

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ZIMBABWE’S PRIMARY HEALTH CARE SYSTEM: DOES IT WORK?

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ABSTRACT

Primary health care (PHC) is a strategy that seeks to respond equitably, appropriately, and effectively to basic health needs and to address the underlying social, economic and political causes of poor health, to provide accessible essential health services and to involve the participation of communities. In 1980, Zimbabwe adopted the PHC approach aimed at directing resources towards the disadvantaged populations while emphasizing active participation of communities in transforming their health. A pyramidal referral model was adopted where rural clinics (grass root/primary level) provided maternal and child care, family planning services and treatment of minor ailments, referring patients with more serious conditions to district (secondary level) then provincial (tertiary level) for general specialist services and quaternary level (central hospitals) for specialist and sub-specialist services. However, entrenched political and economic structures seem to have retarded full execution of this pyramidal referral system in Zimbabwe. Consequently, peripheral facilities are often seen as providing poor quality of services due to perceived inequitable distribution of resources, while the referral system has seemingly been rendered ineffective. The main aim of this survey was to analyse the achievements of the PHC approach as a national strategy, shaped by the 21st century challenges in Zimbabwe. The results showed that some considerable segments of the population, especially in rural areas, farms and peri-urban informal settlements, still remain at the periphery of the health services delivery system. The inequity and inefficiency in the pyramidal health care model still exist, thus compromising on health service delivery.

Keywords: Clinic, District Hospital, Health, Primary Health Care, Referral Centre

Subtheme: Promoting and Maintaining Good Health (Preventative Health Care)
1. INTRODUCTION

Globally, governments are searching for ways to improve equity, efficiency, effectiveness, and responsiveness of their healthcare systems. Prior to Zimbabwe’s independence in 1980, thousands of people on the geographic or social periphery of the country received either marginal health care or none at all. Colonial health systems channeled resources to residents of urban areas and white settlers at the expense of the predominantly black rural populations who had the greatest need. About half of public funds for health services went to urban central hospitals serving 15% of the population, while only 24% of funds were devoted to rural areas where 77% of the population lived. The pledge for ‘Health for all by year 2000’ mobilized political support for the post-colonial governments.

In recent years there has been an acceptance of the role of Primary Health Care (PHC) in providing cost effective health care [1, 2, 3]. PHC which was endorsed by the World Health Organisation (WHO) in 1979 has been viewed as a way of achieving ‘health for all’ and overcoming health disparities within and between nations at the time through the provision of equitable and accessible care (i.e. medical treatment, preventative care, health promotion and social care) in, by and for communities. The WHO’s goal of achieving health for all remains. At the time of the Alma-Ata conference in 1978, it was declared that this goal would be reached by the end of the twentieth century but by the early 1990s, it became clear that this would not be the case. By 1995 the WHO had declared this to be a 21st century goal [4].

Zimbabwe adopted the Primary Health Care (PHC) as an approach to health care provision in 1980. The approach tries to address the issues of inequitable distribution of health and identify access to health as a basic human right [5]. However, the advantages and disadvantages of health care systems that rely on medical specialists versus the systems that rely more on general practitioners and primary health care have not been systematically reviewed or a case for primary health care firmly established in the Zimbabwean context. The declaration called on all governments to formulate national policies, strategies and plans of action to launch and sustain PHC as a part of a national health care system to be coordinated with other sectors. This gave rise to WHO’s goal of ‘Health for all by the year 2000’ in an effort to make global improvements in health especially for the disadvantaged populations or communities in developing countries. Since the Launch of the Alma Ata Declaration of 1978, considerable positive changes have been noted in the health situations of many countries in the world. There have been significant modifications noted in the global disease patterns, demographic profiles and in the socio-economic environment. Governments have shown commitment in different areas in order to make the PHC concept work for the benefit of their people. Zimbabwe was also represented at Ama Ata in 1978 and together with other countries; it also adopted the concept of PHC. The Declaration marks the point at which PHC was formalized as a form of care and also defined at a global scale. Great strides have been made amid economic challenges that affected Zimbabwe at the beginning of the 21st century.

1.1. Primary Health Care: An Overview

Primary Health Care is defined as essential health care that is based on practical, scientifically sound and socially acceptable methods and technology made universally accessible to individuals and families in the communities through their full participation and at a cost that the community and country can afford to maintain at every stage of their development in the spirit of self-reliance and self-determination [6]. PHC forms an integral part both of the country’s health system and the overall social and economic...
development of the community. It is the first level of contact with individuals, families and communities with the national health care system bringing health care closer to where people live and work. It constitutes the first element of a continuous health care process [6]. PHC is a means of providing a comprehensive universal, equitable and affordable health care service. According to the Alma Ata Declaration of 1978 there are four main goals of PHC and these are:

- Reduce exclusion and social disparities in health (universal coverage reforms)
- Organize health services around people’s needs and expectations. Channeling health resources to those that need them most and strengthening prevention and control of preventable diseases (service delivery reforms)
- Integrating health into all sectors (public health reforms)
- Increasing stakeholder participation

The Government of Zimbabwe, in line with the Primary Health Care strategy of organizing services, aims at ensuring the provision of quality and safe health services that meet the needs of the people through a network of health facilities organized to function on the basis of increasing levels of sophistication. Patients with more complex health problems are expected to be referred up the referral chain. Each level of care is expected to provide a package of well-defined services provided by appropriately trained health professionals as explained below.

1.2. The Zimbabwean National Health Service

The Zimbabwean National Health Service has four levels: the primary (rural health centres), secondary (district hospitals), tertiary (provincial hospitals) and the quaternary (central hospitals) as shown in Fig 1. Municipal clinics and doctors’ private surgeries in both rural and urban areas also operate at primary level, providing treatment of minor ailments, continued care to clients with chronic illnesses, maternal and child care and attending to emergency cases. Most health care services are provided by the government (65%) complemented by not-for-profit missionary/ church hospitals and private-for-profit institutions. Traditional healers and herbalists are also an integral part of the health care system, represented by the Zimbabwe National Traditional Healers Association (ZINATHA) [7]. Currently, there is no National Health Insurance system in Zimbabwe. Public health care services are free for pensioners and the under-fives, while others either pay in cash or use private medical aid schemes.

The primary level consists of a network of rural health centres and community health workers. The Rural Health Centres (RHC) provide basic but comprehensive promotive, preventive, curative and rehabilitative care, concentrating on mother and child care including antenatal care, delivery of uncomplicated births, family planning, child health and nutrition, routine immunization for children and anti-tetanus immunization for child-bearing women, environmental sanitation, especially in relation to small-scale water supplies and excreta disposal systems, control of communicable diseases, other specified problems including mental illness, eye diseases and physical and mental handicap, and general curative care including oral health [8].
Within each community are found Village Health Workers (VHW). They are the first line health workers and are the key link between the organized village community and the local health services [9]. They are involved in treatment of simple conditions, disease surveillance and for enhancing health information systems. On-going technical supervision of VHW is provided by the local staff of the rural health centres, which keep the village health workers supplied with medicines and equipment at government expense. Village Health Workers refer and also encourage communities to seek treatment early from a rural health centre or clinic. Rural health centres refer patients to District hospitals (Secondary care facilities).

The district hospitals found in the fifty-nine Zimbabwean districts provides referral and supervisory support to the network of clinics and Rural Health Centres in the district. They also provide comprehensive preventive and curative services. Patients have their first contact with a medical doctor at this level within the health delivery system.

The third level is provincial hospitals which are found in each of the ten administrative and geo-political provinces of Zimbabwe. District hospitals refer patients to Provincial Hospitals (Tertiary care facilities) where patients meet a specialist. The provincial hospital level provides referral support to district hospitals. There are a limited number of specialists at the provincial hospitals. All provincial hospitals train nurses and/or midwives and this helps to boost the staff complement at this level.

Finally, the quaternary level consists of Central hospitals that act as the principal referral centres for patients and together with private-for-profit hospitals, provide more sophisticated type of services. The central hospitals are found in Zimbabwe’s two metropolitan provinces that is, Harare and Bulawayo including Chitungwiza town. Traditional healers and herbalists are also an integral part of the health care system and are represented by the Zimbabwe National Traditional Healers Association (ZINATHA) [10]. The Zimbabwe’s health structure is shown in Fig 1 below.

![Zimbabwe Health System Structure](image)

**Fig 1: Zimbabwe’s Health System Structure**

Source: (Ministry of Health and Child Welfare, 2009)
1.3. Key Elements of Primary Health Care (PHC)

For Primary health care (PHC) to be successful it is essential that health care is made universally accessible to individuals within a given framework acceptable to them, through full participation and at a cost the community and country can afford. It is an approach to health beyond the traditional health care system that focuses on health equity-producing social policy. PHC has basic essential elements and objectives that help to attain better health services for all as illustrated in Fig 2 below.

![Elements of primary health care](image)

Fig 2: Elements of Primary Health Care

Source: (WHO, 2008)

The main elements of PHC are:

**E**-Education concerning prevailing health problems, methods of their identification, prevention and control

**L**- Locally endemic disease prevention and control.

**E**- Expanded programme of immunization against major infectious diseases.

**M**- Maternal and child health care including family planning.

**E** - Essential drugs provision.

**N**- Nutritional food supplement, an adequate supply of safe and basic nutrition.

**T**-Treatment of communicable and non-communicable disease and promotion of mental health.

**S**-Safe water and sanitation.
In the 21st century, these elements were extended to include expended options of immunizations, reproductive health needs, provision of essential technologies for health, health promotion, prevention and control of non-communicable diseases as well as food safety and provision of selected food supplements [11].

1.4 Main Pillars / Principles of Primary Health Care Model

A strong primary health care system is a key of improving the health of all community peoples and reducing health inequalities between different groups. PHC is a fundamental and basic health care that is based on practical, scientifically sound and universally acceptable methods and technology, which available and accessible to all individuals and families in a community as first level of care. PHC services should decrease delay and increase access to the health care system, offering better health outcomes.

Fig 3: Pillars of Primary Health Care


A PHC team is a multidisciplinary group of health and social care professionals who work together to deliver local accessible health and social care services to a defined population in a community. Effective Primary Health Care framework is built on four key pillars which strengthen the delivery of health and wellness care and these are community participation, inter-sectoral coordination, appropriate technology foster and support mechanism.

The four major pillars of PHC framework as shown in Fig 3 are:
1.4.1 Community Participation:

Community participation is a social and proven approach to addressing health care needs of the community people. It means the involvements of the community people concerned in analysis, decision-making, planning, and program implementation, as well as in all the activities and share their needs living in a specific geographic area and establish mechanisms to meet these needs. The responsibility of health rests not only with government but also with individuals, families and communities themselves. Universal coverage by primary health care cannot be achieved without the involvement of the local community. Maximum reliance should be on local resources for the above. Local resources that are used include manpower, money and materials.

1.4.2. Inter-Sectoral Coordination:

Inter-sectoral coordination refers to the collective actions involving more than one specialized agency, performing different roles for a common purpose. Health cannot be improved by intervention within just the formal health sector; other sectors are equally important in promoting the health and self-reliance of communities. Its involve agriculture, animal husbandry, food, industry, education, housing, public works, communication and other sectors. Therefore, these departments need to be involved in attaining health for all. This cooperation requires, strong political will, adapting the administrative system to enable such coordination, making suitable legislation to ensure this happens as well as the incorporation of Development planning that involves all the sectors to avoid duplication of activities.

1.4.3. Appropriate Technology:

Appropriate healthcare technologies are an important strategy for improving the availability and accessibility of healthcare services. It is defined as “technology that is scientifically sound, adaptable to local needs and acceptable to those who apply it and to whom it is applied and that can be maintained by people themselves in keeping with the principle of self-reliance with the resources the community and country can afford.” It means using cheaper, scientifically valid and acceptable equipment and techniques if these are available instead of costly and more sophisticated ones if the community cannot afford those. This means methods, procedures, techniques and equipment [12] that is scientifically valid, adapted to local needs acceptable to users and recipients, and support mechanisms and maintainable with local resources.

1.4.4 Support mechanism made available:

The main target of primary health care is available and accessible at least to essential health care and to first level referral facilities all over the universe. Support mechanism in primary health care is a natural or established process by which something brought about to enhance the quality of life and provides a buffer against adverse life events. In support system people get personal, physical, mental, spiritual and instrumental (and sometimes informational) support that is very important to meet primary health care goal. PHC depend on adequate number and distribution of trained physicians, nurses, [community health workers], allied health professions and others working as a health team and supported at the local and referral levels.
These four levels are however not supported with respect to infrastructure, equipment and health supplies. Moreover, the whole referral system is experiencing some bottlenecks which are exacerbated by either limited or lack of government commitment and support in the form of roads, water and sanitation provision and food security etc. which have a bearing on the health status of the Zimbabwean citizens.

2. AIM OF THE STUDY

The main aim of this study was to analyse the achievements of the PHC approach as a national strategy adopted as part of the Alma Ata Declaration of 1978, shaped by the 21st century challenges in Zimbabwe.

2.1 Objectives of the Study

The main objectives of the study were to:

- Outline the Primary Health Care model
- Describe the principles and strategies of PHC and their implementation in Zimbabwe
- Analyse the achievements and challenges encountered in the implementation of PHC in Zimbabwe

3. METHODS/METHODOLOGY

The analysis examined Primary Health Care reform efforts and challenges encountered in its implementation during the last three decades in Zimbabwe. The study findings drew on descriptive information from semi-structured interviews to obtain people’s opinions and views, reviews of published and gray literature from late 1980s to date, government and government agency websites. A systematic search to retrieve related scholarly literature and referenced articles dating from 1989-2018 was done between August 2017 and May 2018. The review focused on referenced articles that discussed issues and progress related to execution of PHC in Zimbabwe. The rationale for selecting the later part of the 80s was to give a ten-year grace period for the implementation of the PHC approach in Zimbabwe. Keywords were identified and selected from health studies under the ambit of PHC. The selection criteria were developed until the final selection conditions were established [13]. This enabled the study to eliminate scholarly work that was outside PHC framework in Zimbabwe. This was achieved through a search on Google Scholar and Science Direct which helped to achieve the elimination process. The reference list of respective applicable articles was evaluated to identify other appropriate articles and the evaluation continued up to January 2019. Data were also obtained from observations and a series of semi-structured interviews with some service providers and consumers of health services to obtain their opinions and views. The authors also took reasonable precautions to verify the information presented in this paper.

4. RESULTS AND DISCUSSIONS

4.1 Current Primary Health Care System in Zimbabwe

It has been reported that at least 67.72% of Zimbabwe’s population is rural based [14]. Nurses, midwives and clinical officers in both rural and urban settings including municipality clinics, hospital outpatients and inpatients are involved in PHC but nurses make the bulk of the PHC workforce. Nurse-anaesthetists provide the majority of anaesthesia in urban and rural hospitals, where caesarean sections are the main surgical procedures. Doctors in public PHC provide supervision and teaching, develop guidelines and consultations on referred cases. Nearly every district (±250 000 population) has at least two medical
officers; every PHC centre has at least two qualified nurses; 59% of administrative wards have an environmental health technician while in the rural areas 60% of villages have access to a village health worker [8].

This current scenario points to overworking on the part of medical personnel, the reason why nearly every year there is work stoppage by nurses and junior doctors. At the time of writing this paper (December 2018) both junior and senior doctors were on strike citing the following perennial grievances that continue to rock our Ministry of Health; countrywide shortages of basic medicines and equipment at health facilities, no or limited foreign currency for the importation of medicines (underfunding of the health sector), “falling” salaries which they now want the government to pay in foreign currency (USD), poor on call allowances and a review of their work conditions, the poor state of the country’s hospital infrastructure and selling of drugs in foreign currency (USD) by retail pharmacies. The strike has come on top of worsening foreign currency, fuel and medicines shortages in the country, as well as ever-rising prices of basic goods which is making life more miserable by the day for long-suffering citizens thus rendering the PHC framework redundant.

4.2 Zimbabwe’s Constitution and Its Provision for Health

The Constitution of Zimbabwe (2013) [15] explicitly provides for the right to health care in Section 76, sub-section 1 to 4 of the Zimbabwe Constitution, which states that:

4.2.1 Every citizen and permanent resident of Zimbabwe has the right to have access to basic health-care services, including reproductive health

4.2.2 Every person living with a chronic illness has the right to have access to basic healthcare services for the illness

4.2.3 No person may be refused emergency medical treatment in any health-care institution, and

4.2.4 The State must take reasonable legislative and other measures, within the limits of the resources available to it, to achieve the progressive realization of the rights set out in this section”

‘The Constitution further provides, in Section 77 that every person has a right to safe, clean and potable water, and sufficient food (Food Security, Quality and Safety). These rights are directly related to peoples’ health as it not possible to divorce the living conditions of people from their health risks and status. This national health strategy is indeed subordinate to these constitutional provisions and the State has the responsibility to create a conducive environment in which it is possible for all people in Zimbabwe to access basic health services whenever they need them. The Zimbabwean constitution is currently being flouted due to underfunding in the heath sector. In the 2018/19 the health sector was allocated a paltry US$694.5 million [16].

It is important to note the reaffirmation of the principles of the Declaration of Alma-Ata made at the Ouagadougou International Conference on Primary Health Care and Health Systems in Africa meeting of 2008. The Conference expressed the need for accelerated action by African governments, partners and communities to improve health; to respect the importance of the involvement, participation and
empowerment of communities in health development in order to improve their well-being; and recognizing the importance of a concerted partnership, in particular, civil society, private sector and development partners to translate commitments into action [17] Renewed political commitment and creation of an environment that is conducive to health development such as improved peace, security, economic growth are important recipes for improvement of health.

4.3 Key Challenges of PHC in Zimbabwe

The referral chain works best when the patients referred from the lower levels receive the benefit of specialist opinion. In theory, patients are required to present at the primary level first and then be progressively referred to the Secondary, Tertiary or Quaternary levels depending on the complexity of illness. In practice, the experiences of the past decade have shown that the referral chain has broken down, with all referral hospitals replicating the work of the Primary level [7; 8]. At Harare and Mpilo Central hospitals, it is estimated that about 75% of patients presenting are self-referred [8]. The situation is also worsened by public employed doctors who undertake dual practices. They see patients at their privately-owned surgeries (that is at primary level) and the very same doctor refers the patients to a public hospital where they put the patients under their private care. This practice becomes costly on the part of the patients as well as causing confusion on the whole referral system.

Financial challenges experienced in 2008/9 and the current macro-economic situation in Zimbabwe increased poverty and disruption of the referral system and increased usage of complementary medicines which are cheaper, readily available and accessible. The uncontrolled practice of complementary medicines has been reported to fuel the problem of defaulting on the part of patients with chronic diseases like Tuberculosis, hypertension and diabetes mellitus. These current challenges have been exacerbated by the exodus of experienced doctors and nurses from the public sector into the private sector, the Southern Africa region and abroad. Thus there has been increased workload on the part of medical personnel. The government worsened the situation further through a recruitment freeze in the public sector Strikes by doctors and nurses pressing for better salaries and working conditions are the order of the day and this has also disrupted of the referral system. Health services being rendered by poorly qualified personnel e.g. nurse aides and First aid attachés

The burden of health care today in the third world is overwhelming, with falling GNP, smaller health budgets, and the increased burden posed on health services by AIDS. This means being proactive in increasing preventive health care interventions in order to reduce burden of disease presenting for curative services, and harnessing the invaluable human resource of dedicated community health workers at community level to make primary care, both curative and preventive, accessible to a greater majority of households at relatively low cost. Procurement, storage, transport and distribution of health supplies, and health information management all need to be integrated for more cost-effective delivery of health care.

The health of children is much entwined with the health of their parents, and one cannot expect to achieve significant strides in the health of one group without the other. Zimbabwe’s population is young, a scenario typical of countries with high fertility rates with the proportion of children under age 15 remaining at 43 %t since the 2010-11 Zimbabwe Demographic Health Survey (ZDHS). It was further reported that half of the population in Zimbabwe is below age 18 years while 5% percent are age 65 or older [18]. PHC is not sufficient in itself to achieve sustained improvement in health. Alleviation of
poverty, universal education, more equitable distribution of national resources, and reduction or cancellation of the developing world’s foreign debt are all important factors in ensuring improved health for all. Without these the hope of achieving health for all in the developing world would appear to be a fading dream.

Supervision stands out as the weakest link in CHW programmes. This is particularly true for large-scale national programmes, which commonly lack regular supervision and support. In the very worst cases CHW may not even know who their supervisors are or what the can expect from them. In Zimbabwe, supervision is left mostly to health staff at the clinics; however, these nurses may not fully understand the CHW or their own roles properly. Another weak link to CHW effectiveness that is closely related to supportive supervision is lack of infrastructure and logistical support. CHW programmes are frequently affected by lack of reliable transport and drug supplies. The reason for this is that CHWs generally operate on the periphery both in terms of organisations and geography. As such they are the first to lose on supervisory visits as well as drug supplies.

Community Health Workers optimal performance remains unclearly defined. Currently, there is a long and unresolved debate about the question of how many functions one CHW can effectively perform, considering the potential scope of activities they are expected to perform. The performance of CHW regarding the quality of care depends on a variety of factors falling under individual factors (motivation, attitudes, competences, adherence to guidelines and job satisfaction) and end user/community level factors (broader health outcomes like uptake of health services [19].

Retention of Community Health Workers is important for continuity of health services at the community level, especially in view of the background of the important role CHW play in involving the communities to participate in their own health. A complex set of factors (monetary, non-monetary, community level factors) affect CHW’s motivation and attrition, and how these factors play out varies considerably from place to place. In Zimbabwe, the attrition of CHWs has largely been anecdotal and the Ministry of Health and Child Care has in recent years commissioned the establishment of an electronic inventory that will be used to track continuation of practice of CHWs, although this is still limited to VHWs. The question of whether CHWs should be volunteers or be paid in some form has remained controversial and unanswered for a long time. There has been a shift and growing realisation that volunteerism can be sustained for long periods if the prevailing macro-economic environment remains favourable.

Generally, community health workers are poor; they expect and require an income. Even though in many programmes they are expected to spend only a small amount of time on their health-related duties, leaving time for other breadwinning activities, community demand often requires full-time performance. For example, in contexts like Zimbabwe where numerical adequacy of VHW has always been disproportionate to the population served, the cadres have reported spending more time undertaking the duties than expected [20].

If the Primary Healthcare Approach is to be implemented effectively, strong community systems are essential. Although community structures exist to assist in both health promotion and provision of health services, they need to be strengthened beyond supporting the Village Health Worker (VHW). The role of traditional and local leadership, community structures and community participation needs to be elevated if health interventions are to be effective and sustained over time. Communities play a major
role not just in receiving the services they need, but also in co-production of these services and their funding and governance.

4.4 Challenges of Zimbabwe’s Healthcare which warrants PHC

Primary health care requires a paradigm shift in socioeconomic status, distribution of resources, a focus on health system development, and emphasis on basic health services [21]. The Zimbabwe government’s investment in the health sector has been inadequate and the country has generally depended on donor support and direct budget support to run the public health institutions. Most of the funding in the health sector has been from donors of which this is no sustainable The health sector has as a result failed to provide adequate services to the people especially those do not have medical insurance of which more than 90% of Zimbabwean population does not have. The crisis in the health sector is dramatized by these six horror facts about the state of the health sector.

In Zimbabwe, there is no national health insurance system despite promises by the government to come up with a National Health Insurance Scheme. More than 11 million Zimbabweans, representing 90% of the population have no access to medical aid. On average, the Zimbabwean government spends on average just over $22 on an individual health. In 2018/19 budget, the government has allocated $301 million to the health sector for a country of over 17 million people. This is a far cry especially if compared with countries with $650 million for South Africa, $390 million for Botswana and $200 million for Angola [22].

The Zimbabwe Demographic Survey report released in 2016 shows that both the under-five and infant mortality rates are improving but very slowly. The country’s infant mortality rate (the number of infants dying before reaching one year) is currently at 50 per 1 000 live births [23; 18] and is one of the highest in the world [24] while the under-fives mortality is estimated at 69 per 1 000 live births and the neonatal mortality rate is 29 per 1 000 live births [18]. Free health policies for the under-fives’ and pregnant mothers not working well. Although the adult mortality rate (15-49 years) has dropped from 12.7 for both sexes from the previous ZDHS of 2010/11 to 7.6 and 7.5 per 1000 for women and men respectively [18], more commitment needs to be shown by the government in the area of health maintenance. The government of Zimbabwe is failing to honour its promises of giving health grants to health institutions due to the current liquidity crunch prevailing in the country.

Antenatal services are poor. A recent visit to one of the Harare municipal clinics ANC unit showed a long queue of pregnant mothers waiting to be attended to. Health promotion talks are no longer being given and in some centres this is done haphazardly. The mothers were sharing experiences and wrong information as they waited to be attended to. A remark from one first timer mother “What the nurses are doing is wrong. They leave us exposed to wrong information and shared myths which are never corrected by the rightful practitioner. When we go back home, we will try these shared experiences to deal with discomforts of pregnancy e.g. swallowing red chilies to treat heart burn, does that work? ’

Maternal mortality is defined as “the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the cause of death”. It was reported that Zimbabwe’s maternal mortality rate was 443 out of 100 000 live births in 2015 [25]. At Independence in 1980, the country was reported to have a low maternal mortality rate of just 90 per 100 000 live births. However, in 1994 the gains in the health sector plummeted to 253 per 100 000 live births [26].
The ZDHS (2015) reported that the maternal mortality rate was 0.9 deaths per 1 000 women aged 15-49 years. In Zimbabwe, the major causes of maternal mortality are bacterial infection, uterine rupture (scar from a previous caesarean section tearing during an attempt at birth), renal and cardiac failure as well as hyperemesis gravidarum (condition characterised by severe nausea, vomiting and weight loss during pregnancy).

Zimbabwe has suffered immensely from a brain drain of doctors. There are now 1.6 doctors for every 10 000 people. Most government rural health centres are manned by two doctors who have to perform multiple tasks. Linked to this, there are just seven nurses and trained midwives for every 10 000 people in the country. The paucity of medical staff is also reflected in the number of specialist doctors which has deteriorated over the years [27].

Due to poor funding of the health sector, 98% of drugs used in public health centres are funded by donors. The donor community has also equipped a number of rural health centres such that Zimbabwe now has the uncanny distinction of patients shunning main referral hospitals to be treated in rural hospitals [24]. There is unavailability of drugs in public pharmacies. Drugs have become very expensive in private pharmacies as the drugs are now being sourced from outside Zimbabwe, cost of drugs are now rated against the USD in most private pharmacies. An interview with two local pharmacists revealed that a prescription of nifedipine, an anti-hypertensive drug is now costing 1USD for 10 tablets or its equivalent in USD Bond note which is now between 3.5-5 bond per one RTGS USD. This situation has led to defaults particularly amongst patients with chronic diseases like Diabetes Mellitus, hypertension, asthma etc.

Currently people with HIV, diabetes, hypertension, tuberculosis (TB) and other chronic conditions travel to hospitals or private facilities to obtain treatment, adding the burden of cost and transport to the existing demands for managing their conditions and raising barriers to uptake and adherence. It would be important to discuss opportunities and means for decentralizing chronic disease care so that resources to manage chronic metabolic problems like diabetes, hypertension, HIV are brought closer to communities strengthening possibilities for building expert patient roles in patient-centred care.

In addition, there are gaps in the resources and support for prevention and promotion activities by EHTs, VHWs and clinics that leave communities susceptible and dependent on curative care. Very few facilities have a nutrition garden to provide therapeutic or community intervention for nutritional needs. Prices of basic commodities are now beyond the reach of the majority poor people of Zimbabwe. This has led to poor food choices and malnutrition amongst the under-fives and the elderly. From the economic crisis of 2008/9, history has repeated itself in the second half of 2018. The big question that arises is "What is Zimbabwe’s goal as a nation towards meeting the targets of the current SDGs”

A report by TARSC [28] on problems in the environments for health, noted that while safe water and sanitation infrastructure was present, there was need to monitor functioning and use of these services as this was much poorer. In urban areas unreliable functioning, prolonged cuts leading to use of unsafe alternatives, and in rural areas untreated poor quality water sources undermine health, as do waste disposal in open pits and public sites. Improving access to safe water, sanitation and waste disposal is a widely shared priority across rural and urban areas. Reported urban diarrhoeal disease rates (recall, 2008/9) were generally higher in urban than rural areas indicating the potential for epidemic outbreaks
in more crowded urban areas. The same outbreaks were reported in 2018, with more cases reported in urban areas like Budiriro, Glen View, Kuwadzana suburbs and showing an almost endemic pattern.

4.5 Need for paradigm shift in Zimbabwe’s PHC

Zimbabwe needs to take bold steps to accelerate the re-engineering of its healthcare sector to promote primary health care systems that improve the health status of its population. The traditional legacy of curative and hospital-centric approach to health care is simply unsustainable as doctors and nurses are not enough. Hospitals and clinics cannot be built everywhere hence The PHC route which is cheaper, effective and readily accessible. Health experts say the PHC system is based on disease prevention, promotion of healthy lifestyles and the establishment of a system whereby health care workers work closely with communities, mapping areas, understanding the culture, beliefs and habits of the community, socio-economic status as well as prevalent health conditions through horizontal and not vertical management of patients.

Many health care workers and health care users in Zimbabwe had been socialised in curative and hospital-centric approach. Incorporation of safe and effective approaches into primary health-care systems is advocated for [11]. In 2002, the WHO issued its first comprehensive guidelines to help countries such as Zimbabwe develop policies to regulate traditional medicine. The PHC aims to deliver a more personalised PHC system that provides services closer to home and makes communities healthier. PHC is widely seen as having a part to play in helping reduce acute demand pressure on hospitals by better managing chronic conditions and proactively supporting high need populations. People are increasingly impatient with the inability of health services to deliver levels of national coverage that meet stated demands and changing needs. Needs are rarely met. Most governments would agree that health systems need to respond better and faster to the challenges of a changing world and PHC can be an important tool to do that.

5. CONCLUSIONS

In as much as the PHC approach was declared in good faith to improve the health of the under privileged, there are some major challenges that have hindered the achievement of its goals. These were highlighted as: shortage of experienced health professionals e.g. doctors, nurses, environmental technicians and dieticians. As a result of this shortage, the quality of care being given to patients is compromised. Inadequate public budget failed to sustain the efficient running of the PHC services like essential drugs for most health centres, medical equipment etc. and building health centres facilities within a reasonable distance of 8-10km. The problem of geographical accessibility is still evident in Zimbabwe some countries due to natural population growth and some agrarian reform programmes and lack of transport. When it became a reality that “Health for All” would not be achieved by 2000, world leaders took another proactive step to develop elements of PHC further discussed under ‘Millennium Development Goals (MDGs), highlighting the target(s) set for each goal and the extent to which they had been achieved globally up to 2015. Following the expiration of the MDG era in 2015, came the SDGs that seek to build on the Millennium Development Goals. The 17 Sustainable Development Goals (SDGs) and their 169 targets that seek to realize human rights and to achieve gender equality and empowerment of all women and girls were presented.
The Zimbabwean experience suggests that Primary Health Care transformation can be achieved voluntarily in a pluralistic system of private health care delivery, given strong government and professional leadership working in unionism. It can also be achieved through the adoption of a specific National PHC strategy that is backed by clear service entitlements, with resources effectively applied to community and primary care levels of the healthcare system as an entry point to wider PHC oriented changes.

6. RECOMMENDATIONS

Safe water and sanitation infrastructure was present there is need to monitor functioning and use of these services as this was much poorer. In urban areas unreliable functioning, prolonged cuts leading to use of unsafe alternatives, and in rural areas untreated poor quality water sources undermine health, as do waste disposal in open pits and public sites. Local government earmarked revenue for waste collection should not be reallocated to other spending, and residents should be brought into monitoring waste dumping. The authors of this paper agree with TARSC (2009)’s recommendation that boosting the number of Environmental Health Technicians (EHTs) and supporting them with resources (fuel, materials) to monitor and treat water will help to address the problem. Local government earmarked revenue for waste collection should not be reallocated to other spending, and residents should be brought into monitoring waste dumping. Residents and business can provide initial support with clean up campaigns in urban areas. Routine waste collection and water treatment services and more reliable provisioning need to be improved as a public health priority.

The current social and economic conditions mean that households face challenges in meeting nutritional needs and those vulnerable groups like women and children need to be protected. Services that have high coverage should be located close to communities’ providers of primary care clinic services (central, local government, mission and other private) through budget, resource allocation and incentive mechanisms, monitored by communities, local government and health workers. Furthermore, Central government financing obligations to local government need to be clarified and reliably honoured so that services are not compelled to unfair charges on poor communities in contradiction to national policy.

Financial mechanisms need to be found for allocating, ring-fencing and monitoring the resources for clinics and community health (given that it is currently buried in district budgets and managed at that level) that are acceptable and trusted by funders and communities. Logistics problems such as communication need to be addressed. There are opportunities for innovation: With the advent of new technology, cellphones can be used for emergency or medical communications, passing information, tracking services and reporting outbreaks, update on drug stocks, orders, or through handheld personal digital assistants to communicate data in the health information system. There are opportunities in this for moving away from old paper based health information data flows to less cumbersome electronic forms.

There are gaps and shortfalls undermine PHC. These often relate to resource gaps to primary care services, and people having to travel to further services for care. Clinics need resources to provide adequate quality maternity services for normal deliveries without charge, backed by improved referral and waiting mother facilities at hospitals. Increased health financing and thus improved drug supplies are a priority for health workers and communities and if provided at primary care level would avoid people seeking care from higher level services at significantly greater distances.
National health policies and plans according to the Primary Health Care approach with a view to strengthening health systems need to be put in place where key dimensions of PHC are much less available in urban areas. A clear approach to PHC for urban areas appears to be missing despite the apparent rise in urban population over the last few years due to economic hardships. There is need to develop and implement an effective and appropriate approach to PHC in urban areas, through dialogue with Municipal health services providers, local residents, local authorities and other stakeholders in order to improve access, equity and quality of health services to better meet the health needs of the populations;

Measures like making health a basic right of the people and showing a strong political, social, and economic resolve have led to improved health statistics over the years in many parts of the world. In addition, indigenous "health services" and "practitioners." have been found to be more trusted and accepted by semiliterate and semi-skilled masses. Integration of modern and traditional medicine would help in the spread and acceptance of Primary Health Care and also reduce costs. The approach has been implemented successfully in India, where Ayurvedic practitioners also work at Primary Health Centres performing equally well [29]. With the advent of new technology, another way to achieve a healthy population is through liberal use of information technology apparatus for health education and communication. Mass media and advocacy through television and radio have always been the preferred preventive tools. With spreading information technology, satellite and wireless communications could prove a vital connection between a tertiary care hospital and an inhospitable primary care centre.

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15. Constitution of Zimbabwe Amendment (No. 20) Act, 2013 [Zimbabwe], 22 May 2013, Available at: https://www.refworld.org/docid/51ed090f4.html Accessed 18 December 2018


LOCAL SOLUTIONS FOR LOCAL PROBLEMS: THE BATTLE BETWEEN HERBALISTS AND PHARMACEUTICALS.

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ABSTRACT
Zimbabwe's traditional medical knowledge is gradually eroding. Resuscitating the knowledge is rather difficult since it is housed in the innermost minds of the practitioners who have reservations in documenting their work. Local pharmaceutical laboratories are flooded with exotic concoctions at the expense of home blended medicines to treat local diseases. This study seeks to explore the hidden notions of traditional herbal practitioners who are not publicing their herbs. Participants were drawn from villages in Manicaland. Traditional herbal practitioners give clients herbs and advise. A mixed design approach was used. Most traditional herbal practitioners practice without patents. They have no documents showing that they are registered practitioners. Most herbs used lack common terminology. There is no ownership and originality. The quantities, temperatures and storage mechanisms for the herbs are not known. Basing on these results, it is impossible to fill pharmaceutical industry with indigenously blended medicines. Recommendations are that traditional herbal practitioners should be educated to stock their inventions in pharmacies.

1.1 INTRODUCTION
Like any other country, Zimbabwe uses herbs to cure ailments affecting its people. Though traditional medicines are popular and useful, their documentation is scanty. Traditional medicine has always been at the heart of most African people and in particular the Shona people of Zimbabwe (14). Zimbabweans are divided by two philosophical lines of thinking though there are those who live in between. One of the philosophies is that of western medicines in which patients believe in drugs which would have passed through laboratories. The other philosophy is related to those who believe that traditional medicines are good and have the answer to most of our traditional ailments. The medicines are found within the vicinity of their communities and are cost effective (14).

The term traditional healer is an umbrella concept that encompasses different types of healers with different types of training and expertise. Most of these practitioners should be registered with Zimbabwe National Traditional Healers Association (ZINATHA) though there are some who are not. According to 11, all African regions, traditional healers are very resourceful and play a pivotal role in many spheres of the people's lives since they are ‘medical knowledge storehouses. They are also educators about traditional culture, cosmology and spirituality. (11) add that traditional herbalists
serve as counsellors, social workers and skilled psychotherapists as well as custodians of indigenous knowledge systems.

1.1 Traditional Healing

Before getting into literature related to the study, some important definitions need to be done. One may wonder what a traditional healing is. It is “the sum total of all knowledge and practices, whether explicable or not, used in diagnosing, preventing or eliminating a physical, mental or social disequilibrium and which rely exclusively on past experience and observation handed down from generation to generation, verbally or in writing” and “health practices, approaches, knowledge, and beliefs incorporating plant, animal and mineral based medicines, spiritual therapies, manual techniques and exercise, applied singular or in combination, to treat, diagnose and prevent illnesses or maintain well-being” (11). Traditional healing varies from culture to culture and from region to region in all the African countries.

1.2 Pharmaceuticals

According to (17), a pharmaceutical company, or drug company, is a commercial business licensed to research, develop, market and/or distribute drugs, most commonly in the context of healthcare. Pharmaceuticals can deal in generic and/or brand medications. They are subject to a variety of laws and regulations regarding the patenting, testing and marketing of drugs, particularly prescription drugs.

1.3 Patent

A patent is an exclusive right granted for an invention - a product or process that provides a new way of doing something, or that offers a new technical solution to a problem (10), (12) and (4). In this regard, if herbalists want their medicines to be marketed and get stoked in pharmacies, they need to come up with new inventions and get patents. In order for a traditional herbalist to get a patent, he/she needs to follow procedures.

According to (2), an herbal invention has to satisfy the examiner in many aspects including its novelty, inventive step, industrial applicability and enablement. According to the Guidelines, inventions that are mere discovery, against the rule of nature, not using the rule of nature, or non-technical in character are not considered as inventions.

According to Department of Deeds Companies and Intellectual Rights (4) and 16, in Zimbabwe, for an invention to be patented, it needs to be practically useful, posses new characteristics in the body of knowledge, have an inventive step and its matter must be acceptable as patentable under the national patent law. However, in this (4), there are items which are not patentable and they include scientific theories, mathematical methods, plant or animal varieties, discoveries of natural substances, business methods, methods for medical treatment, frivolous (playful) applications, applications contrary to law (firearms), substances used as food or medicines and defence purpose inventions, secret knowledge, disclosed/lapsed inventions and software. Thus patents are granted after the invention has passed the required test.

According to (10) and (12), one has to acquire a Provisional patent which costs US$80. The provisional patent is mostly for those who plan to exhibit their idea at a show or exhibition forum. It is valid for 6 months, and tangible progress has to be made in 6 months since the protection expires soon after. The second patenting plan is valid for 20 years and it lasts 4 – 6 months (on paper) to acquire at a cost of: application fees – $400, advert fees – $40 and certificate – $80. The Application is the initial process in which thorough description is done expressing the idea's uniqueness. This takes about 4 months to verify to and fro (these variables are more specific to idea). Advert fees are
for the idea to be advertised in order to verify uniqueness and lasts 3 or so months. And lastly, the certificate stage is where the idea is certified as truly yours. The truth is the processing of acquiring the patent is long and tedious.

Literature related to the establishment of ZINATHA and most of its works are found in the capital which is Harare. The capital houses the offices of ZINATHA and most of its clients. According 2, 3 and (14), advertisements on buildings and streets advertise ZINATHA Pharmacy Styles. If the streets and walls of buildings in Harare are advertising works of ZINATHA, is it the same with other towns and rural areas of the country. Do the herbal practitioners in rural areas have the patents to protect their inventions? What knowledge on patents do the herbalists have for stocking their inventions in pharmacies? Do pharmacies accept the inventions of herbalists? All these questions need to be answered in this study

2 OBJECTIVES

Practitioners in small towns and rural areas are not well visible but they are known by patients. Their medicines are not found in the market and local pharmacies. It is against this backdrop that this study was made. It seeks to answer the following questions:

- What are the patentable mechanisms/modalities in place for traditional herbal practitioners to stock their artworks in pharmacies
- What are the perceptions of traditional herbal practitioners towards pharmacies
- What are the challenges faced by traditional herbal practitioners in discharging their duties to the people of Manicaland.
- What could be done to synchronize the relationships between local traditional healers and pharmacies

3.0 METHODOLOGY

The study has its catchment area in Manicaland which is a province in Zimbabwe. Four student teachers doing attachment teaching practice (ATP) in Chipinge district and Honde Valley assisted. These students were picked to participate after exhibiting their knowledge of traditional medical systems in a lecture before ATP deployment. In addition, six herbal practitioners from Chipinge, Mutare and Honde Valley participated. The traditional healers were visited through the assistance of the students. They answered interview questions and were very cooperative. Those in rural areas of Mutare, observations and discussions were done since they were near the town. Also three professionals from pharmacies were chosen to provide an in-depth insight on the relationship between pharmacies and herbal practitioners. In addition the study employed a mixture of quantitative and qualitative research paradigm mostly known as mixed approach paradigm. This was done because quantitative is more reliable; it measures attitudes and behaviours of both the student teachers and the
herbalists and is more objective. In this regard, an observation list and a interview guide were structured to solicit information from the participants.

In addition a qualitative research design was also used in order to have an in-depth exploration of what the participants think, feel or do when they are practising their work. In order to have such information, semi-structured discussions were done with the participants. This therefore means that results of the study cannot be over generalised about the people of Manicaland because it only covers aspects of three districts.

Numbers as well as descriptions interplayed during data presentation. They also complemented each other in data analysis and data interpretation. This was done in order to come up with quality results. All the effort was put to allow for triangulation, to assess and establish the range of social networking cyber crimes, find the impact of the cyber crimes on those offended and suggest ways of helping people not to fall victims. The study presents its data using tables, pictures and descriptions in Microsoft Excel.

The data was collected through face-to-face interview for participants who were illiterate as well as a self-administered format for women who can read and write. The purpose of the study was explained to the patients and those who consented were interviewed. Participants were assured of their confidentiality and given the liberty to opt out of the study at any time while filling the form or being interviewed. A consent form was signed to confirm their willingness to participate in the study. To help minimize social desirability bias, data collectors were extensively trained on the rubrics of data collection process such as not being judgmental, being neutral, and avoiding asking questions that can influence participant response.

4.0 RESEARCH FINDINGS.

This section presents data which was gathered during the study. Pictures were employed for clarity in some areas. Subthemes from the research objectives were formulated and the data is presented using those subthemes.
4.1.1 Demographic data of participants

Table 1 below shows the total number of participants for the study.

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
<th>%</th>
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</thead>
<tbody>
<tr>
<td>Female</td>
<td>6</td>
<td>9</td>
<td>12</td>
<td>100</td>
</tr>
<tr>
<td>%</td>
<td>40</td>
<td>60</td>
<td>100</td>
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</tbody>
</table>

Table 1 above shows total number of people who participated in this study. The study had more females than males for no definite reasons. The people who participated are a composition of four student teachers on ATP, six herbal practitioners, three pharmacy professionals and two patients who visited some of the herbal practitioners.

4.1.2 Mechanisms put in place for herbalist to stock their medicines in pharmacies.

During the progress of the study, a document from the Department of Deeds, Companies and Intellectual Property (DDCIP) was found. The document explains the Intellectual Property Rights as well as Patents among other things. It further gave a list of items which are patentable and those which are not patentable. The following are some of the items which are patentable in the (4): the invention needs to be practically useful to the people, possess novelty - new characteristics in the body of knowledge, have an inventive step and its matter must be acceptable as patentable under the national patent law. If an invention meets the above mentioned qualities, it is therefore deemed patentable.

However, the same (4) has a set of items which are not patentable and they include scientific theories, mathematical methods, plant or animal varieties, discoveries of natural substances, business methods, methods for medical treatment, frivolous (playful) applications, applications contrary to law (firearms), substances used as food or medicines and defence purpose inventions, secret knowledge, disclosed/lapsed inventions and software.

It is very unfortunate that most traditional herbal practitioners' medicines fall under substances used as food or medicines and they are not patentable. (11) and (8) points out that sometimes an animal can be slaughtered and the blood would be poured on the head and foot of the sick person for cleansing purposes. It is very difficult for such a ritual to be documented and then practised in a pharmacy. This is a serious prohibitive section of the country's laws. Traditional healers mostly use their herbs together with sadza, water, porridge or drinks. It then implies that even if they want to apply for patents, the effort is hampered by that section.
The following are DDCIP of Zimbabwe documents on Intellectual Property and Patents.

**Fig 1:** Source: DDCIP 2018

**Patents**

What is a patent?

An official document conferring a sole right/privilege or license to an inventor for a limited period, in Zimbabwe 20 years. The official document is specifically called Letters Patent. It is different from the invention itself.

What is an invention?

"...any new and useful art, whether producing a physical effect or not, process, machine, manufacture or composition of matter which is not obvious or any new and useful improvement thereof which is not obvious, capable of being used or applied in trade or industry and includes an alleged invention"

How to make an application

**FORM OF COMPLETE SPECIFICATION**

- Fully describes the invention and the manner in which it is to be performed.
- Discloses the best mode of performing the invention, the address for services, full postal, residential and business address.
- States that the inventor owns the invention in respect of a particular territory.
- Mentions a convention country, number and date of such application.
- Carries a claim page defining the subject matter for which protection is sought.
- The claim (s) must relate to a single invention, be clear and fairly based on the matter disclosed in the specification.

**What can be patented?**

- Must be useful (practically).
- Must be new—must have some new characteristic which is not known in the body of existing knowledge in its technical field (prior art).
- Must show an inventive step which could not be deduced by a person with average knowledge of the technical field.
- The subject matter must be accepted as patentable under the national patent law.

**What cannot be patented?**

- Scientific theories.
- Mathematical methods.
- Plant or animal varieties.
- Discoveries of natural substances.
- Commercial / business methods (ways of doing business).
- Methods for medical treatment (as opposed to medical products).
- Frivolous applications—those against established natural laws.
- Applications contrary to law e.g. firearms.
- Substances used as food or medicine.
- Defense purpose inventions.
- Secret knowledge.
- Process of human production.
- Disclosed/lapsed inventions.
- Software.

**Fig 2:** A DDCIP of Zimbabwe document on Intellectual Property and Patents.

Source DDCIP 2018
4.1.3 Zimbabwe - Register or Apply for Patent

<table>
<thead>
<tr>
<th>Procedure</th>
<th>[edit]</th>
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<tbody>
<tr>
<td>1. Application for patent registration can be made at the Department of Deeds Companies &amp; Intellectual Property.</td>
<td></td>
</tr>
<tr>
<td>2. Application forms can be obtained from the below office location that are mentioned.</td>
<td></td>
</tr>
<tr>
<td>3. The applicant will be advised to advertise the Patents &amp; Trademarks in a journal for a fee.</td>
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</tr>
<tr>
<td>4. If there is no opposition for filing the patent after three months of advertising then the patent will be filed.</td>
<td></td>
</tr>
<tr>
<td>5. If there are opposition to the filing of the patent then it has to be dealt with and clarified.</td>
<td></td>
</tr>
<tr>
<td>6. Following are some office address locations which can be of help.</td>
<td></td>
</tr>
</tbody>
</table>

**Department of Deeds Companies & Intellectual Property**
Harare Office:
Century House,  
East, 38 Nelson Mandela Avenue,  
Harare.  
Phone: +263 4 777373, 775545-6  
Fax: +263 4 777372

Bulawayo Office
Physical Address:
Tredgold Building  
2nd Floor room 222 Fort  
Steadleopold Takawira Street Bulawayo

Postal Address:
Box 214 Bulawayo  
Contact numbers: 091 61601-2

Fig 3 Adopted from Adapted from ZIPTA, ARIPO & WIPO publications
The above information shows that the government of Zimbabwe has some mechanisms which can be used by herbalists to register their inventions though the process is cumbersome. The long waiting time, the amount of money required, the offices to be visited and all the bureaucratic steps to be taken...
make some of the traditional herbal practitioners to surrender and continue to practice their inventions in their backyards.

4.2 The perceptions of traditional herbal practitioners and pharmacies towards each other.

There has been a battle between traditional healers and pharmacies for a long time. The two seem to be going on very well today but tomorrow it will be a different story (9) and (8). Traditional herbal practitioners claim that at times their work is done at the home of the patient and such rituals are done using living plants or animals. From the discussions done with the pharmacies, such rituals are impossible and cannot be done in their pharmacies, thus to pharmacies that is not a practical invention.

4.2.1 Performance of live rituals.

Traditional healers do not separate the natural from the spiritual, or the physical from the supernatural (11). This will cause them to address health issues from two major perspectives - spiritual and physical. Every traditional healer has their own unique way of dealing with the situation at hand, and thus generalising their processes of healing is completely impossible.

The table 2 shows the rituals done by traditional healers and cannot be done in pharmacies.

<table>
<thead>
<tr>
<th>Rituals</th>
<th>Traditional Healer</th>
<th>Pharmacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spiritual Cleansing</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Spiritual Protection</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

Some of the plants and rituals need to be performed while they are alive or dead. For example, traditional healers may slaughter a cow, a bull, a chicken or may use a living plant for the ritual. Documenting all the processes so that they can be performed in a pharmacy is next to impossible. Pharmacies do not have such capacities. Interviews done with the patients of traditional herbal practitioners show that cleansing rituals were helpful to them. Thus traditional healers perceive pharmacies as having low capacities to carry out all their roles.

On the other hand, pharmacies perceive traditional healers’ medicines as impure and lack uniformity. They claim pharmaceutical practitioners it that the herbs lack documentation, expiry dates, quantities to be used and even proper branding labels. This was seconded by (11) who wrote that differences
exist in the preparations of decoctions and infusions both within healers and from place to place. (7) are of the view that herbal supplements are an attractive alternative to pharmaceuticals; the former actually receives less governmental regulation. Because of the fact that the government put strict regulations on how to run pharmacies and not traditional healers, pharmacies tent to think they are upright when doing their business. That means they encourage patients to think twice before they visit traditional healers. They talk of all the risks and were to report them if they visit the traditional healers especially if they are not registered with ZINATHA. Thus the battle continues.

Furthermore, discussions with pharmacy professionals reveals that most dietary supplements by traditional herbal practitioners are unlicensed, and the traditional herbal practitioners are not required to demonstrate efficacy, safety, or quality. Although herbs are often promoted as natural and therefore harmless, they are not free of adverse effects. Herbal food and medicines are sometimes associated with adverse effects especially when our country is having difficulties in securing clean water and sanitation materials. Risks of taking contaminated medicines are very high given that they are processed at home in at times in open space. This affects of all levels of severity and all age groups who use the medicines.

In addition, pharmacy schools are reluctant to encourage their staff to work hand in groove with herbalists. At the end, graduates from school of pharmacies qualify without herbal knowledge and thus cannot assist patients along herbal lines. However, there are many sources of information such as the Internet. When asking about the use of herbal products and other supplements, a pharmacist should not inadvertently discourage the patient from taking an herbal product or make them feel they have to hide their use. Thus there should be a synergy between a pharmacy and traditional herbal practitioners in for the sake of the patient.

Patients’ perceptions on the use of herbas vary. Those who are deeply into western medicines perceive herbs as satanic and very demonic. Those rooted in African tradition believe that their diviners, those who can speak to their ancestors and then to God, who can then give them the advice on how to heal ailments. Both patients and traditional healers believe that there are certain African ailments which are better treated by African medicines and these include and not limited to epilepsy (phari), dzungu and nhova and even playing around with the womb of a female so that she can give birth to male or female child.

(5) supports the idea by writing that there are African diseases which need to be treated by African herbs and also physical cleansing need to be done. During the interview, one of patients confidently said that dzungu can be healed by herbalists and not in pharmacies. The medicine is not patented and is not in the pharmacy. The traditional
herbal practitioner, who cures dzungu when contacted, was not prepared to give the medicine. That is the problem with African traditional healers. They do not document nor give the name of the herb. They just provide the herb and it is very useful. Thus some patients perceive herbs as very useful and same though some of them are not found in pharmacies.

4.3 Challenges faced by traditional herbal practitioners in discharging their duties to the people of Manicaland.

Some of the traditional herbal practitioners are willing to share their knowledge with the public. The problems arise when their work is stolen through the internet in the name of being advertised in order to get a patent. When interviewed about their challenges, traditional herbal practitioners sighted quite a number of challenges. One of them is this wide spread use of the internet and journals where their works are advertised. They wait for a long time only to be told that their invention is a replication of another invention and therefore is not acceptable. This may end up disheartening them considering the money spent, the effort, the time and the expectations. One traditional herbal practitioner said that it is better to stay and practice their works to local patients than to find their works fully advertised on the internet with someone else claiming ownership.

4.2.1 Lack of Knowledge as a hindrance factor

Furthermore, the study went on to look at various curricula in place for learners which accommodate Intellectual Property Rights and Patents as part of the education to be imparted to learners. It was sadly noted by the study that the curricular for business studies is the only one which imparts knowledge to learners about the subject in question. Most of the learners who do not undertake business studies graduate without that important and crucial knowledge on new inventions. In other words, most traditional herbal practitioners do not have the knowledge on the modalities to register themselves as practitioners as wells as securing patents for their inventions. In short there is lack of knowledge among traditional herbal practitioners.

4.3.2 Financial and time resources as prohibitive factors

Another stumbling block to effectively allow traditional herbal practitioners get patents for their inventions is finance. The amount of money which needs to be pumped out by a traditional herbal practitioner in order to get their invention registered is too much. The amount is in between $600 and $ 1000 and this is not definite since prices for items are changing so much during the time when this presentation was done (4). Most of the traditional herbal practitioners do not earn so much from assisting people. So to raise such an amount is impossible and therefore their products will not be given the opportunity to be advertised and then get the certificate. This does not mean their products are not new useful or not new inventions; it is because they cannot afford to raise the amount needed by the government.

In addition, the traditional herbal practitioners are supposed to wait for close to a year or more while their invention is not yet in use but undergoing certification processes. This time is too
much because traditional healers live with the people in communities, and they apply their medicines whenever there is a patient. (7) supports the notion by adding that the time lag is attributable to bureaucratic differences in how agreements were structured and negotiated at policies on herbal patents. An invention can be patented if the claims presented in the patent application meet the twin criteria of novelty and non-obviousness. Thus bureaucratic measures are killing the herbal industry. The truth is the processing of acquiring the patent is long and tedious.

4.4 Strategies towards harmonisation of the relationship between local traditional healers and pharmacies

The most important issue to consider is the plight of the patient. In Zimbabwe, life has gone high and so costly such that many civil servants and ordinary people cannot afford it. As a result of these hardships, many people are suffering from different ailments. When traditional herbal practitioners were asked about possible solutions which could be employed so that they could put their medicines in pharmacies, they said that the government should come to their rescue by decreasing the requirements for acquiring patents. Already their patients do not pay so much and thus raising the money to get a provisional, apply for the patent, advertise and then get certification is difficult. That is, the government should remove bureaucratic procedures and allow herbals to be sold in pharmacies.

Safe use of herbs should be included as educational efforts to assist patients. Most herbs have no measurements, storage conditions and time frame for use. Both the patients and traditional herbal practitioners should be given education to understand the benefits and dangers of herbs and encourage providers to ask their patients about their use of herbs without being judgmental either from the herbalists or pharmacist to allow open communication.

Pharmaceutical professionals think that a closely monitored curricular should be put in place for all learners to get attached to an herbalist before graduating. This will allow them to have the much needed knowledge when patients visit them. In addition, they think that traditional herbal practitioners lack knowledge to document their artworks. It is for the good of the traditional herbal practitioners to unite and speak with one voice as to the branding of their medicines. (13) echo the same sentiments by writing that one of the most basic problems with the use of herbs is that there is lack of consistent terminology when describing what category herbs fall under. It becomes very difficult for a learner to learn all the names of herbs from different practitioners as the names of their medicines differ from practitioner to and from place to place. So the best is to build a place where they put their inventions and then the pharmacies order from that organisation. The herbalists would then be paid through loyalty.

If the process of registering herbs speeds up and herbs are found in pharmacies, patients will be the happiest people because getting western and local herbs will be under one roof. Pharmacies are nearer to patients in towns than going to the herbalists in rural areas.
In addition, registering and getting patents reduces vulnerability of herbal practitioners. Traditional herbal practitioners are taken to task if ever a patient dies at their homes or after using their medicines. This will be a huge achievement for them. There will be no more game of blaming each other between herbalists and patients.

Traditional herbal practitioners think that the internet is robbing them their inventions in broad daylight. They are suggesting that there be transparency in the processing of patents. It is very difficult to accept and believe if an herbal practitioner is told that their inventions already exist. Because of their lack of knowledge, putting all the details for their inventions down proves to be a mammoth task. The common language for writing the steps is English and therefore old people in the herbal industry cannot read and write. Steps should be put to assist old people document their inventions using vernacular language.

Another suggestion by 100% of the participants is that both herbalists and pharmacies should cherish the heritage of their own country. If pharmacies accept indigenous herbs, cultural heritage is preserved from being lost future generations to see. Studies show that indigenous knowledge about herbal medicines is continuously getting lost through factors such as acculturation (blending of cultures) and biodiversity (variations among living things). Documenting of local herbs assists in furthering studies and discovering of more medicines for various ailments.

Strategies for the safe use of herbs should include educational efforts directed at both the consumers and healthcare providers about the benefits and dangers of herbs and encouraging providers to ask their patients about their use of herbs without being judgmental, ensuring open communication with patients.

Picture 1 below shows an aloe with different terminology among the study's participants. One herbalist refers to it as gavakava, the other said it is called teu and the last said its chikohwa. The uses of the aloe also differ from place to place. It can be used to treat wounds, treat male sexually transmitted diseases while others use it to treat chicken ailments.
Discussion of findings

The study made some discoveries which need to be mentioned. The first discovery is that there are documents made by the Zimbabwe government through the Department of Deeps, Companies and Intellectual Property to cater for new inventions. It was also discovered that the document has list of items which cannot be patented. One of the prohibited items is food and medicines. This becomes a prohibiting legislative since most of herbs are food and medicine related. Therefore, herbalists cannot make any inventions.

Apart from the above point, the study discovered that the procedures and finances needed for a traditional herbal practitioner to have a patent are not within their reach. Financial costs to get a patent cost in between $600 - $1000 at the time when this study was carried. This money cannot be raised considering the hardships currently being experienced by most Zimbabweans. In addition the amount of time is a year or more waiting for the certificate for a patent to be issued. Again this waiting time is too long because most traditional herbal practitioners will start using the herbs without approval. This is therefore very dangerous because practising without a patent; the protection is not guaranteed to the practitioner.

Another discovery is that the majority of the herbalists have little knowledge to document their inventions. They think that it is a waste of time considering the meagre money they get from their patients.

The education curricular of Zimbabwe does not impart knowledge about intellecction property rights and patents to all learners except for those doing business studies. That stage is a bit late because many inventions are done along the way before they start businesses.
The curricular for pharmacies also does not include possibilities for trainees to get attached to herbalists so that when they come of age they will be able to assist all patients. Pharmacies are also calling for collective terminology to the herbs used by traditional healers as these differ so much from traditional herbal practitioners to the other. Collective terminology will assist during branding and distribution.

Traditional herbal practitioners believe that African ailments are best treated using local solutions and among the solutions, the traditional healer needs to attend to a patient physically and spiritually. This therefore means that some of the rituals need to be done physically or spiritually on the patient and cannot be done in a pharmacy.

Lastly, for the good of the country's culture and heritage, traditional herbal practitioners and pharmaceutical institutions should harmonise their relationships. This will go a long way in assisting the patient by providing convenience whenever one needs medical attention using the western or African philosophies.

5 Conclusion

After going through all the observations, discussions and interviews with the participants the following conclusions were made.

- There are mechanisms put in place by the government through the Department of Deeds and Companies Intellectual Property to assists new inventors register for patents.
- The mechanisms in place have high demands such as money, time and effort before an invention is registered and therefore the traditional herbal practitioners cannot afford them.
- There are possibilities of an herbalist losing their inventions through electronic means while waiting for patent to be approved and therefore traditional herbal practitioners have lost confidence in the process.
- Herbal patients believe that there are ailments which cannot be cured using pharmacy medicines which means local ailments can be cured by local herbs.
- Traditional herbal practitioners believe that there are African ailments such as spiritual cleansing and spiritual protection. Such activities cannot be documented nor can they be carried out in pharmacies during the absence of the traditional healer as the processes vary from herbalist to herbalist.
- Pharmaceutical institutions think that their medicines are more superior to that of herbalist which is the main problem hindering the coming together of the industries to preserve the knowledge and culture of the country.
- All traditional healers in the country should have same branding of their inventions so that pharmacies will not have difficulties in studying, stocking and selling the products.
5 Recommendations

The study made some recommendations which are as follows:

• Efforts should be put in place to reduce the amount of time and money needed by herbalists to register and get patents for their inventions.
• There are certain problems/ailments which cannot be solved in pharmacies and therefore they are performed at the herbalist or patient's homesteads.
• The education curricular should include and avail content on intellectual property rights and patents to all learners starting from primary education.
• The government should come up with one organisation where traditional herbal practitioners put their artworks for branding and distribution to pharmacies for conformity as well as uniformity.
• Formalised herbal practice will assist practitioners if some of their patients die so that the relatives of the deceased will not held them responsible for killing their relatives.

References

5. Ethonobiol, E. (2015). Medical plants used to treat the most frequent diseases encountered in Amba. Accesses [13/10/2018]
DIETARY ADEQUACY OF MENUS SERVED IN FIVE VOCATIONAL TRAINING COLLEGES IN MATABELELAND SOUTH PROVINCE IN ZIMBABWE

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ABSTRACT
A considerable number of youths in Zimbabwe are in vocational institutes and a considerable number are boarders in those institutes. Adequate diet is vital during this stage because youths require fuel to perform physical and cognitive functions. The purpose of this study was to evaluate the adequacy of meals served to boarding students at five vocational institutes in Matabeleland South in Zimbabwe.

Menus for five Vocational Training Colleges (VTC) were used to assess food variety score (FVS) and dietary diversity score (DDS). The FVS was calculated by counting the number of food items consumed in a week in each VTC. The DDS was estimated by classifying these food items into nine food groups namely starchy staples, whole grains, legumes, dairy, meats (beef, poultry, fish, eggs), vegetables, fruits, oils/fats/butter and sugary foods. A questionnaire and an interview were also used to assess factors related to food production management.

The age of students ranged from 16 to 40 years. Findings from this study indicated that the highest number of food items consumed by this group of students according to the menu was fifteen. A mean FVS of 14 ± 1.41 (range12 to 15) was obtained. This indicated low FVS and the standard deviation showed that there was heterogeneity in the menus served. The VCT with the least FVS (12) served two meals a day; tea break and lunch. Food items consumed frequently (> 4 times a week) by all of the colleges included sadza, porridge, bread, rice and tea. Foods consumed 2 to 3 times a week included, beef, beans, and cabbage. Foods that were less frequently (< 2 times a week) consumed were fish, choumolia, soy chunks, coleslaw salad and dairy products.

Food groups that were served more often were starchy staples (M = 13, SD = 7.31) followed by sugary foods (M = 12.6 SD = 3.13) and then fat foods (M = 7.8, SD = 3.49). The food group which followed were meats (M = 5.2, SD = 1.09). The next highest to meats were vegetables (M = 3.6, SD = 1.14). Legumes like vegetables were served less frequently (M = 3.00, SD = 1.2). Fruits and wholegrains were not served in all VCTs.

The interview revealed that two colleges had agro-based projects while three did not have.
FVS and DDS were low. The typical diets of the college students had high energy-based foods and animal protein. Fruits and whole grains were not served at all. Agro based projects were limited. Promotion of agro-based projects is necessary in order to improve diet of students.

KEY WORDS: Vocational College Students, Menus, Food Variety Score, Dietary Diversity Score

INTRODUCTION

The dietary habits of populations (including young adults) in low-to-middle income countries have rapidly shifted to less-healthy diets consisting of processed foods, away-from-home food intake, and increased use of edible oils and sugar-sweetened beverages in line with the global nutrition transition. (1) These patterns of change in dietary intake related to the global nutrition transition are particularly important in the context of current theories of the developmental origins of adult disease. (2)

These shifts in diets are a risk factor for the development of overweight/obesity and its associated morbidities. They contribute to the occurrence of a group of disorders known as the metabolic syndrome which include abdominal obesity, hypertension, dyslipidemia, and disturbed metabolism of glucose or insulin (3). The metabolic syndrome increases the risk of developing non communicable diseases (NCDs) such as cardiovascular diseases, diabetes, chronic respiratory diseases, and cancer (3, 4).

Yet unhealthy diets are a key modifiable behavioral risk factor for non-communicable diseases (NCDs). In recent years, the global pattern of unhealthy diets driving the occurrence of metabolic disorders and NCDs has become more important in low-to-middle income countries because of the double burden of diseases in such countries. In these countries infectious and NCDs now jointly constitute major causes of morbidity and mortality (4).

Studies among university students in developing countries have previously shown high prevalence of obesity. For example in South Western Nigeria, previous research revealed that Consumption of meat, milk, and fruits and vegetable was low, and in the same study, Weight classification by body mass index (BMI) indicated that 29% of the students were overweight, 6% were obese, and 13% of the male students were underweight (5). Sixty percent of university undergraduates consumed the recommended minimum number of servings of grain foods while 60%, 85%, and 40% of students did not meet the recommended dietary allowance (RDA) for protein, calcium, and iron respectively (5).

In Zimbabwe a study in 2013 by Manwa regarding students’ dietary patterns of University of Zimbabwe, presented similar results with the study in Nigeria (6). This study revealed that diets of students lacked variety. Data obtained from the clinic showed that 90% of all the students who visited the clinic had clinical signs of malnutrition of more than five nutrients while 10% had malnutrition of less than five nutrients.

Many college or University students are in the youth stage. Youth stage is a period of rapid growth and development and is a period of transition from adolescent to adulthood. The rate of growth in youths increases the demand for nutrients (7).

Experts recommended that nutrition of youths should be adequate because youths are reported to be sensitive to inadequate nutrition (8). Nutritional adequacy means that, sufficient intake of essential nutrients to fulfill
requirements for optimal health (9). Adequate nutrition is vital during the stage of youths because they require fuel to perform physical and metabolic functions. Nutrition also influences a youth’s cognitive development and lifelong skills performance. Many studies have demonstrated the positive effects of adequate nutrition on cognitive function and college performance (10). Nutritionally adequate diets can also delay and prevent the development of non-communicable diseases.

Fulfilment of a high-quality diet is particularly difficult among poor populations in low-income countries where diets are dominated by starchy staple foods, and nutrient-dense animal source foods. Fruits and vegetables are often unavailable or unaffordable (11).

Dietary diversity (DD), the number of foods or food groups consumed, is a key dimension of dietary quality, with diverse diets increasing the likelihood of adequate intake of essential nutrients (12). It has been established that DD can be used as an indicator of micronutrient adequacy of diet (13, 14). This indicates that in order to meet nutritional requirements diets should be varied.

The Central Statistics of Zimbabwe (15) in 2010 revealed that there were about 283,931 youths in vocational training colleges (VCT). VCTs in Zimbabwe train students in lifelong skills such as carpentry, hospitality and tourism, engineering and construction. According to the Ministry of Youth, Indigenisation and Economic Empowerment there are about 42 VCTS in Zimbabwe and 5 of them are found in Matabeleland South Province. Matabeleland South Province of Zimbabwe is located in Natural Regions VI and V. Region VI and V are characterised by very low and erratic rainfall (< 650 mm per year). Meals for students are provided at the institutes through government voted funds (16).

The funding is included in the government budget plan according to the enrolment of each VCT (17). The centre meals in VCTs are supplemented by Agricultural based projects, (Agro Projects) that is done as entrepreneurship skills development course to alleviate hunger in vocational training centres.

Majority of college students eat at college dining facilities with limited healthy food options. On campus students, in particular, use college dining facilities to eat meals. If students do not attain adequate nutrition daily, a decrease in academic or physical performance can result. Establishing good eating habits during this time is critical, because these behaviours often continue through adulthood and can be very difficult to change once they are established.

Although dietary patterns and nutritional status of youths in some Universities/colleges in Zimbabwe have been studied information on the dietary quality of meals served to youths in universities/colleges is scarce in Zimbabwe. In addition the population of students in these studies were not sufficiently representative of the Zimbabwean young adult population. This study aimed at assessing the menus of the five VCTs. This assessment is important because it will help tailor college specific dietary interventions.
OBJECTIVES

The objectives of this study were to assess nutrition adequacy of diets served to students in the five VCTs in Matabeleland South Province. The study also assessed factors that have an influence on the provision of the diet by the colleges.

METHODS

A mixed method approach was used to collect and analyse data. Quantitative methods were used for calculating Food variety and dietary diversity scores (FVS and DDS respectively). FVS was calculated by counting the number of different food items eaten during the weekly menu. DDS was defined as the number of food groups consumed weekly. The DDS included nine groups: starchy staples (bread, sadza, rice), whole grains, Legumes (beans, soy chunks), dairy (lacto, fresh milk), meats (beef, poultry, fish, eggs), Vegetables (choumolier, cabbage coleslaw), fruits, oils/fats/butter and sugary foods (tea, porridge).

Qualitative orientation was used to interviewing key informants so as to collect more information about factors influencing offering of meals to students. Five VCTs from Matabeleland South were conveniently chosen to participate in this research. VCTs have been encouraged to use locally available commodities or ingredients for diet of student’s meals from Agro-based projects namely market gardening and animal husbandry.

Meal planners were the key informants. In each institution one person who is in charge was interviewed in the presence of the Principal for the institute who authenticated the data and interview proceedings. The interview guide was used to solicit information from the clients. The interviewer took down responses as he conducted the interview.

Permission to conduct the study was initially obtained from the principals of the colleges. Once permission was granted informed consent was later obtained from the meal planners of the colleges. The meal planners agreed to give their menus to the researchers to be evaluated. The names of the colleges were kept confidential and hence pseudonyms A, B, C, D, and E were used instead. The menus for the five VTCs are shown in table 1 to table 5.

Table 1: Menu for Vocational College A

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Sun</td>
<td>Buttered porridge</td>
<td>Tea &amp; bread</td>
<td>Sadza &amp; cabbage</td>
<td>Rice &amp; chicken</td>
</tr>
<tr>
<td>Mon</td>
<td>Buttered porridge</td>
<td>Tea &amp; buttered bread</td>
<td>Sadza &amp; beef stew</td>
<td>Sadza &amp; soya chunks</td>
</tr>
<tr>
<td>-----</td>
<td>-------------------------</td>
<td>-----------------------------</td>
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<td>------------------------</td>
</tr>
<tr>
<td>Sun</td>
<td>Sour porridge</td>
<td>Buttered Bread &amp; Tea</td>
<td>Sadza &amp; Roast Beef</td>
<td>Sadza &amp; Beans</td>
</tr>
<tr>
<td>Mon</td>
<td>Sour porridge</td>
<td>Buttered Bread &amp; tea</td>
<td>Sadza Beef &amp; Cabbage</td>
<td>Sadza &amp; Green Vegetables</td>
</tr>
<tr>
<td>Tues</td>
<td>Sour porridge</td>
<td>Rice and Tea</td>
<td>Sadza &amp; Lacto</td>
<td>Sadza &amp; Beef Stew</td>
</tr>
<tr>
<td>Wed</td>
<td>Sour porridge</td>
<td>Buttered Bread &amp; tea</td>
<td>Sadza &amp; Beans</td>
<td>Sadza &amp; Beans</td>
</tr>
<tr>
<td>Thur</td>
<td>Sour porridge</td>
<td>Rice and Tea</td>
<td>Sadza &amp; Chaumollia</td>
<td>Sadza &amp; Mackerel</td>
</tr>
<tr>
<td>Frid</td>
<td>Sour Porridge</td>
<td>Rice and Tea</td>
<td>Rice &amp; Coleslaw</td>
<td>Sadza &amp; beans</td>
</tr>
<tr>
<td>Sat</td>
<td>Sour porridge</td>
<td>Buttered Bead &amp; tea</td>
<td>Sadza &amp; Lacto</td>
<td>Sadza &amp; Roast Beef</td>
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</table>

Table 2: Menu for Vocational College B
Table 3: Menu for Vocational College C

<table>
<thead>
<tr>
<th>Day</th>
<th>Breakfast 0700 -0730hrs</th>
<th>Tea Breakfast 1000 - 1030 hrs.</th>
<th>Lunch 1300 – 1400hrs</th>
<th>Supper 1800 - 1900 hrs.</th>
</tr>
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<tbody>
<tr>
<td>Sun</td>
<td>Buttered porridge</td>
<td>Tea &amp; bread buttered</td>
<td>Rice and chicken &amp; coleslaw</td>
<td>Sadza &amp; chaomolia/ rape</td>
</tr>
<tr>
<td>Mon</td>
<td>Buttered porridge</td>
<td>Tea &amp; buttered bread</td>
<td>Sadza &amp; beans</td>
<td>Sadza &amp; beef stew</td>
</tr>
<tr>
<td>Tues</td>
<td>Buttered porridge</td>
<td>Tea &amp; Rice</td>
<td>Sadza &amp; soya chunks</td>
<td>Rice &amp; mackerel</td>
</tr>
<tr>
<td>Wed</td>
<td>Buttered porridge</td>
<td>Tea &amp; buttered bread</td>
<td>Sadza &amp; beef stew</td>
<td>Sadza &amp; chicken</td>
</tr>
<tr>
<td>Thur</td>
<td>Buttered porridge</td>
<td>Tea &amp; rice</td>
<td>Sadza &amp; lacto</td>
<td>Sadza &amp; beans</td>
</tr>
<tr>
<td>Fri</td>
<td>Buttered porridge</td>
<td>Tea &amp; buttered bread</td>
<td>Rice &amp; beans</td>
<td>Sadza &amp; cabbage</td>
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</tbody>
</table>

Table 4: Menu for Vocational College D

<table>
<thead>
<tr>
<th>DAY</th>
<th>Breakfast 0700 -0730hrs</th>
<th>Tea Breakfast 1000 – 1030 hrs.</th>
<th>Lunch 1300 – 1400hrs</th>
<th>Supper 1800 - 1900 hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun</td>
<td>_</td>
<td>Buttered bread &amp; Tea</td>
<td>Sadza &amp; Beef Stew</td>
<td>_</td>
</tr>
<tr>
<td>Mon</td>
<td>_</td>
<td>Buttered bread &amp; tea</td>
<td>Sadza &amp; Cabbage</td>
<td>_</td>
</tr>
<tr>
<td>Tues</td>
<td>_</td>
<td>Rice and Tea</td>
<td>Sadza &amp; Beans</td>
<td>_</td>
</tr>
<tr>
<td>Wed</td>
<td>_</td>
<td>Buttered bread &amp; tea</td>
<td>Rice Chicken &amp; Coleslaw</td>
<td>_</td>
</tr>
<tr>
<td>Thur</td>
<td>_</td>
<td>Rice and Tea</td>
<td>Sadza &amp; Lacto</td>
<td>_</td>
</tr>
<tr>
<td>Fri</td>
<td>_</td>
<td>Rice and Tea</td>
<td>Sadza &amp; mackerel</td>
<td>_</td>
</tr>
<tr>
<td>Day</td>
<td>Breakfast</td>
<td>Tea Breakfast</td>
<td>Lunch</td>
<td>Supper</td>
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</tr>
<tr>
<td></td>
<td>0700 -0730hrs</td>
<td>1000 – 1030 hrs.</td>
<td>1300 – 1400hrs</td>
<td>1800 - 1900 hrs.</td>
</tr>
<tr>
<td>Sat</td>
<td>_</td>
<td>Buttered bread &amp; tea</td>
<td>Sadza &amp; Beef Stew</td>
<td>_</td>
</tr>
<tr>
<td>Sun</td>
<td>Buttered porridge</td>
<td>Buttered bread &amp; Tea</td>
<td>Sadza and beef stew</td>
<td>Sadza &amp; green vegetables</td>
</tr>
<tr>
<td>Mon</td>
<td>Buttered porridge</td>
<td>Buttered bread &amp; tea</td>
<td>Sadza &amp; Sour Milk</td>
<td>Sadza &amp; curried Beans</td>
</tr>
<tr>
<td>Tues</td>
<td>Buttered porridge</td>
<td>Rice and Tea</td>
<td>Sadza Soy Chunks</td>
<td>Sadza &amp; grilled Fish</td>
</tr>
<tr>
<td>Wed</td>
<td>Buttered porridge</td>
<td>Buttered bread &amp; tea</td>
<td>Rice Chicken &amp; Coleslaw Salad</td>
<td>Sadza &amp; Cabbage</td>
</tr>
<tr>
<td>Thur</td>
<td>Buttered porridge</td>
<td>Rice and Tea</td>
<td>Sadza &amp; Mixed Vegetables</td>
<td>Sadza &amp; Beef Stew</td>
</tr>
<tr>
<td>Frid</td>
<td>Buttered porridge</td>
<td>Rice and Tea</td>
<td>Sadza &amp; sour Milk / Lacto</td>
<td>Sadza &amp; Curried Beans</td>
</tr>
</tbody>
</table>
RESULTS

The following section will provide results for FVS and DDS for the five colleges. Findings from this study indicated that the highest number of food items consumed by this group of students according to the menu was fifteen. See table 6. A mean FVS of $14 \pm 1.41$ (range 12 to 15) was obtained. This indicated low FVS and the standard deviation showed that there was heterogeneity in the menus served. The VCT with the least FVS (12) served two meals a day: tea break and lunch. Food items consumed frequently (> 4 times a week) by all of the colleges included sadza, porridge, bread, rice and tea. Further descriptive analysis on items consumed revealed that foods consumed 2 to 3 times a week included, beef, beans, and cabbage. Foods that were less frequently (< 2 times a week) consumed were fish, choumolia, soy chunks, coleslaw salad and dairy products. Wholegrains and fruits and fruit juices were not served by all VCTs.

Table 6: Food variety scores of five Vocational Training Colleges (A, B, C, D, E)

<table>
<thead>
<tr>
<th>Vocational Training Colleges</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of Food</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Butter</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Porridge</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Tea</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Bread</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Sadza</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Cabbage</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Rice</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Chicken</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Beef</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Fish</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Chaumolia</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Soy chunks</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Fruit and fruit juices</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Whole grain</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Coleslaw</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Beans</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Dairy</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total FVS</td>
<td>15</td>
<td>13</td>
<td>15</td>
<td>12</td>
<td>15</td>
</tr>
</tbody>
</table>
Table 7: Weekly Food variety score of each food item served weekly in each VCT

<table>
<thead>
<tr>
<th>Vocational Training Colleges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food items</td>
</tr>
<tr>
<td>-------------</td>
</tr>
<tr>
<td>Butter</td>
</tr>
<tr>
<td>Porridge</td>
</tr>
<tr>
<td>Tea</td>
</tr>
<tr>
<td>Bread</td>
</tr>
<tr>
<td>Sadza</td>
</tr>
<tr>
<td>Cabbage</td>
</tr>
<tr>
<td>Rice</td>
</tr>
<tr>
<td>Chicken</td>
</tr>
<tr>
<td>Beef</td>
</tr>
<tr>
<td>Fish</td>
</tr>
<tr>
<td>Choumolia</td>
</tr>
<tr>
<td>Soya chunks</td>
</tr>
<tr>
<td>Fruit and fruit juices</td>
</tr>
<tr>
<td>Wholegrain</td>
</tr>
<tr>
<td>Coleslaw</td>
</tr>
<tr>
<td>Beans</td>
</tr>
<tr>
<td>Dairy</td>
</tr>
</tbody>
</table>

The classification of foods by DDS is shown in table 8. From the table it is shown that the food groups that were served more often were starchy staples (M = 23, SD = 7.31) followed by sugary foods (M = 12.6 SD = 3.13) and then fat foods (M = 7.8, SD = 3.49). The range for these food groups was 11 to 28, 7 to 14 and 4 to 10 respectively. The food group which followed were meats (M = 5.2, SD = 1.09), and the range was 4 to 7. The next highest to meats were vegetables (M = 3.6, SD = 1.14). The range was between 2 and 5. Legumes like vegetables were served less frequently (M = 3, SD = 1.2). Fruits and wholegrains were not served in all VCTs.
Table 8: Dietary diversity scores for the five Vocational Training Colleges and number of times served weekly

<table>
<thead>
<tr>
<th>Vocational Training Colleges</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>Mean± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starchy staples (bread, sadza, rice)</td>
<td>28</td>
<td>27</td>
<td>28</td>
<td>11</td>
<td>21</td>
<td>23±7.31</td>
</tr>
<tr>
<td>Whole grains</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0±0</td>
</tr>
<tr>
<td>Legumes (beans, soy chunks)</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>3±1.2</td>
</tr>
<tr>
<td>Dairy (lacto, fresh milk)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1±0</td>
</tr>
<tr>
<td>Meats (beef, poultry, fish, eggs)</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>5.2±1.09</td>
</tr>
<tr>
<td>Vegetables (choumolier, cabbage coleslaw)</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>5</td>
<td>3.6±1.14</td>
</tr>
<tr>
<td>Fruits,</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0±0</td>
</tr>
<tr>
<td>Oils/fats/butter</td>
<td>10</td>
<td>4</td>
<td>11</td>
<td>4</td>
<td>10</td>
<td>7.8±3.49</td>
</tr>
<tr>
<td>Sugary foods (tea, porridge)</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>7</td>
<td>14</td>
<td>12.6±3.13</td>
</tr>
</tbody>
</table>

The key informant interview revealed that the distance between the colleges and major suppliers of foods ranged between 20 km and 100km. Four of the colleges did not have adequate dry ingredient and cold storage facilities. With regards vehicles two colleges owned vehicles and the other three relied on hiring vehicles to go and purchase food. The colleges did not have meal planners with nutrition qualifications.

DISCUSSIONS

Low FVS and DDS in these colleges is a cause of concern because this could lead to micronutrient deficiencies. This finding is consistent with those of other studies among university students in South Western Nigeria and Zimbabwe (6, 7)

Reduced fibre intake in the diet of these students that emerged from these findings is similar to results elsewhere. For instance studies among university and college students in Saudi Arabia, United States and Nigeria found that whole grains were rarely eaten and as such college students failed to satisfy whole-grain recommendations. Whole grains, fruits and vegetables are some of the recommended sources of fibre (18). The set daily value of fibre is at 25 grams per day and in this pattern of eating this target cannot be met (18). Fibre has numerous health benefits. It has a protective effect against weight gain in adults. In addition to helping with weight maintenance, fibre is associated with a reduced risk for developing cardiovascular disease and type II diabetes (18).

Furthermore insufficient intake of fruits and vegetables, which are major sources of vitamins, minerals, and phytochemicals (19) may lead to micronutrient deficiencies. The consumption pattern of fruits and vegetables in this study is poorer than obtained in other universities in South Western Nigeria. In Nigeria it was reported that 40% of females and 20% of males ate adequate amounts of fruits and vegetables. (6, 20). However the results in VCTs in Matabeleland South corroborated the findings in Cameroun undergraduates wherein consumption of fruits and vegetables was very low (21). Inadequate consumption of this group of
foods in particular fruits may be explained by inadequate cold storage, lack of vehicles as well as lack of agro-based projects in some VCTs. As revealed by the interview in this study only two out of five VCTs had agro based projects.

This group of students is at risk of micronutrient deficiencies and cardiovascular diseases in the future. According to Layede and Adeoye vitamins and minerals are protective against chronic diseases and most specifically coronary heart diseases in particular potassium. (18). It is because of these numerous benefits that fruits and vegetables have been included in dietary guidelines of many countries. (22).

CONCLUSION

FVS and DDS were very low in Matabeleland South VCTs. Consumption of starchy staples, tea and fatty foods was high while consumption of vegetables was very low. Wholegrains and fruits were not served at all. Forty percent of the VCTs had agro based projects.

RECOMMENDATIONS

Colleges should establish agro-based projects so as to increase FVS and DDS in particular the intake of fruits, vegetables and dairy products. Ministry of Higher and Tertiary education should establish standards for controlling and monitoring the diet of VCTs. Such studies should be conducted periodically to avoid the effects of low FVS and DDS in tertiary education institutions.

REFERENCES


KNOWLEDGE, ATTITUDES, AND PRACTICES CONCERNING BIOLOGICAL HAZARDS AMONG HEALTH CARE WORKERS. A CASE STUDY OF HARARE CENTRAL HOSPITAL.

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Abstract

The study assessed knowledge, attitudes, and practices concerning biological hazards among health care workers at Harare Hospital. A mixed methods approach was used in which the study was descriptive, quantitative and backed with a qualitative aspect. Questionnaires were completely filled by 16 doctors, 94 nurses, and 6 nurse aides. Seven experts were enrolled for interviews using purposive sampling and three focus groups were conducted, each focus group comprised of seven members. According to the study, the arrangement of infection control workshops was poor, only 4% of respondents always attend infection control workshops. Health care workers were not being vaccinated against hepatitis B upon employment; only 14% of the respondents were fully vaccinated against hepatitis B. About 90% of the respondents confessed that personal protective clothing was not always available. Though respondents confessed having adherence to hand washing, there are shortages of running water, which need to be addressed.

1: Background

Globally, the healthcare workforce represents 12 percent of the working population (1). Health care workers are exposed to blood and body fluids in healthcare facilities, which constitutes a significant risk of transmission of HIV and other blood borne pathogens.

According to a survey done in 2012 in three hospitals and two clinics in Zambia, nurses reported the largest number of injuries (2). On average the annual sharps injury rate was 1.3 injuries per worker, and service workers (housekeepers, laundry, ward assistants) had the highest rate of these injuries, 1.9 per year. Injuries were mostly related to improper disposal methods. Needle stick injuries accounted for the largest proportion of injuries (60%), and 15% of these injuries were related to procedures with a higher-than-average risk for infection. Although workers (88%) reported the availability of post
exposure prophylaxis, the services were not being fully utilized. According to the same study, only 8 percent were fully vaccinated against hepatitis B, this shows that a greater number of health workers are at a high risk of contracting hepatitis B.

A study that was done at Bindura provincial hospital revealed that there was poor utilization of the infection control manual, as 42% of the nurses did not utilise the manual, either they did not know about it (24%) or it was not available (18%). According to the same study infection control workshops were poorly organised, 68% of the participants did not attend any infection control workshop (3). This shows that there is lack of opportunity for the majority of healthcare workers in Zimbabwe to acquire knowledge on prevention and control of biological hazards after their basic training.

Health care workers are highly exposed especially to biological hazards. In the medical wards, nurses look after patients with highly infectious diseases, such as tuberculosis, hepatitis B, and community-acquired pneumonia. There is little training when it comes to issues of safety among health care workers at Harare hospital. There is scarcity of personal protective equipment such as gloves and facemasks for execution of duties safely. The shortage of running water has led to poor hygienic practices, further exposing health care workers to diarrheal diseases. The effects of occupational injuries and diseases among health care workers include economic loss, physical loss and psychological loss such as depression and stress. All these have a negative impact on the workers, their families, and the nation at large. At least three nurses sustain needle stick injuries per month and only a few accept to be tested for HIV at the hospital clinic. About twelve nurses have tested TB positive in 2017 and most of them work in the medical wards (Harare hospital infection control records 2017). About fifteen junior doctors reported to have encountered a needle stick injury or a blood splash in 2016 (Harare hospital staff clinic register 2016). Upon employment, nurses are not receiving vaccination against hepatitis B. Data on biological hazards among health care workers and their mitigation measures remain scarce in most countries in sub-Saharan Africa and Zimbabwe in particular. Hence, there is need for understanding of biological hazards among healthcare workers to inform occupational safety and health policy and programs for healthcare workers.

2: Objectives

2.1 General objective

To assess knowledge, attitudes and practices concerning biological hazards among health care workers at Harare Hospital

2.2 Specific objectives

To establish biological hazards faced by health care workers at Harare Hospital

To assess the level of knowledge on biological hazards among health care workers at Harare hospital.
To analyze the attitude of health care workers at Harare hospital in terms of minimization of biological hazards’ exposure.

To evaluate the practices that are in place to protect health care workers from biological hazards.

3: Methodology

A mixed methods approach was used in which the study was descriptive, quantitative and backed with a qualitative method. This design enabled use of various research instruments such as questionnaires, interviews, and focus group discussions in the study.

In this study, the researcher targeted clinical staff. There are 80 nurse aides, 1100 nurses, and 216 doctors at the hospital. The selection of the study population was influenced by the fact that all clinical staff was affected by biological hazards.

A sample of 140 was drawn with the use of probability-sampling method to distribute questionnaires. Non-probability sampling method was used to select interview and focus group participants.

Permission to do the research was granted by the research and ethics committee at Harare central hospital.

4: Results

4.1 Socio economic demographic data

As shown in table 4.1, a total of one hundred and forty questionnaires were distributed at Harare central hospital and 116 were returned while 24 were not returned which was 83% of the distributed questionnaires. The highest response rate was from the nurses, which is 85%, followed by doctors who had 80% response rate. Nurse aides had the lowest response rate, 60% managed to return completely filled questionnaires.
Table 4.1 Questionnaire response

<table>
<thead>
<tr>
<th></th>
<th>N denotes number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Doctors</td>
</tr>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td>Number of</td>
<td>20</td>
</tr>
<tr>
<td>questionnaires</td>
<td></td>
</tr>
<tr>
<td>distributed</td>
<td></td>
</tr>
<tr>
<td>Number of</td>
<td>16</td>
</tr>
<tr>
<td>completed</td>
<td></td>
</tr>
<tr>
<td>questionnaires</td>
<td></td>
</tr>
</tbody>
</table>

The majority of the participants were female (69%) compared to their male counterparts (31%). More females than males represented nurses and they had the highest proportion of representation compared to other professions. The majority of the respondents (57%), were in the age group 30 – 39 years followed by age group 20 – 29 years old (32%) and age group 40 – 49 years (9%), lastly, only 2% were in the 50-59 years category. In terms of marital status, majority of participants (57%) were married. Most of the respondents (40%) had the minimum experience, which is 0-2 years experience. The highest level of experience among respondents was 11-15 years and only 5% of respondents were in that category. Majority of the doctors (80%) had the least experience, that is, 0-2 years. Majority of the respondents (60%) were not trained in infection control.

Table 4.2 Demographic characteristics of health care workers

<table>
<thead>
<tr>
<th>Demographic Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristics n=140</td>
</tr>
<tr>
<td>Total</td>
</tr>
<tr>
<td>Male</td>
</tr>
<tr>
<td>Female</td>
</tr>
<tr>
<td>%</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>1. Gender</td>
</tr>
<tr>
<td>2. Age</td>
</tr>
<tr>
<td>Group 1</td>
</tr>
<tr>
<td>Group 2</td>
</tr>
<tr>
<td>Group 3</td>
</tr>
<tr>
<td>Group 4</td>
</tr>
<tr>
<td>3. Profession</td>
</tr>
<tr>
<td>Doctor</td>
</tr>
</tbody>
</table>

596
<table>
<thead>
<tr>
<th>Nurse</th>
<th>94</th>
<th>81</th>
<th>30</th>
<th>26</th>
<th>64</th>
<th>55</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nurse Aide</td>
<td>6</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>5</td>
</tr>
</tbody>
</table>

4. Experience

<table>
<thead>
<tr>
<th>Group 1</th>
<th>0-2 yrs</th>
<th>46</th>
<th>40</th>
<th>16</th>
<th>14</th>
<th>30</th>
<th>26</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 2</td>
<td>3-5 yrs</td>
<td>42</td>
<td>36</td>
<td>12</td>
<td>10</td>
<td>30</td>
<td>26</td>
</tr>
<tr>
<td>Group 3</td>
<td>6-10 yrs</td>
<td>22</td>
<td>19</td>
<td>6</td>
<td>5</td>
<td>16</td>
<td>14</td>
</tr>
<tr>
<td>Group 4</td>
<td>11-15 yr</td>
<td>6</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

5. Trained in infection control

<table>
<thead>
<tr>
<th>Yes</th>
<th>46</th>
<th>40</th>
<th>16</th>
<th>14</th>
<th>30</th>
<th>26</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>70</td>
<td>60</td>
<td>20</td>
<td>17</td>
<td>50</td>
<td>43</td>
</tr>
</tbody>
</table>

Source: Field data

4.2 Biological hazards at Harare Hospital

Participants had fear of different infections, which ranged from airborne, blood borne, diarrheal and contagious infections. Examples of infections, which participants named as highly infectious, were TB, HIV, hepatitis B, dysentery, cholera, typhoid, meningococcal infection. Majority of the participants had TB as the most feared, highly exposed to, and poorly controlled infection. TB was the most named biological hazard.
4.3.1 Knowledge of health care workers on hand hygiene

Respondents exhibited high levels of knowledge on hand hygiene. Most of the respondents (96%) knew when to wash hands, that is after handling contaminated equipment, before and after touching patients. According to the surgeon, he washes his hands before doing invasive procedures like canula insertion and after touching the patient and he practices thorough hand washing (scrubbing) in theatre before performing surgery. Most participants were sure of when to wash hands through provision of examples, however there was no mention of the WHO (2009) five moments of hand wash. One of the nurses confessed that, she did not read posters of hand hygiene guidelines, which were placed on the water basins. She also pointed the fact that running water was not always available. It was also revealed by some nurses that at times they end up not washing hands because using water from the containers is annoying since there are serious shortages of running water at the hospital.

Sufficient knowledge was shown when 90% of the respondents believed that healthcare associated pathogens could be found on normal and intact skin of patient.

Concerning what to use for hand hygiene, most of the respondents (60%) had sufficient knowledge. They believed that antiseptic for hand hygiene effective as soap and water if hands are not visibly dirty.
However, during interviews, some nurses believed that soap and water is more effective compared to alcohol gel, they indicated that it depends on how busy one will be, due to pressure of work at times; they ended up using alcohol gel. In terms of care of hands after hand washing, only 29% of the respondents had sufficient knowledge, they knew that regular use of hand cream does not increase the likelihood of colonisation of harmful bacteria.

Source: Field Data

*Fig 4: Knowledge of health workers on standard precautions*
4.3.2 Knowledge on Standard precautions

Questions on standard precautions focused on personal protective equipment usage such as gloves, facemask, and gown and there was one question on disposal of sharps. Knowledge on protection provided by gloves was moderate, 64% of the respondents knew that gloves do not provide complete protection against infection. The wearing of gloves has been recommended to reduce the transmission of pathogens from health care workers to patients and the contamination of health care worker’s hands (4). In light of Boyce and Pittet recommendations were made that health workers should be fully informed of the limitations of wearing gloves and that they do not offer full protection. About 66% of the respondents knew that gloves need to be exchanged with a new pair even if there is no visible contamination. One of the physicians confessed that he wears gloves when doing procedures on the patient, however he raised the fact that gloves are insufficient such that one pair can be used several times even on a different patient before discarding them. Of note is that the physician showed that he puts significance to personal protective clothing and he said he would stop working in the absence of gloves. Upon questioning, a midwife confessed that in the labor ward, at times there is pressure of work such that they end up using the same gloves on a different patient.

Majority of the respondents (95%) knew that a wet gown should always be removed as soon as possible. Majority (98%) of the respondents knew that disposable needle and syringes should not be used several times for the same patient. One of the doctors indicated that he knew how sharps should be managed but he also explained that shortage of sharps’ boxes causes them to discard sharps inappropriately.

4.4 Practices of health care workers

CONCERNING BIOLOGICAL HAZARDS

4.4.1 Administrative issues

There were three administrative issues, which were assessed namely; workshop attendance, provision of hepatitis B vaccine, and provision of personal protective equipment. According to table 4.5, only 3% of the respondents always attend infection control workshops, 40% of the respondents sometimes go to infection control workshops and the majority (57%) had never attended any infection control workshop.

One of the nurses indicated that workshops were poorly arranged at the hospital, and she did not attend a workshop of any form since she came to the hospital.

Furthermore, the infection control nurse indicated that arrangement of workshops relied on donor funding, thus it is difficult for everyone to benefit.
In terms of vaccination against hepatitis B, only 12% had full vaccination against hepatitis B, they received all the three doses required. According to (5) Hepatitis B virus (HBV) infection is a serious blood-borne disease.

Majority of the respondents (90%) had the view that personnel protective clothing is not always available. One of the doctors commented that apart from shortage of personal protective clothing most of the essential equipment that is required is not available and they gave patients prescriptions to buy for themselves. Casualty officer stressed the point that the shortage of resources causes stress since most of the cases he attends are emergency cases. The availability of resources has an influence on the compliance of infection control guidelines, easily accessible resources and materials contribute to higher compliance among health care workers (6).

**Table 4.5: Administrative issues concerning health care workers’ practice**

<table>
<thead>
<tr>
<th>Practice N=116 Administrative issues</th>
<th>Total</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attended infection control workshops</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Always</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Sometime</td>
<td>46</td>
<td>40</td>
<td>14</td>
</tr>
<tr>
<td>Never</td>
<td>66</td>
<td>57</td>
<td>20</td>
</tr>
<tr>
<td>Vaccinated against hepatitis B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Once</td>
<td>18</td>
<td>16</td>
<td>10</td>
</tr>
<tr>
<td>Twice</td>
<td>8</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Fully</td>
<td>14</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>Never</td>
<td>76</td>
<td>65</td>
<td>16</td>
</tr>
<tr>
<td>Personal protective clothing is always available</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>12</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>No</td>
<td>104</td>
<td>90</td>
<td>32</td>
</tr>
</tbody>
</table>

Source: Field Data

**4.4.2 Practice of standard precaution**

There were 12 questions on practice of standard precautions. Majority (95%) of respondents had appropriate practice; they always wear gloves when touching blood or other body fluid or mucus membrane. Some of the respondents (3%) were not consistence in use of gloves when touching blood or body fluids. Use of personal protective equipment (gloves) is one of the practices required to achieve a basic level of infection control (7). Most of the respondents (83%) had appropriate practice; they
always change gloves between patient contacts. One of the doctors indicated that at times gloves are scarce and he ends up using the same gloves on a different patient, thus predisposing the patients to infection. Disposable gloves should not be reused; only 9% of the respondents reuse disposable gloves.

In terms of wearing facemasks, the practices of 69% of the respondents were appropriate, they wear facemasks when undertaking procedures likely to generate splashes. However, upon further interrogation nurses and nurse aides indicated that they wear facemasks only when they are highly exposed. In terms of wearing of nose masks, there was poor compliance among respondents only 21% always wear a nose mask when working within 1-2metres of patients with expectoration. Majority of respondents (86%) had appropriate practice, they never reused disposable nose masks.

A minority (10%) had poor practices, they never wear gowns to protect themselves. Most of the participants who confirmed that they wear gowns were midwives and nurse aides. Soiled gowns need to be removed as soon as possible, majority of the respondents (86%) were complying, while 14% of the respondents had inconsistency practice, and they do it sometime. In terms of sharps management, majority of the respondents (81%) handle needles appropriately, they never manipulate needles (bending, breaking), furthermore 95% of the respondents always dispose sharps immediately in the safety box. Majority of the respondents (71%) never reuse disposable needle and syringe for the same patient, while (26%) are inconsistent in their practice and they do it sometime. Upon further investigation, some nurses indicated that due to shortage of insulin syringes, they end up reusing them for the same patient thus predisposing the patient to infection.

Table 4.6: Health care workers’ practice concerning standard precautions

<table>
<thead>
<tr>
<th>Practice of standard precautions</th>
<th>N=140</th>
<th>Total</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>%</td>
<td>No</td>
<td>%</td>
</tr>
<tr>
<td>Use of gloves</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wearing gloves when touching blood or other body fluid</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Always</td>
<td>110</td>
<td>95</td>
<td>36</td>
<td>31</td>
</tr>
<tr>
<td>Sometime</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Never</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Always</td>
<td>Sometime</td>
<td>Never</td>
<td>Never</td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------</td>
<td>----------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>Change of gloves between patient contacts.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Always</td>
<td>96</td>
<td>83</td>
<td>28</td>
<td>24</td>
</tr>
<tr>
<td>Sometime</td>
<td>16</td>
<td>14</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Never</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Reuse of disposable gloves.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Always</td>
<td>10</td>
<td>9</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Sometime</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Never</td>
<td>102</td>
<td>87</td>
<td>34</td>
<td>29</td>
</tr>
<tr>
<td>Use of masks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wearing of facemask when undertaking procedures.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Always</td>
<td>80</td>
<td>69</td>
<td>20</td>
<td>17</td>
</tr>
<tr>
<td>Sometime</td>
<td>32</td>
<td>28</td>
<td>16</td>
<td>14</td>
</tr>
<tr>
<td>Never</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wearing nose mask when working within 1-2metres of coughing patients.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Always</td>
<td>24</td>
<td>21</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Sometime</td>
<td>58</td>
<td>50</td>
<td>22</td>
<td>19</td>
</tr>
<tr>
<td>Never</td>
<td>34</td>
<td>29</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Reuse of disposable nose mask.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Always</td>
<td>8</td>
<td>7</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Sometime</td>
<td>8</td>
<td>7</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Never</td>
<td>100</td>
<td>86</td>
<td>30</td>
<td>26</td>
</tr>
<tr>
<td>Use of gloves</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------------------------------------------</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Wearing of gown/apron to protect skin/clothing when undertaking procedures likely to generate splashes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Always</td>
<td>64</td>
<td>55</td>
<td>20</td>
<td>17</td>
</tr>
<tr>
<td>Sometime</td>
<td>40</td>
<td>34</td>
<td>16</td>
<td>14</td>
</tr>
<tr>
<td>Never</td>
<td>12</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Removal of soiled/wet gown as soon as possible</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Always</td>
<td>100</td>
<td>86</td>
<td>28</td>
<td>24</td>
</tr>
<tr>
<td>Sometime</td>
<td>16</td>
<td>14</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Never</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Reuse of disposable gown.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Always</td>
<td>18</td>
<td>16</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Sometime</td>
<td>22</td>
<td>19</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Never</td>
<td>76</td>
<td>65</td>
<td>20</td>
<td>17</td>
</tr>
<tr>
<td>Sharps Management</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manipulation of needles (bending, breaking).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Always</td>
<td>6</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sometime</td>
<td>16</td>
<td>14</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Never</td>
<td>94</td>
<td>81</td>
<td>30</td>
<td>26</td>
</tr>
<tr>
<td>Disposal of sharps immediately in safety box.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Always</td>
<td>110</td>
<td>95</td>
<td>34</td>
<td>29</td>
</tr>
<tr>
<td>Sometime</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Never</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

| Reuse of disposable needle and syringe for same patient. |  
| --- | --- | --- | --- | --- | --- |
| Always | 4 | 3 | 0 | 0 | 4 |
| Sometime | 30 | 26 | 10 | 9 | 20 |
| Never | 82 | 71 | 26 | 22 | 56 |

Source: Field Data
4.5 Attitude of health care workers

Concerning biological hazards

In terms of policies and procedures that govern infection control, all respondents (100%), believed they should be adhered to all the time. According to a nurse in charge who works in the medical wards, the hospital was not doing much to protect employees from contracting infections like TB, patients were taking longer to be diagnosed of TB and during that time infection can be spread, since they is no quarantining.

Majority of nurses indicated that they have never seen the infection control manual since they came to the hospital, however they have seen charts that are placed on walls and mostly they do not read them. Albela and Borg (2012)(8) recommended that posters need to be combined with educational sessions in order to have better results in terms of hand hygiene compliance. Though the hospital has policies and procedures to manage infection, it was pointed out by a physician that the workplace design was poor for managing highly infectious diseases. Majority of the respondents (74%) had a negative attitude; they believed that workload affects their ability to apply infection prevention
guidelines. This is why 41% of the respondents felt that they had inadequate time to comply with infection prevention guidelines.

All respondents (100%), had a positive attitude towards hand hygiene, they felt that it is important to wash hands even if they used gloves. Loveday et al., (2016) also indicated that hands must be decontaminated immediately after the removal of gloves (9).

Hand hygiene remains the cornerstone of infection prevention and all health workers must be aware that wearing personal protective equipment (PPE) does not replace the need to carry out safe hand-hygiene practices and hand decontamination (10).

Attitude towards sharps management was positive; majority of the respondents (93%) felt that needles should not be recapped after use and before disposal. Recapping needles is a dangerous practice since many accidental needle stick injuries occur when employees are recapping needles. (11)

5: CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

According to the current study, TB was the most feared biological hazard. It can be concluded that health care workers at Harare hospital are at risk of contracting TB. The work environment thus needs to be improved in order for health care workers to execute their duties without fear thus delivering quality services. The health care workers demonstrated high levels of knowledge. Though most of the respondents were not trained infection control, they exhibited sufficient knowledge in both hand hygiene and standard precautions. Knowledge was related to profession, thus, there is need to reinforce infection control education across all professions since exposure to infection is evident in all professions that is nurse aides, nurses, and doctors.

Health care workers at Harare Hospital had appropriate practices when it comes to most of the standard precautions. Though most of the standard precautions were being practiced appropriately, however the administrative issues that influence practice were lagging behind. Most of the respondents confessed that personal protective clothing was not always available. In terms of vaccination majority of respondents (86%) were not fully vaccinated against hepatitis and workshops were poorly arranged. Though majority of respondents confessed having adherence to hand washing, there is shortage of running water, which needs to be addressed. Administrative issues are key when it comes to

infection control and prevention, thus they need to be addressed for improvement of practices that govern infection prevention and control.
The health care workers attitude towards infection prevention and control was positive, however training was limited and reading material was not always available and these had a negative contribution towards attitude of health care workers.

5.2 Recommendations
The following recommendations were made in light of the study findings;
- The hospital management should set up an infection control committee, which comprises of members of different professions at the hospital; this will help in motivating other members of staff to comply with infection control guidelines. Effective infection control relies on health care worker’s ability to inform and motivate other members of staff to keep a good compliance to hygiene practice. (12).
- The ministry of health should facilitate training of health care workers in infection control post their basic training such that health care workers in order to reinforce the knowledge levels of health care workers in infection prevention and control (IPC).
- The ministry of health in Zimbabwe should come up with a policy indicating that all health care workers should be up to date with immunisation (hepatitis B vaccine) upon employment to reduce the risk of contracting hepatitis B.
- The hospital management should ensure adequate facilities for hand hygiene. For example, hand basins with running water available as well as disposable hand towels, this helps improve hand hygiene compliance.
- The ministry of health should improve in the way in which workshops are arranged such that every health care worker has an opportunity of attending infection control workshops. According the current study about 57% of respondents had never attended any infection control workshop.
- The ministry of health should employ more health care workers to prevent work overload in order to improve the compliance of infection and prevention policies and guidelines. The head of the infection control department should make sure that the infection control manual is available in all wards so that health care workers will have an opportunity to read and know what they are expected to do in terms of infection prevention and control.
- The hospital administration should also ensure that there is availability of reading material in the wards such as the WHO guidelines, charts and booklets that are related to infection prevention and control such the hospital staff will have up to date knowledge on infection control and prevention.
- The head of the infection control department should make sure that the infection control manual is available in all wards so that health care workers will have an opportunity to read and know what they are expected to do in terms of infection prevention and control.
- The hospital administration should also ensure that there is availability of reading material in the wards such as the WHO guidelines, charts and booklets that are related to infection prevention and control such the hospital staff will have up to date knowledge on infection control and prevention.
REFERENCES


4. NATIONAL SECURITY OF ZIMBABWE

A REVIEW OF CYBERSECURITY IN THE BANKING SECTOR IN ZIMBABWE: A CASE OF CHINHOYI

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ABSTRACT

Today’s business landscape is characterised by electronic business processes globally. The business environment now enables global interaction which result in stiffer competition. The Internet has removed geographical barriers to international business. All sizes of business can now do business with anyone, anywhere at any time due to the use of the Internet, ubiquitous and pervasive computing. The current nature of business is heavily driven by information technology. There is a serious downside of cyber-attacks. This paper reviews the state of cybersecurity in Zimbabwe’s banking sector through an exploration of the meanings of cyber-attack and cybersecurity, threats to cyber-security and possible ways of mitigating them and explores best ways in which Zimbabwe can embrace ICT in relation to national security. The paper contributes to the existing literature on cyber-security in a Zimbabwean context so as to give Zimbabweans a platform to harness ICTs in ways that do not compromise security. If cyber-security is not seriously considered business is likely to have a nose dive since customers end up shunning the use of technology.

Key Words
Cybercrime, Cyber security, security threat, information communication technology
INTRODUCTION

The rise of cybercrime is the major negative impact of the use of the modern information communication technology (ICT) infrastructure. It is a serious threat to all the facets of any nation’s economic activity and this threat is more pronounced in the financial services institutions (1). The globalisation phenomenon is increasingly producing immense opportunities for students, researchers, tourists, and business people, and at the same time fuelling economic growth and development. However, among those taking advantage of opening up societies and borders are criminals who engage in the human trafficking and drug trade, arms smuggling, fraud, counterfeiting, and other financial crimes, and increasingly in computer crimes (2). As more people utilise the Internet as a conduit for commerce, there arises a greater opportunity for fraud (3). The positive benefits of ICT infrastructure growth are impressive, but it is also accompanied with growth in cybersecurity risks that threaten to degrade any potential ICT benefits (4).

Business models, both in the financial sector and other sectors have been redefined, with technology now being regarded as a driver rather than an enabler in conducting business operations (5). The use of non-cash based payment systems around the globe has increased the risk of cybercrime in the financial institutions (1). Customers now prefer online services due to their being convenient, cost saving, easier and faster use. In Zimbabwe these activities are administered through banks and cellular network service providers including Econet Wireless, Telecel and NetOne via Ecocash, Telecash and One wallet respectively. While the use of computers and the Internet may raise efficiency in the business operations, the potential benefits need to be weighed against threats posed by the increasing use of the information communication technology (1).

Cybercrime has diverse definitions indicative of its complexity with various forms and motives. Cybercrime refers to computer mediated activities which are illegal or considered illicit by certain parties and which can be conducted through global electronic networks (1); a popular term describing the criminal activities related to cyberspace or the cyber-world. A scholarly consensus on a single definition of the terminology is yet to be achieved (2). Cyber security is therefore needed to combat cybercrime. The state of information security in this region is affected by factors such as the growth of user base, poor security awareness, lack of training for law enforcements, lack of regulations and weak cross-border collaboration (2).
The potential for internet abuse is even greater in and for Africa. Due to the lack of security awareness programmes or specialised training for the law enforcement agencies, many online users are becoming victims of cyber-crime attacks and the incidence of successful attacks is increasing with impunity (2). Additionally, most banks in the region are vulnerable to phishing attacks (2). Information security awareness is therefore crucial for combating cyber-crimes (2).

Due to the style of criminal justice and law enforcement techniques in Africa, most countries in the region, including Burkina-Faso, the Gambia, Ghana, Kenya, Senegal, and Zimbabwe are using emergency laws and ad hoc approaches instead of establishing ascertainable cyber-crime laws and policies against the phenomenon (2).

Cybersecurity consists of the capabilities and measures to protect or defend the use of the cyber environment (networks, computing hardware, applications, data, and infrastructure) against relevant security risks. It can be defined as the organisation and collection of resources, processes and structures used to protect cyberspace and cyberspace-enabled systems from occurrences that misalign de jure from de facto property rights (6); the art of ensuring the existence and continuity of the information society of a nation, guaranteeing and protecting, in cyberspace, its information, assets and critical infrastructure (6), the term is used broadly and its definitions are highly variable, context-bound, often subjective, and, at times, uninformative (6) and there seems to be very little understanding of what the term really entails (7).

The ability for developing nations to determine the most effective and efficient cybersecurity investments is hindered by several challenges:

• The competing demands on a small number of serving government officials who possess a comprehensive understanding of the multidimensional cyber security.

• Limited investment resources.

• Lack of focus from global cybersecurity professionals who could provide capacity-building assistance to disadvantaged partners (4).

OBJECTIVES

The objectives of this paper are to:
1. Develop an understanding of cybercrime and cybersecurity in the Zimbabwean context.
2. Establish the main cybersecurity threats in Zimbabwe.
3. Establish challenges Zimbabwe faces in mitigating cybercrime.
4. Identify policy considerations to curb cyber-attacks in Zimbabwe.

METHODOLOGY

The research employed both descriptive and quantitative methodologies. The researchers administered a questionnaire to selected personnel in 5 banks in Chinhoyi, Zimbabwe. The total population was 78 employees. Purposive and convenient sampling were employed for the reason that not everyone in the organisation of choice was in a position to give useful information since cybersecurity is a concept not well understood especially in developing countries like Zimbabwe. A sample of 30 individuals was conveniently selected from the lowest to the highest rank. Follow up interviews were done on key personnel to clarify issues raised from the questionnaires. A set of questions were prepared and sent to the prospective interviewees via email. This was done 2 weeks before the interview date in order for the respondents to adequately prepare for the interview. The research included a descriptive study, which describes the phenomenon or event as it exists without manipulation or control of any elements under study (8).

As part of this methodology, content analysis was also used to gather facts about cybersecurity and cyber threats in Zimbabwe. This is a qualitative analysis where content or data is analysed through the analysis of text with respect to its content. The frequency of occurrence of terms or phrases was used to develop new insights from different researches. The method was appropriate for the development of an understanding on the concepts of cybercrime and cybersecurity, the establishment of major cybersecurity threats in Zimbabwe as well as the establishment of factors to be considered in developing and implementing cybersecurity policy.
RESULTS PRESENTATION AND DISCUSSION

4.1 Demographics

Figure 27: Gender distribution of respondents

The research considered a sample of 30 respondents of which 20 were males and 10 were females i.e. 67% and 33% respectively (figure 1). Though there were more males than females, the researchers included all the females in the population to improve gender balance. This was possible since convenience sampling was employed.

Figure 28: Qualifications of respondents

Figure 2 shows that all respondents held qualifications ranging from certificate to masters’ degree indicating that everyone who gave information in the research had an adequate foundation to understand cybersecurity. The majority had a diploma and undergraduate degree with 30% and 40% contribution respectively.
Figure 29: Respondents’ employment categories

There was a balanced distribution of senior managers, middle managers and ordinary employees with 28%, 33% and 33% respectively (figure 3). This helped the researchers to obtain a balanced view of the concepts developed.

4.2 Cyber threats to Zimbabwe

<table>
<thead>
<tr>
<th>Employment category</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid Senior Management</td>
<td>8</td>
<td>26.7</td>
<td>26.7</td>
<td>26.7</td>
</tr>
<tr>
<td>Middle management</td>
<td>10</td>
<td>33.3</td>
<td>60.0</td>
<td></td>
</tr>
<tr>
<td>employee</td>
<td>10</td>
<td>33.3</td>
<td>93.3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>3.3</td>
<td>90.7</td>
<td></td>
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<td>5</td>
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</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

Figure 30: Level of cyber threats to Zimbabwe

<table>
<thead>
<tr>
<th>Descriptive Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>Ransomware</td>
</tr>
<tr>
<td>Malware</td>
</tr>
<tr>
<td>Bring your own device</td>
</tr>
<tr>
<td>Password cracking</td>
</tr>
<tr>
<td>Botnets</td>
</tr>
<tr>
<td>Man in the middle</td>
</tr>
<tr>
<td>SQL injection attack</td>
</tr>
<tr>
<td>Insufficient recovery planning</td>
</tr>
<tr>
<td>Denial of service</td>
</tr>
<tr>
<td>Spam</td>
</tr>
<tr>
<td>Hacking</td>
</tr>
<tr>
<td>Pharming</td>
</tr>
<tr>
<td>Phishing</td>
</tr>
<tr>
<td>Eavesdropping</td>
</tr>
<tr>
<td>Misuse of employee privileges</td>
</tr>
<tr>
<td>Cyberbullying</td>
</tr>
<tr>
<td>Valid N (listwise)</td>
</tr>
</tbody>
</table>

615
In as much as every country is threatened by cybercrime, each has its own share of the cake. Figure 4 shows the threats common to Zimbabwe. The research indicated that Zimbabwe experiences similar threats to other countries. All the common threats to a country are experienced in Zimbabwe. Some of the common threats are ransomware, malware, bring your own device, password cracking, Botnets, man-in-the-middle attack etc. It therefore suggests that Zimbabwe needs to have policy measures similar to what obtains in other countries including the developed world.

4.3 Common ways of perpetrating cybercrime in Zimbabwe

<table>
<thead>
<tr>
<th>Descriptive Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>Fast flux</td>
</tr>
<tr>
<td>Zombie computer use</td>
</tr>
<tr>
<td>Scavenging</td>
</tr>
<tr>
<td>Denial of service</td>
</tr>
<tr>
<td>Social engineering</td>
</tr>
<tr>
<td>ATM fraud</td>
</tr>
<tr>
<td>Impersonation</td>
</tr>
<tr>
<td>Skimmers</td>
</tr>
<tr>
<td>Credit card fraud</td>
</tr>
<tr>
<td>False data entry</td>
</tr>
<tr>
<td>Illegal transfer of money</td>
</tr>
<tr>
<td>Identity theft</td>
</tr>
<tr>
<td>Valid N (listwise)</td>
</tr>
</tbody>
</table>

Figure 31: Common ways of perpetrating cybercrime in Zimbabwe

The research indicated that the most common ways by which cybercrime is committed in the Zimbabwean context include fast flux, use of zombie computers, scavenging, denial of service, and social engineering:

Fast flux is a technique used by cybercriminals to confuse the DNS of a victim’s network to prevent identification. The criminal then creates hosts or nodes that join and drop the network quickly but in that short time does some unwanted activity. The process works faster than the network administrators can identify them. Zombie computers are connected to a compromised network by hackers and used to perform malicious tasks. In scavenging criminals sift through lost material of an organisation in dumb sites or bins in order to locate any information unlawfully. This is why the disposal of material is a serious concern.
Criminals can use their networks of software to disturb the victim organisation traffic thereby depriving the legitimate users their access to the network. This process is termed denial of service (DoS). Attackers use malicious computer software to clog the victim’s computer memory such that the later will no longer have space for running its own programs resulting in the computer malfunctioning. Finally the victim is denied his/her normal services.

In social engineering criminals pretend to provide helpful information to the users especially through social media. When the unsuspecting users follow the instruction given, their data or information can be stolen and used to perpetrate criminal activities.

### 4.4 Challenges in mitigating cybercrime in Zimbabwe

<table>
<thead>
<tr>
<th>Descriptive Statistics</th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Third party agreements</td>
<td>30</td>
<td>1</td>
<td>4</td>
<td>2.30</td>
<td>.952</td>
</tr>
<tr>
<td>Increase in the num of perpetrators</td>
<td>30</td>
<td>1</td>
<td>5</td>
<td>2.23</td>
<td>.935</td>
</tr>
<tr>
<td>Threats are everywhere &amp; everchanging</td>
<td>30</td>
<td>1</td>
<td>4</td>
<td>2.17</td>
<td>1.117</td>
</tr>
<tr>
<td>Lack of knowledge</td>
<td>30</td>
<td>1</td>
<td>3</td>
<td>1.97</td>
<td>.615</td>
</tr>
<tr>
<td>Lack of resources</td>
<td>30</td>
<td>1</td>
<td>4</td>
<td>1.93</td>
<td>.785</td>
</tr>
<tr>
<td>Rapid Changes in technology</td>
<td>30</td>
<td>1</td>
<td>4</td>
<td>1.93</td>
<td>.868</td>
</tr>
<tr>
<td>New risks through IOT</td>
<td>30</td>
<td>1</td>
<td>3</td>
<td>1.87</td>
<td>.571</td>
</tr>
<tr>
<td>Inadequate crime laws</td>
<td>30</td>
<td>1</td>
<td>4</td>
<td>1.70</td>
<td>.837</td>
</tr>
<tr>
<td>Valid N (listwise)</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 32: Challenges in mitigating cybercrime in Zimbabwe

Though individuals and organisations in Zimbabwe are working hard on curbing cyber-attacks, a number of challenges exist which poses problems to those trying to do so. Figure 7 indicates that the major challenges faced by Zimbabwe in mitigating cybercrime include third party agreements, an increase in the number of cybercrime perpetrators, threats being everywhere and ever-changing and lack of knowledge.

**Third party agreements.**

In many cases, organisations subcontract companies either to install their network of process their data into information and in some cases store sensitive data. These third parties are difficult to trust or control.
In the worst cases the contracted company can also subcontract a different service provider. Once this chain exist, there are more chances of abuse or stealing of data and information.

**An increase in the number or cybercrime perpetrators.** Developments in technology have enabled many people to manipulate the Internet eventually opening avenues for criminals to do unscrupulous acts.

**Lack of knowledge through education and awareness.** The researchers noted that many people are not aware of the safe ways of using the cyber technology and hence possible threats in using them. Most importantly people are not informed on the various ways available in protecting their information and systems.

**Threats are everywhere and ever-changing**

Due to ubiquitous and pervasive computing cybercrime is no longer limited to people with academic qualifications in ICT or those working in such departments. Nowadays everyone is a potential culprit. It is therefore a challenge to put robust measures that policies can adequately address. However, the researchers discovered that it is best to have a viable and flexible ICT policy framework that can be changed anytime to suit the technological developments.

4.5 Cyber security policy considerations for Zimbabwe
Figure 33: Elements to be included in cybercrime policy in Zimbabwe

Figure 8 shows elements indicated by respondents as critical in ICT policy formulation for Zimbabwe. The major considerations shown are continual training of users, research and development, planning ahead, signing in to social media accounts, entrusting untrained computer users with sensitive soft data. This indicated that the respondents were cognisance of the fact that technology is ever-changing and that users of ICT need to keep abreast with these developments through research and development. Organisations should therefore include an element of research and development for all computer users.

4.6 Why Cybersecurity Policy

The continuously increasing reliance of institutions on their information systems has posed new problems such as systems attacks by use of malicious code, denial of service attacks, and theft of data (9). A very good information security policy should address the goals of the policy, and the actions related to them; the roles and responsibilities of the personnel; information security education; protected data processing; disaster preparedness and recovery; repercussions from neglecting the policy (9).
The major objective of a security policy is to provide management direction and support for information security in accordance with business requirements and relevant laws and regulations (9). Even though an organisation has the best policies and procedures in place, they are of little value to the organisation when its users do not recognise them and if they also do not know what those policies mean in their day-to-day duties (9). Most users in an organisation have a perception that security is the sole responsibility of the IT security department and not theirs. Hence they tend to take issues with information security not very seriously.

Governments need to adopt a careful balancing act to ensure that there are appropriate regulations that allow them to deal with cybercrime and terrorists without infringing on online freedoms or providing opportunities for security services to spy on their citizens (10).

Zimbabwe Cybercrime and Cybersecurity Bill (2017) is an instrument that addresses the associated issues whilst allocating the responsibilities to the already existing Ministry of ICT.

The Cybercrime Bill of Zimbabwe does not define cybersecurity. However, the Cyber Policy defines cybersecurity as the implementation of measures to protect information communication technology infrastructure including critical information infrastructure from intrusion and unauthorised access. It includes the adoption of policies, programmes, technology, procedures, protocols and good practices to better govern the use of cyberspace. The researchers advocate for every organisation, be it government or private to have a viable and communicated cyber security policy to improve on what (11) noted that no state owned enterprise had a formal security awareness programme for staff and the various departments and no formal policies covering IT security whilst others had interim policies in progress.

CONCLUSION

Zimbabwe has similar challenges in the face of cyber threats to those of most developing countries in Africa except countries such as South Africa and Kenya who have better ICT infrastructures. Common ways by which cybercrime is committed in Zimbabwe include; Illegal transfer of money, Credit card fraud, ATM fraud, Phishing or identity theft and Denial of Service (DoS). Common challenges in combating cyber-attack involve; lack of resources, inadequate cybercrime laws and lack of knowledge through education and awareness campaigns. Every cybersecurity policy must include prevention measures that include cyber laws, education, policy evolution, seminars, workshops, tight IT security and Constant change of ICT technology. It was also noted that no state owned enterprise had a formal security
awareness programme for its members and others had no formal policies covering IT security whilst others had interim policies in progress.

RECOMMENDATIONS

➢ The researchers recommend that every organisation needs a viable cybersecurity policy. The policy has to be understood by all members of an organisation. No state owned enterprise was found to have a formal security awareness programme for staff and the various departments and no formal policies covering IT security whilst others had interim policies in progress (11).

➢ Governments need to adopt a careful balancing act to ensure that there are appropriate regulations that allow them to deal with cybercrime and terrorists without infringing on online freedoms or providing opportunities for security services to spy on their citizens (10).

➢ Every member of an organisation has to subscribe to and be supportive of the cybersecurity policy. As noted by 9 that even though an organisation can have the best policies and procedures in place, they are of little value to the organisation when its users do not recognise them and if they also do not know what those policies mean in their day-to-day duties. The issue of cybersecurity should be addressed by all stakeholders (8). It should be made clear in the policy that cybersecurity is every member’s responsibility just like product quality.

REFERENCES


