



**THE 4<sup>th</sup> NATIONAL RESEARCH DISSEMINATION CONFERENCE**



**HELD AT CROSSROADS HOTEL, LILONGWE, MALAWI FROM  
25<sup>TH</sup> TO 26<sup>TH</sup> JANUARY 2023**

**National Commission for Science and Technology (NCST)**

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**PROCEEDINGS OF THE FOURTH NATIONAL RESEARCH DISSEMINATION  
CONFERENCE HELD AT CROSSROADS HOTEL, LILONGWE, MALAWI FROM  
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## **PROCEEDINGS OF THE FOURTH NATIONAL RESEARCH DISSEMINATION CONFERENCE**

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## **Foreword**

It is with great pleasure and expectation that The National Commission for Science and Technology (NCST) presents the proceedings of the 4<sup>th</sup> National Research Dissemination Conference (NRDC). The conference is held every two years, and represents a very important platform for advancing knowledge and fostering collaboration across diverse fields of study.

It brings together scholars, researchers, and practitioners from various disciplines, with distinctive experiences and expertise. The result is an extensive compilation of research findings, innovative concepts and solutions that reflect the dynamic and evolving nature of our disciplines.

The importance of this conference exceeds the presentation of individual papers. It demonstrates a shared commitment to the dissemination of research findings, promoting dialogue, and generating new research questions towards the development of new products and services.

The Commission expresses its sincere appreciation to all presenters, keynote speakers, session chairpersons, and reviewers whose important input helped to have the proceedings compiled. Their commitment made sure that these proceedings not only reflect the nature of current studies, latest advancements and emerging trends but also serve as a catalyst for future research and interdisciplinary collaboration for the benefit of society.

NCST looks forward to various ways in which the insights shared here will continue to impact and enrich our disciplines as we implement our national research agenda towards the realization of Malawi 2023.

Gift Kadzamira  
**Director General**  
**National Commission for Science and Technology**

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The National Commission for Science and Technology (NCST) and National Planning Commission (NPC) extend their heartfelt gratitude to all institutions and individuals that made the Fourth NCST Research Dissemination Conference a success. Special recognition is extended to all conference presenters and participants without whom the research dissemination conference would not have been materialise. NCST extends also its gratitude to Malawi Bureau of Standards (MBS), PresCane and MWAPATA Institute for their financial support towards the conference. The Commission shares the conviction that research and development has little or no impact if its results are not shared and utilized to inform decision making and implementation.



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## **Introduction**

The global political, technological and socioeconomic space is undergoing speedy growth. Never the less, the importance of research to socioeconomic development is well recognized world over. Significant developments that have been made in the fields of education, health, agriculture, engineering, industries, telecommunication, energy, ICT have largely been possible due to innovations and research. In an effort to foster evidence-based policy formulation, the National Commission for Science and Technology (NCST), alongside other partners organized the Fourth National Research Dissemination Conference (NRDC), from 25<sup>th</sup> to 27<sup>th</sup> January 2023 at Crossroads Hotel, in Lilongwe with a theme: “**Research, innovation and entrepreneurship: The key Drivers to an Inclusively Wealthy and Industrialized Nation**”. The Conference is a biennial event.

## **Aims and Objectives of the Conference**

The aim of the conference was to provide a platform for researchers, policy makers, analysts and implementers; development partners; and academics to share novel research findings from different sectors, discuss lessons learnt, best practices and solutions to challenges impeding research for development in Malawi.

Specifically, the conference intended to achieve the following objectives:

- Provide a platform for researchers and innovators to present and showcase their work.
- Promote uptake of research that can foster evidence-based policy formulation, programs design, projects’ prioritization, monitoring and evaluation.
- Promote knowledge, skills exchange and transfer across stakeholders.
- To promote collaboration, networking and partnerships among researchers, innovators, government and development partners in the country.

## **Conference Sub-Themes**

To facilitate alignment of research to development planning, the conference sub-themes were structured around accelerators to Malawi’s new vision 2063 as follows;

- i. Agricultural Productivity and Commercialization
- ii. Education & Human Capital for Social-Economic Development
- iii. Environment & Natural Resources Management and Climate Change
- iv. Health, population and Nutrition
- v. ICT, Financial Inclusion and Knowledge Management
- vi. Infrastructure, Energy, Transport and Engineering
- vii. Social sciences, Humanities and Inclusivity
- viii. Trade, Industrial Development and Tourism
- ix. Urbanization and Rural Development

## **Participants**

The Conference brought together a cross-section of participants including policy makers, researchers; academicians, NGOs, private sector, development partners, entrepreneurs and other interest groups. Over 250 participants attended the conference physically and over 2000 participated virtually through Zoom and live streaming on NCST and National Planning Commission (NPC) Facebook pages.

### **Call for Conference papers**

A call for papers was published in the Nation and Daily times including, social media, NCST website and those of stakeholders. It ran for a period 30 days and closed on 22<sup>nd</sup> August 2022. A total of 114 abstracts were received and the abstracts underwent preliminary screening for compliance to the call requirements. 101 abstracts were selected for peer review and 86 were recommended for presentation at the conference.

### **Structure of Conference**

The conference was delivered through two strategies; physical and virtual participation where internet-based platforms were shared to participants to attend the conference. The conference comprised official opening ceremony; key note addresses, research papers presentations; and innovation exhibitions.

It was officially opened by the Minister of Education, Honourable Agnes Nyalonje. Other speakers during the opening ceremony included the Chairperson, Board of Commissioners for NCST, Prof. Emmanuel Kaunda; the Director of Knowledge and Learning, Dr Joseph Nagoli who represented the Board Chairperson for NPC, The Director of Science Technology and Innovation Dr Chomora Mikeka who represented the Principal Secretary for Ministry of Education and the host Acting Director General for NCST Mrs Gift A. Kadzamira.

### **Financing**

The conference was organized and funded by NCST alongside other partner institutions including; National planning Commission (NPC), Malawi Agriculture Policy Advancement and Transformation Agenda (MwAPATA) Institute, PresCane and Malawi Bureau of Standards (MBS). The support ranged from costs of hosting the conference at Cross-roads Hotel, conference materials, publicity and publications. Participants were required to pay a registration fee of MK80,000 and also support themselves or by their respective institutions in terms of their transport and upkeep.

# **AGRICULTURAL PRODUCTIVITY AND COMMERCIALIZATION**



## Assessing the potential of microbial consortia-based biofertilizer in integrated soil fertility management for improved maize productivity

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### Abstract

Decline in soil fertility is one of the major challenges derailing agricultural production in Malawi. This is exacerbated by increasing population that puts pressure on land resources leading to continuing of soil degradation. Over the years use of inorganic fertilizer has been considered as a quick solution in alleviating soil fertility challenges. However, escalating fertilizer prices and the effects of overdependence of chemical fertilizers to the environment put the agricultural sustainability into question. Therefore, a study was implemented in the 2021/22 growing season with the aim of assessing the potential of integrating microbial consortia-based biofertilizer in soil fertility management for maize productivity. A study was implemented at Bunda, Chitedze and Nachisaka EPA in Dowa. A randomized complete block design (RCBD) was implemented in each of the sites. Treatments included biofertilizers and combinations with inorganic N fertilizers such as ConsortiumA+46kgN/ha, ConsortiumA+69kgN/ha, consortiumB, consortiumMP+46kgN/ha, ConsortiumMP+69/ha, consortiumDHART+46kgN/ha, ConsortiumDHART+69/ha and control (Recommended fertilizer- 92kgN/ha). Results showed maize grain yield ranges of 4073kg/ha (under consortiumA+46kgN/ha) to 72133kg/ha (under consortium B) for Bunda site, 1942 kg/ha (under consortiumMP+69kgN/ha) to 3353kg/ha (under recommended fertilizer rate) for chitedze site, and 4839 (under consortiumA+69kgN/ha) to 8032kg/ha (under consortiumDHART+46kgN/ha) for Nachisaka site. There were significant differences ( $P<0.05$ ) in yields among treatments in the different sites. For Bunda site consortiumB showed significantly higher ( $P<0.05$ ) yields than the rest of the treatments while at Nachisaka consortiumDHART+46kgN/ha led to significantly higher ( $P<0.05$ ) yields than all combinations that never included consortiumDHART. Site was also noted to have significant effects on the yield differences. From this study it is noted that there is a huge potential of integrating microbial consortia-based biofertilizer in maize production. However, more comprehensive studies are required as the performance of various microbial consortia-based biofertilizers are varying with sites.

**Keywords:** Biofertilizer, inorganic fertilizer, maize productivity, microbial consortium

### Introduction

Agriculture plays a significant role in the economies of most African countries and it is viewed as a sector that is able to contribute significantly towards curbing major drawbacks such as hunger and poverty on the continent. As is the case in most of African countries, the Malawian economy is predominantly agro-based. On the other hand, Malawi is rated as one of the poorest countries in the world (World Bank, 2018). The poverty is attributed to a large extent to low agricultural productivity as well as small farm sizes, and land degradation due to increase in population (FAO, 2015). Furthermore, in many parts of sub-Saharan Africa including Malawi soil degradation continues to be one of the limiting factors to crop production (Zingore *et al.*, 2015; FAO, 2018). On the other hand, in the past few years there has been a need to increase in food supply, especially from plant sources, owing to the growth in human population. This has resulted in the increased need for soil fertility improving approaches. Many approaches have been tried and a few

still being practiced due to limited adoption as influenced by various challenges associated with technologies. For instance, use of organic/compost manure faces challenges of bulkiness and low quality of the feedstock. Additionally, livestock based-manure faces a challenge of diminishing herd sizes and moreover a small number of farmers own livestock (Ajayi *et al.*, 2007). Hence, use of chemical or inorganic fertilizers in order to maintain productivity is considered as a quick solution to the challenge of declining soil fertility (Thomas and Singh, 2019). However, increased use of inorganic fertilizers is associated with a myriad of negative environmental effects such as reduction in soil biodiversity, deterioration in soil quality, as well as air and water pollution (Muhammad *et al.*, 2020; Ramasamy *et al.*, 2020). Moreover, fertilizers are beyond the reach for resource poor farmers. On the other hand, the sustainability of investments that go into subsidies for inorganic fertilizers in Malawi is yet to be proved (Komarek, 2017).

Therefore, there is a need to reduce dependence on inorganic fertilizers while maintaining the necessary productivity in in agriculture sector. This can be achieved by finding a substitute to inorganic fertilizers with a soil amendment that will be sustainable. Microbial biofertilizers are considered as one of the eco-friendly interventions. They are considered renewable and help maintain biodiversity, and are known to increase nutrient uptake by plants (Thomas and Singh, 2019; Ramasamy *et al.*, 2020). Microbial based-biofertilizers are classified into broad groups based on their specific functions and include the phosphorus-solubilizing microbes, potassium-solubilizing microbes as well as nitrogen-fixing microbes. Nitrogen fixing microorganisms can either be free living, symbiotic or associative symbiotive (Kour *et al.*, 2020).

Studies have highlighted that while the usage of biofertilisers has been successfully applied in developed countries; in developing countries several factors such as inadequate scientific knowledge on the biofertilisers have hindered their utilization (Ramasamy *et al.*, 2020). Moreover, popular biofertilisers in most sub-Saharan countries including Malawi are based on rhizobial strains that are generally symbiotic nitrogen fixers. However, soils in these countries are not only deficient of nitrogen but also other nutrients such as phosphorus, potassium and zinc (Munthali, 2007; Zingore *et al.*, 2015; FAO, 2018).

Therefore, the research was aimed at developing biofertilisers based on diverse microbial species/strains (consortia) that have a potential to solubilize the limiting essential nutrients in Malawi soils. The targeted essential nutrients include phosphorus (P), potassium (K), zinc (Zn) and nitrogen (N) with a quest for balanced plant nutrition. Specifically, the study was aimed at identifying indigenous microbial strains with a potential of enhancing soil fertility through solubilisation of various nutrients (nitrogen, phosphorus, potassium and zinc) and nitrogen fixation. Secondly to assess performance of microbial based biofertilisers in increasing productivity of maize crop.

## **Materials and methods**

### **Soil sampling, testing, and microbial isolation**

Soil samples were obtained from different sites. Samples were used for isolation, also subjected to nutrient testing and used for pot experiments. Biochemical assays for isolation of nitrogen fixing and other nutrient (nitrogen, phosphorus, potassium, zinc) releasing microbial consortia from root nodules and rhizospheric soils were conducted using procedures according to Deaker *et al.* (2011). Picovskaya (1948) culture medium as indicated by Karpagam and Nagalakshmi, (2014) with the pH adjusted to 6.6 was used to isolate microbes that solubilize several forms of inorganic phosphates viz calcium phosphate, iron phosphate and rock phosphate. Isolation of potassium solubilizing microbes was done according to methods described by Sugumaran and Janartham, (2007) Saravanan *et al.*, 2003 method was used for zinc solubilizing microbes. The solubilization

ability of various strains were tested on some benchmark soils with know characteristics. Extractable phosphorus, potassium and zinc in the soils as influenced by microbial consortia biofertilisers enhanced solubilisation was determined by Mehlich-3 method (Mehlich, 1984). Mineral N will be determined by a KCL based colorimetric method as outlined by Anderson and Ingram (1989).

### Assessing effects of microbials strains and biofertilizer effects on crop productivity

Determination of soil fertility improvement and maize yield as influenced by the obtained microbial isolates and different potential microbial consortia biofertilizers' combinations with inorganic fertilizers was conducted in the greenhouse and field experiments on maize crop. Firstly, 39 microbial isolates that showed solubilization potential on benchmark soils were used to test their effects on growth of maize plants in the greenhouse. Hence, treatments included 39 microbial isolates plus a control without any application making up to 40 pots. Another set of 40 pots were set with all the treatments as in first set was also planted but to this second set both microbial isolates and inorganic fertilizer (23: 10: 5 + 6S +1Zn) were applied. This implied that the pot experiment involved testing of two factors, application of microbial isolates and inorganic fertilizers. On the other hand, the field experiment was arranged in a randomized complete block design (RCBD) on each site. Treatments included sole application of biofertilizers and other treatments where biofertilizers were applied with different rates of the inorganic fertilizers. A list of treatments that were implemented in the field is indicated in Table 1. Plants heights and grain yield were the data obtained from the green house and field experiments, respectively. Maize grain yield was quantified according to a procedure by Mloza-Banda (1994).

Table 1 List of the treatments for field studies at Bunda, Chitedze and Nachisaka

<b>Treatments</b>	
1	Control (Recommended rates)
2	DARS + UREA 46N /ha
3	DARS + UREA 46N /ha split
4	DARS/BUNDA + NPK + UREA (1/2 rate for both)
5	DARS/BUNDA + UREA 69N /ha
6	DARS/BUNDA + UREA 69N /ha split
7	DHART + NPK + UREA (1/2 rate for both)
8	DHART + UREA 46N /ha
9	DHART + UREA 46N /ha split
10	DHART + UREA 69N /ha
11	DHART + UREA 69N /ha split
12	MP + NPK + UREA (1/2 rate for both)
13	MP+ UREA 46N /ha
14	MP+ UREA 46N /ha split
15	MP+ UREA 69N /ha
16	MP+ UREA 69N /ha split
17	New Consortium (BIO)

Key: MP, DARS/Bunda, DHART and New Consortium are all different biofertilizers; 46N = 46 kg N ha<sup>-1</sup>, 69N = 69 kg N ha<sup>-1</sup>, recommended fertilizer = 92 kg N ha<sup>-1</sup>

## Results and discussion

### Effects of microbial isolates and inorganic fertilizer on growth of maize plants

Figures 1 and 2 show results on maize growth indicated by plant heights as influenced by microbial isolates and inorganic fertilizer. There were significant differences ( $p < 0.05$ ) in plant heights as influenced by microbial strains and inorganic fertilizers. From the graphs it is noted that microbial strain numbers 6, 10, 11, 19 and 30 are consistently having significant influences on maize plant growth without any application of inorganic fertilizers. This positive influence of microbial inoculants on maize was also reported from studies from other parts of the world. Chen et al (2020) based on a study on conservation tillage in China inoculation with plant growth promoting rhizobacteria enhanced maize plant growth. Hussain *et al* (2013) also reported effects of microbial inoculants on maize growth which was attributed to the ability of the microbial strains tested on releasing of enzymes such as phosphatase and organic acids that help to solubilize phosphorus and other nutrients. On the other hand, microbial isolates numbers 27 and 34 are significantly influencing maize plant growth to a large extent when with treatment also receives inorganic fertilizers. Tang *et al* (2020) reported positive influences of microbial inoculants involving different species of bacteria which led to increase in maize growth, nutrient uptake and nutrient use efficiency, which was attributed to the ability of the microbial species to solubilize nutrients in the soil. Bueno *et al* (2022) noted varied effects of microbial-based biofertilizers in which performance of some microbial strains were improved at certain concentrations of inorganic fertilizers, which other microbial strains were suppressed with increase in inorganic fertilizers.

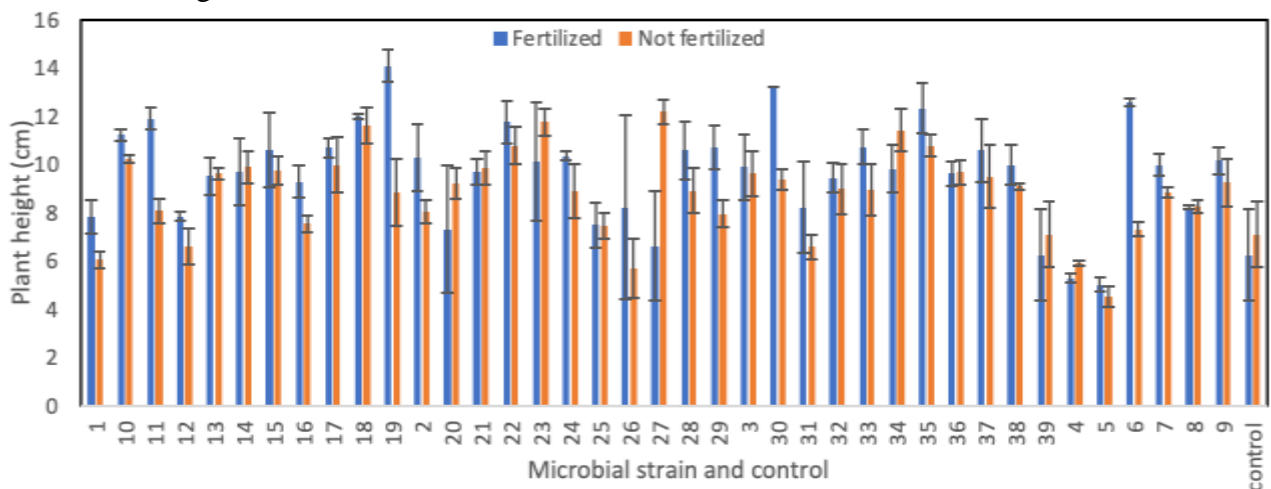


Figure 1 Effects of microbial strains and inorganic fertilizer on maize plant heights (week 5)

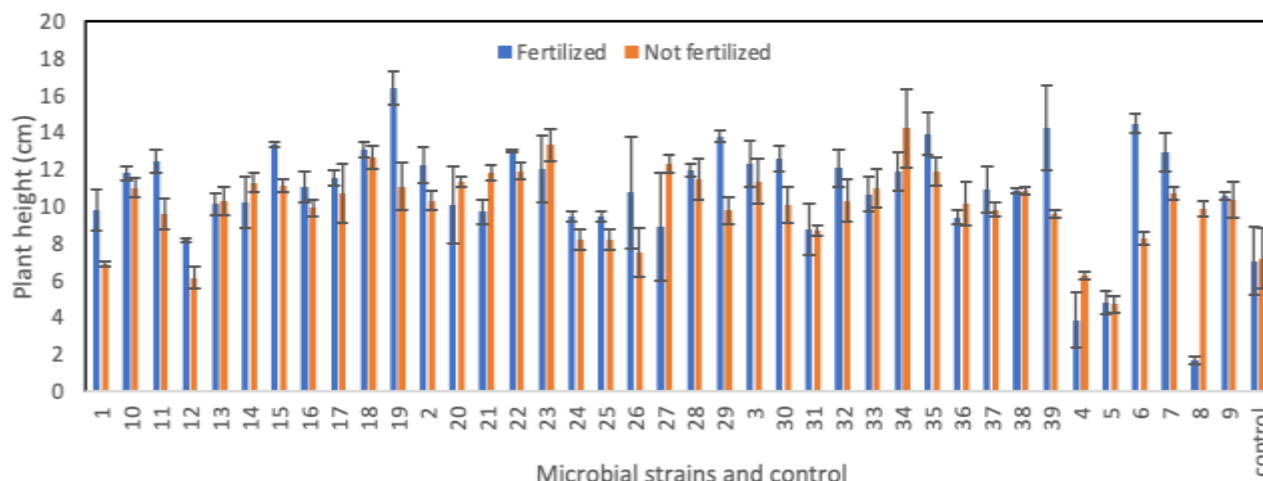


Figure 2 Effects of microbial strains and inorganic fertilizer on maize plant heights (week 7)

### Effects of biofertilizers and inorganic fertilizers on maize grain yield

Maize grain yield results as influenced by biofertilizers and inorganic fertilizers are presented in Figures 3, 4 and 5, for Bunda, Chitedze and Nachisaka study sites, respectively. In these results for each site the biofertilizers and inorganic fertilizers are considered in combinations as a an integrated practice or a sole consortium biofertilizer. Results show that there were significant differences among treatments. For the Bunda site it noted that BiofertilizerMP+69N produced significantly higher ( $p < 0.05$ ) yield than a number of combinations involving DARS/Bunda, DHART and New Consortium biofertilizers. For the Chitedze site it is noted that the recommended fertilizer, combinations of DARS/Bunda and DHART also showed positive performance. On the other hand, at Nachisaka site DHART+46N and DHART +69N showed significantly higher ( $p < 0.05$ ) maize grain yield than most of the treatments. From these results it is noted that biofertilizer combinations in integration with inorganic fertilizers are bringing different implications varying with sites. Renoud *et al* (2022) noted effects of sites on proliferation and functioning of soil fertility enhancing Azospirillum. The environmental factors such as soil properties including slight variations in pH influence microbial community functioning. On the other hand, interactive effect of the soil amendments and site shows that there were significant effects in grain yields among the treatments (Figure 6). Nachisaka showed significantly higher ( $p < 0.05$ ) grain yield than Bunda and Chitedze. This can be attributed to the general soil fertility differences of the sites.

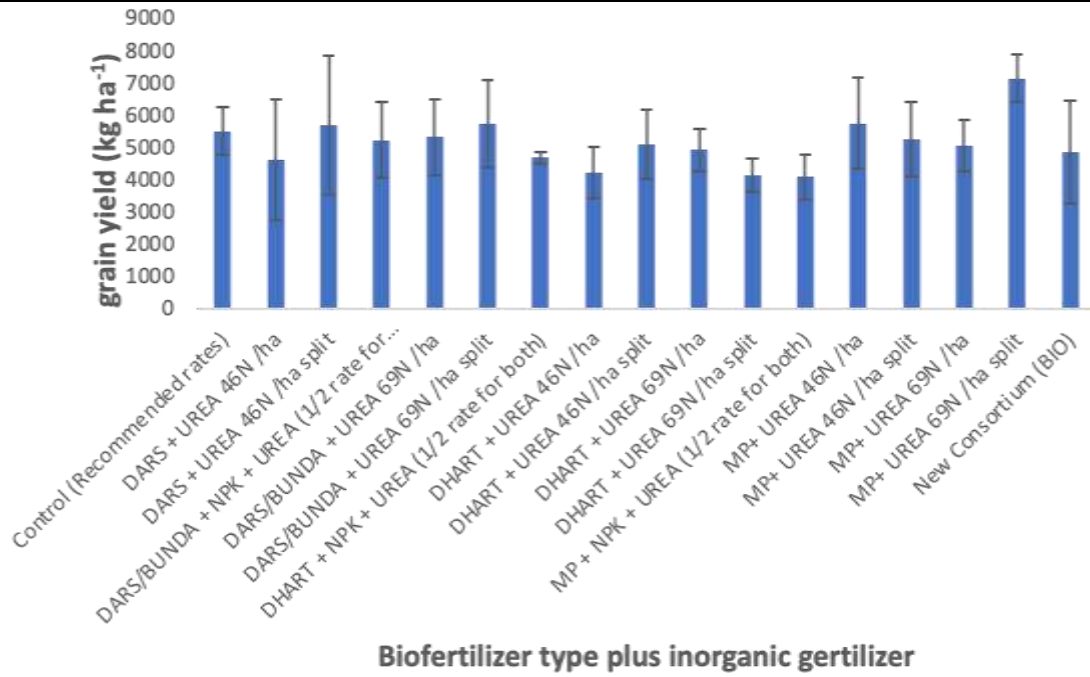


Figure 3 Effects of biofertilizers and inorganic fertilizers on maize grain yield at Bunda site

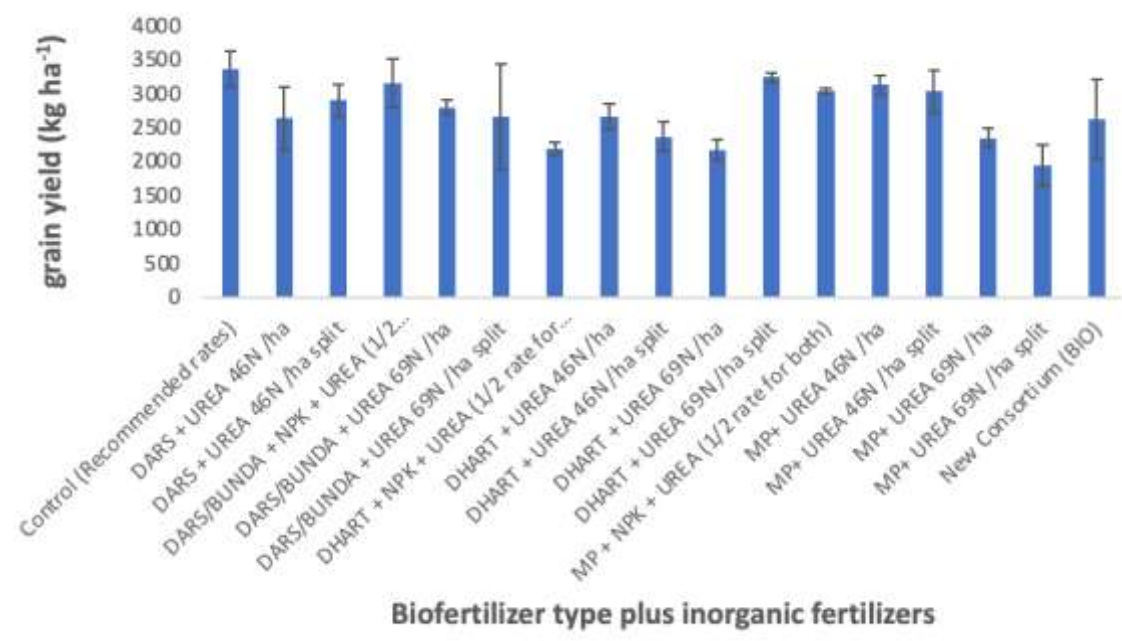


Figure 4 Effects of biofertilizers and inorganic fertilizers on maize grain yield at Chitedze site

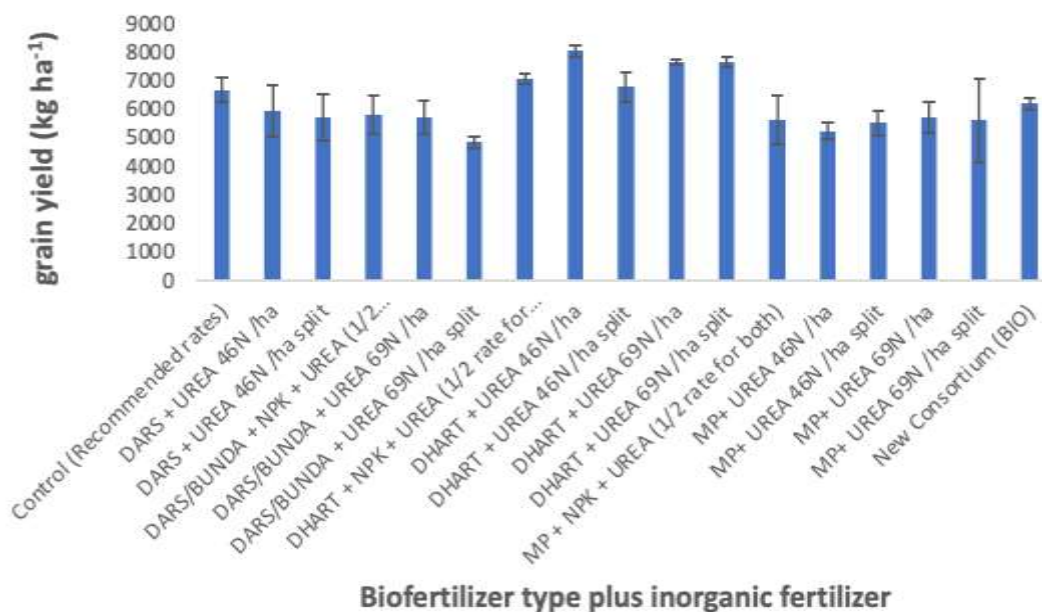


Figure 5 Effects of biofertilizers and inorganic fertilizers on maize grain yield at Nachisaka site

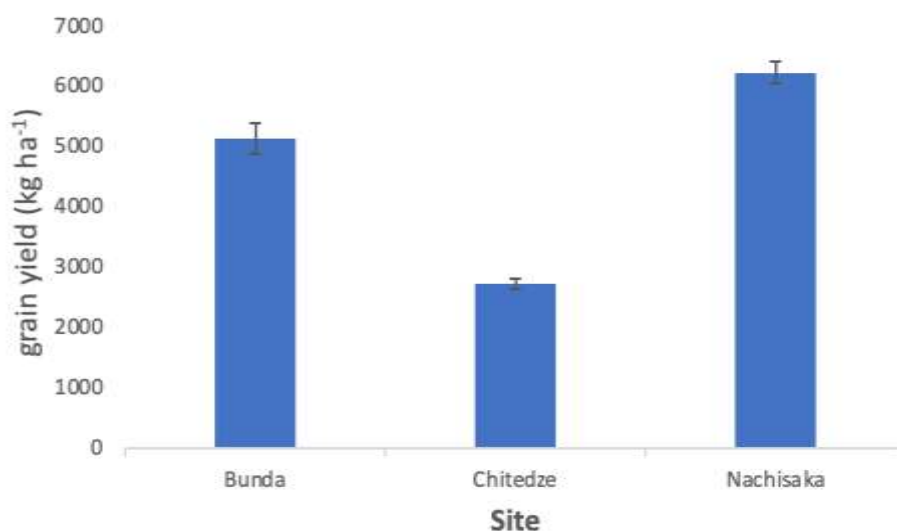


Figure 6 Grain yield at Bunda, Chitedze and Nachisaka sites as influenced by interaction of site and treatments

**Conclusion**

From this study it is noted that different microbial strains influenced growth both as microbial strain treatments and in interaction with applied inorganic fertilizer. There are a good number of microbial strains with potential of being used for production of biofertilizer combinations. Biofertilizers both in integration with inorganic fertilizers as a sole application influenced increase in maize grain yields. Site has an influence on the performance of biofertilizers and on the overall grain yields. From this study it can be recommended that additional seasons of field experiments on the various biofertilizer combinations to ascertain the effects of site influences will be important.

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## Soil moisture and Nutrient Monitoring Innovations for Optimizing Irrigation Benefits

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### Abstract

Production of more crop yields with less water is the greatest challenge that the irrigation sector faces. This project applied a learning by doing approach using innovative tools that monitor soil moisture and nutrient to enhance productivity while minimizing resource use under irrigation farming. The tools used are chameleon sensor and wetting front detectors. The Chameleon illustrates information on soil moisture status by colours – blue, green and red colours representing adequate moisture, moderate and dry soil status, respectively. They were deployed to irrigation schemes between 2015 and 2022 and four schemes with two lead farmers and twenty follower farmers per scheme were sampled for this report. During implementation, farmers participated in tools installation, soil moisture and nutrient data collection and in making irrigation decision through learning by doing. The chameleon system was combined with online communication and learning system. The results showed that soil moisture and nutrient monitoring innovations optimized irrigation benefits in various ways. The tools gave farmers new frames of reference to identify water and nutrient management problems for them to promptly change their irrigation tradition by acting on information provided. Intrinsically, their actions led to reduced irrigation intervals thereby reducing the amount of water, time, and labour by 50 % and also reduced conflicts for irrigation water by 75 % among farmers. Crop yields and average gross margins increased by > 80 % and threefold across all irrigation schemes and crops, respectively. Use of soil moisture and nutrient monitoring technologies became a rigor that the scientists easily communicate science to lay farmers and initiate the movement of farmers who know how to use water in times of scarcity. It can be concluded that adoption of combined use of sensor monitoring innovation and learning systems transform irrigation into profitable and sustainable investments in Malawi.

**Keywords:** Irrigation, chameleon sensors, learning by doing, soil moisture and nutrient monitoring.

### Introduction

Soil is a media of plant growth and hence fundamental in the food value chain as it acts as a reservoir of water, gases and nutrients for good plant growth. The soil is greatly reliant on the interactions between water and gaseous phases which stimulates plant roots access to mineral nutrients (Mengel *et al.*, 2001). A well-managed soil allows more water and nutrients to be infiltrated and reserved with plant reach by minimising run-off and less to be leached by permitting a deep rooting zone. For this reason, soil water must be maximised regardless of the farming system, as it can help optimise the trade between water and carbon that can improve crop yield at the farm level. Passioura and Angus (2010) accentuated that only water and nutrients that is transpired and utilised by the crop contribute to crop production. For this reason, all runoff, direct evaporation from the soil surface, leaching below the root zone, and residual moisture at harvest reduce crop yield, water and nutrient use efficiency below its potential. Henceforth, if farmers in Africa want to turn all the soil water and nutrient into crop yield at potential level, there is the need for them to learn how to manage the soil, crop and other inputs in a way that

maximises transpiration and hence maximised crop yields (Passioura and Angus, 2010). However, soil water and nutrient management by smallholder farmers especially under irrigation have typically been by trial and error resulting into great crop yield losses in the sub – Saharan Africa (Guy Sela, 2019).

Experience shows that there is a long history of measuring soil water and nutrient in the irrigation industry to control water inputs using sophisticated equipment (gypsum block, tensiometer and neutron probe), however, most farmers still use tacit knowledge (soil feel) and equipment is just used as a guide as reported in Australia (Stirzaker *et al.*, 2014; Charlesworth, 2005). It has been proven in other studies that prior experiential knowledge is priority over the use of the tools thus adaptive management (Whittenbury and Davidson, 2010). Meffe *et al.* (2002) defined adaptive management as ‘the process of treating natural resource management as an experiment such that the practicality of trial and error is added to the rigour and explicitness of the scientific experiment, producing learning that is both relevant and valid’. Hsaio *et al.* (2007) commended that a learning-by-doing approach that relies on farmers having access to monitoring tools improves water use efficiency in agricultural systems. Adaptive management assists in avoiding scientific’ approaches to try completely displace subjective experiences (Whittenbury and Davidson, 2010). A study was implemented with a hypothesis that simple soil water and nutrient monitoring tools that provide information that farmers can easily understand are essential for the practice of adaptive management (AM) in irrigated agriculture. The aim of the study was to adapt the use of sensor farmer–friendly monitoring technology in measuring soil water and nutrients for improved efficiency of resources in the food value chain for climate change adaptation.

## **Materials and Methods**

### **Location**

The project consisted of on-farm demonstrations for adaptation purposes. On – farm demonstrations were implemented at Nanzolo Irrigation Scheme in Chikwawa (2015 – 2018), Bwanje Irrigation Scheme in Dedza (2015 – 2018), Bethani Irrigation Scheme in Rumphi (2018 – 2022), and Malengwe Irrigation Scheme in Chitipa (2018 – 2022). Various crops – maize, common beans, and tomatoes were used in the study.

### **Study Description**

The Chameleon wi-fi field readers and sets of sensor arrays and the fullstop wetting front detectors were deployed to four irrigation schemes that were selected. Twenty-two farmers per irrigation scheme were selected. Within these twenty-two farmers, two were lead farmers and twenty were follower farmers. The chameleon sensor arrays and fullstop wetting front detectors were installed on each farmer’s field. The sensor arrays were installed at 10 cm, 15 cm, 30 cm, and 45 cm depth whereas the fullstop wetting front detectors were installed at 20 cm and 40 cm.

Soil moisture and nutrients data was being collected for a minimum of three days per week. The chameleon wi-fi field reader was being used to measure soil moisture status which was later being tethered with a phone in order to upload the data onto the website. Water abstracted from the fullstop wetting front detectors was being tested for Nitrates every time an irrigation was carried out. The results from the Nitrate tests were being recorded and entered manually onto the website. During implementation, farmers participated in tools installation, soil moisture and nutrient data collection and in making irrigation decision through learning by doing. The chameleon system was combined with online communication and learning system.

### **Description of the simple soil moisture tools**

#### **Chameleon and Chameleon sensor array**

The Chameleon Reader (Fig. 1) measure soil water status and displays the level of soil water suction as blue (wet soil), green (intermediate soil moist) and red lights (dry soil). Chameleon illustrates information on soil moisture status by colours - blue, green and red colours representing adequate moisture, moderate and dry soil status, respectively (Stirzaker *et al.* 2014).



Figure 1 Chameleon wi-fi field reader and set of sensor arrays

#### **Full stop Wetting Front Detector Assembling and installation**

At least a 20 cm or larger in diameter hole was augured for the wide end of the detector funnel and another 5-20cm in diameter for the narrow end of the funnel. Filter sand was poured into the funnel until it covered the locking ring by at least 1 cm. The detector was lowered into the hole and measured the distance to the locking ring then the fullstop wetting front detector (Fig. 2) was buried. The site over the detector was watered with at least 20 litres or more after installation to trigger the float.

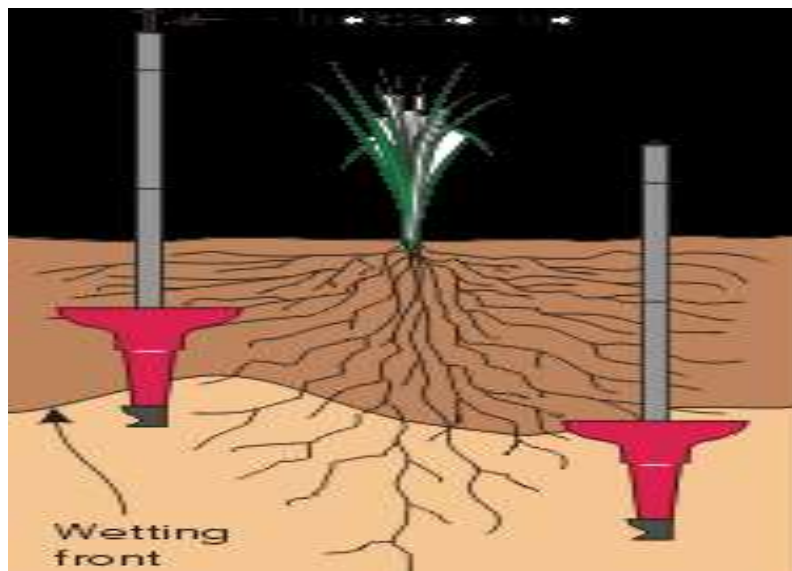


Figure 2 Fullstop wetting front detector

#### **Data collection and Visualization**

The chameleon Wi-Fi Field Reader was being connected to a sensor array, and paired to a Wi-Fi connection, to send data to the web once, twice or three times per week which could instantly be

visualized as raw data or as a pattern. Field data collectors facilitated field data collection and uploading on the website with farmers' involvement.

## Results

### Effect of application of chameleon sensors on gross margins at irrigation schemes

Farmer discussion groups regularly reported substantial increases in yield post-introduction of the tools at the four irrigation schemes in Malawi. Although there have been a large number of written farmer testimonies, it was hard to know how widespread success is, since it is often the lead group who volunteer such information. However, the project collected data from 198 farmers and provided robust data on environmental, social and economic impacts. The figure 3 gives some insight into data collected at Bwanje Irrigation scheme: A plot of gross margin of green maize and beans showed that farmers progressively increased their profit from 2016 to 2018 for beans (Figure 3). The profit was lowest in 2016 (MK 172 540.00) and highest in 2018 (MK 1 777 940.00). On the other hand, the profit was highest in 2016 (MK 1 573 940.00) and lowest in 2018 (MK 1 468 069.00) for green maize (Figure 3).

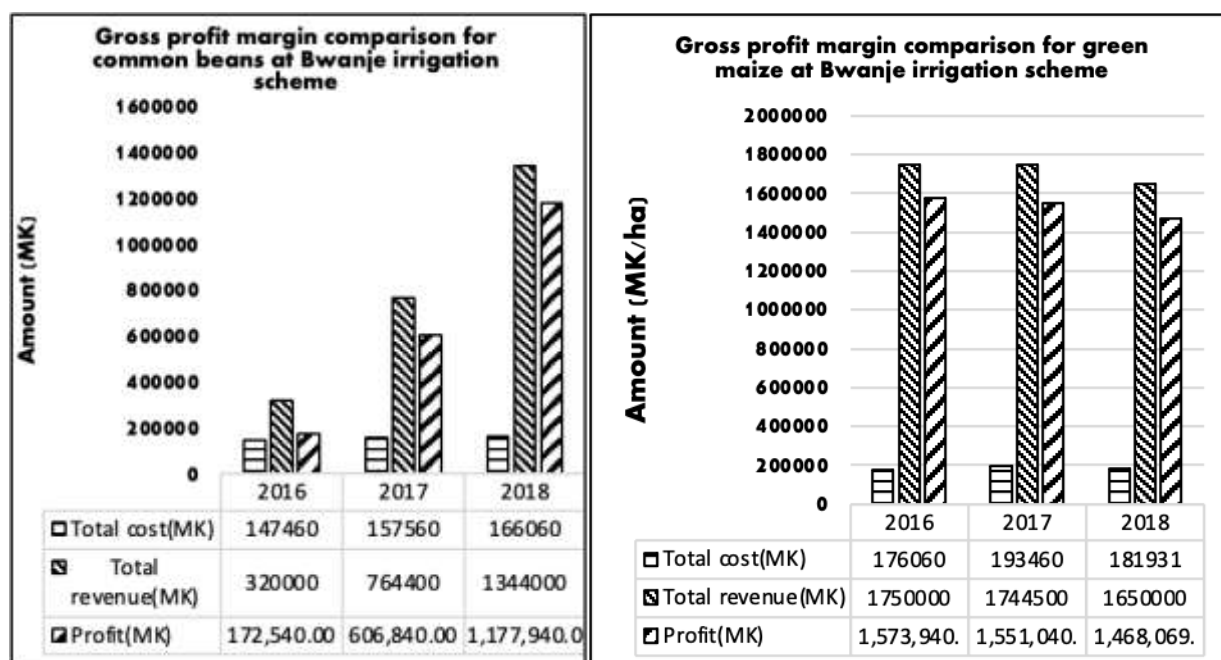


Figure 3 Gross margin analysis for green maize and beans at Bwanje irrigation scheme

### Influence of the tools on Water and nitrate leaching and number of irrigations among smallholder farmers at four irrigation schemes.

Preliminary observation by farmers who used the tools in the four seasons – it was reported that tools helped them to reduce the frequency of irrigation. Farmers did not need to irrigate when there was adequate moisture monitored using chameleon sensors. This led to saving water and time and minimised leaching of nutrients (that is associated with over-irrigation). This meant the community could increase crop production and optimal nutrients usage by the crops. Tools facilitated a change in community attitudes towards irrigation – from the current *ritual irrigation* to irrigation that is based on crop water/moisture demand. This change in attitude is noticeable among the farmers in the four schemes in Malawi. In 2016, 74% of the farmers overirrigated (blue), 9% green (moist) and 17% red (dry) (Figure 4a). Over – irrigation increased Nitrate leaching (45% of fields) at the time that farmers started learning using tools in 2015 – 2016. With time of learning using tools in 2017 and 2018, farmers started reducing irrigation resulting in less nitrate leaching from the irrigated fields (Figure 4b).

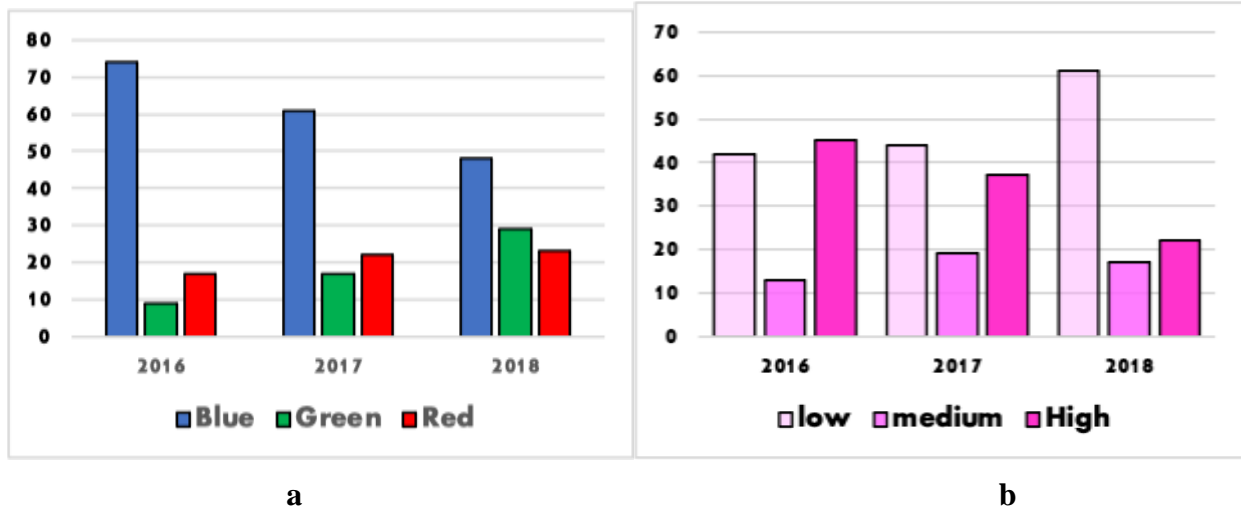


Figure 4 Influence of sensors on irrigation (4a) and Nitrate leaching (4b)

Once the farmers got information with the use of the soil moisture and nutrient monitoring tools they made the decision to improve water and nutrient management. Other farmers used to irrigate 13 times in maize and 9 in beans per season before the tools. Use of tools has helped them to decrease the number of irrigation events in each season (Figure 5). A reduction in number of irrigation led to decreased amount of water used to irrigate crops. The estimated amount of water applied reduced steadily between 2017 and 2018 after learning to make irrigation decisions with tools. Similarly, new schemes - Tadala, Matabwa and Mthumba started saving water after learning by doing from the early adopting schemes of Bwanje, Nanzolo and KCGL.

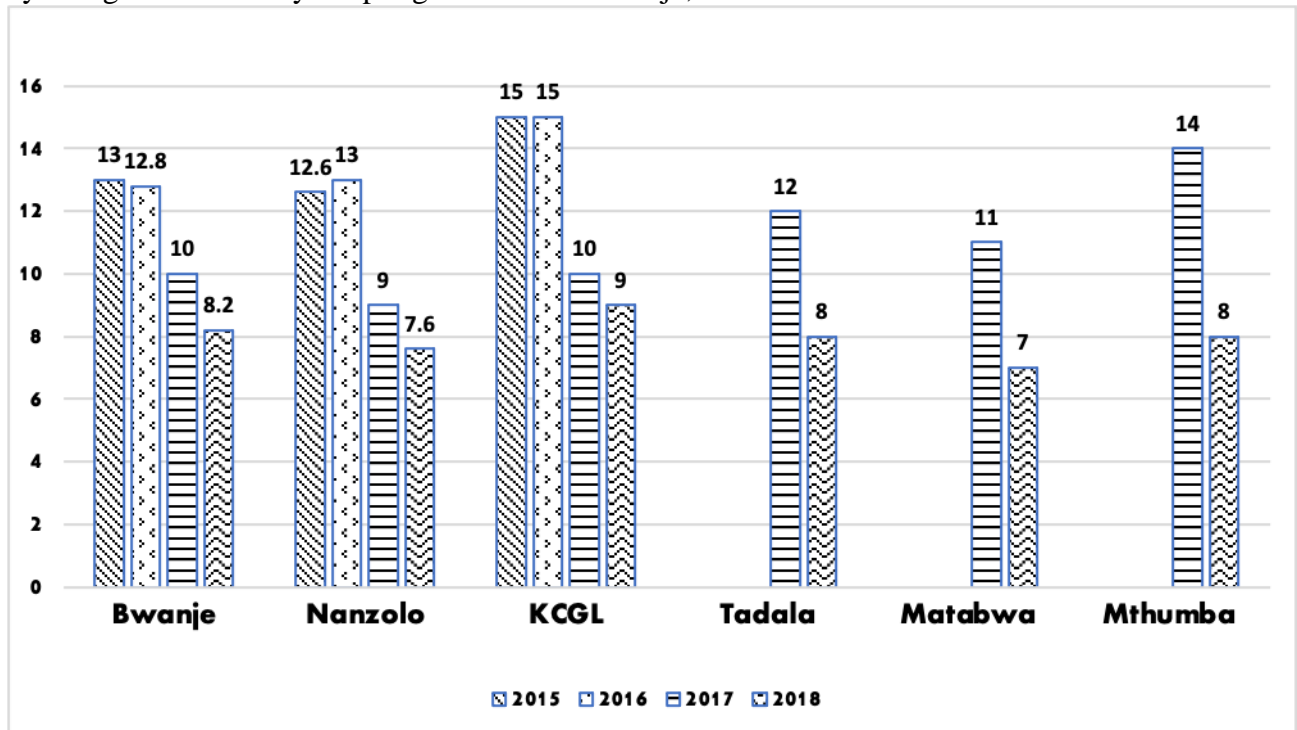


Figure 5: Number of irrigations per season

A baseline survey finding (2015) showed that (33.04%, n=40) had been involved in a conflict and 66.4% (n=69) reported that they had heard of conflict in their communities pertaining to water use (Figure 6a). In 2017 only 16.8% of farmers under intervention have been involved in a conflict while 33.4% of farmers under control were involved in water related conflict within the implementing schemes (Figure 6b).

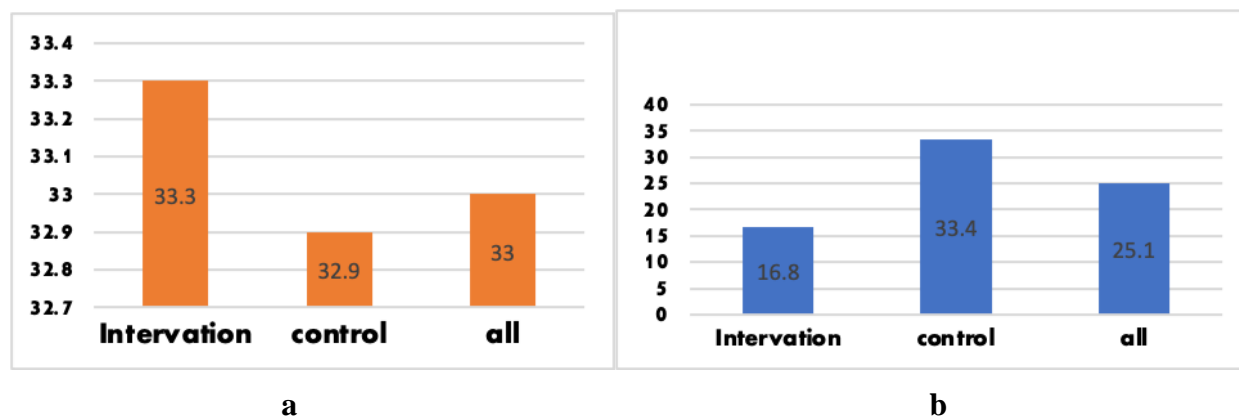


Figure 6 Level of conflicts at irrigation schemes in 2015 (6a) and 2017 (6b)

### Discussions

This study revealed great economic, social and environmental benefits that can be realised by learning by doing at irrigation community level using adaptive water and nutrient management in food value chains with simple soil moisture and nutrient tools as the focal point of learning. On-farm demonstrations demonstrated that use of the tools can economically help smallholder farmers to improve crop yields, reduce amount of irrigation water (water-saving), labour and time to irrigate (time and labour saving) consequently crops can be grown based on their actual water requirement and limited financial input for labour and water pumping costs. With such tools, a well-managed soil is realised as it allows more water and nutrients to be infiltrated and reserved with plant reach by minimising run-off and less to be leached by permitting a deep rooting zone (Passioura and Angus, 2010). Furthermore, the results of on-farm demonstrations prove that application of chameleon reader and sensor can easily help improve adaptive water management at farm level for climate change adaptation.

Adaptive water management for climate change adaptation is realised from the knowledge – learnt from the use of tools that it helped improve crop yields through better management of irrigation water, soil nutrients, and salt by using simple tools. One of the most unexpected outcomes from the introduction of the tools in the irrigation schemes is a greater understanding of conflict on the schemes. Well-functioning schemes need coordinated action – not only for shared responsibilities like paying for water fees and contribution to canal maintenance but also for coordinated buying on inputs and marketing of produce. The social capital necessary to underpin such activities is probably our least understood aspect of smallholder schemes. The use of chameleon sensors in an adaptive way exposed bad management (those denied sufficient water by the governance system) and also those who break the rules (use water out of turn or take too long to irrigation thus delaying others access). For example, one farmer reported that “there was favouritism as far as water distribution is concerned. The authority of water distribution fall in the hands of the Group Village Headman as such once you crossways with him then you hardly receive water in your field hence much red was recorded.” Another reported that she “is among farmers who are close to the water hydrant thus giving her easy access to irrigation water as such getting water for her field was easy hence the blue being the majority state.”

Use of tools in irrigation water and nutrient management provided a novel way to condense large amounts of information to give new insights into equity and governance of water and how it relates to crop yield at scheme level.

### **Conclusions**

The study aimed at improving adaptive water and nutrient management using simple farmer-friendly monitoring technology in measuring soil water and nutrients for improved efficiency of resources in the food value chain for climate change adaptation. The study combined objective and subjective knowledge to generate enough scientific, economic and social testimonies that the use of tools in monitoring soil moisture from farmers through focus groups and farmer discussion groups improve water management and crop productivity.

Farmers used less water in response to persistent blue colour on the Chameleon. This usually took the form of increasing the time between irrigation events. There was reduction in conflict over water in the schemes as more water became available, particularly to downstream users. Time saved from not irrigating was invested in other activities such as weeding or off-farm income-generating activities. Yields were also greatly improved and increased due to the use of the soil moisture monitoring tools.

Overall, the chameleon sensors and WFD gave satisfactory results in monitoring and managing soil water as the colour patterns helped to show when to irrigate. It can, therefore, be seen as a useful tool in irrigation water management through continuous soil water monitoring in Malawi.

### **Acknowledgements**

We wish to express our heartfelt indebtedness to Department of Agricultural Research Services (DARS) and Department of Irrigation Services in the Ministry of Agriculture, Irrigation and Water Development (MoAIWD) for facilitating implementation of the VIA Project, the technical team comprising of Mr. James Mwepa, Ms. Faith Fandika and Ms. Ellacy Chisale who gave enthusiastic and motivating technical support during the data collection and analysis. Thanks, Commonwealth for Scientific and Industrial Research Organization (CSIRO) in Australia, Association for Strengthening Agricultural Research in East and Central Africa (ASARECA), University of Pretoria and Department of Agricultural Engineering at LUANAR for mutual and solitary efforts during the VIA project implementation. Many thanks also go to Irrigation & Drainage Research Attendants and staff of Kasinthula Agricultural Research Station with whom we shared knowledge and work in many different ways to accomplish the project objectives. Finally, I would like to acknowledge ACIAR funding on the “Virtual Irrigation Academy for improved water productivity in Malawi, Tanzania and Republic of South Africa” that has helped to study simple soil moisture and nutrient monitoring tool at on-station and on-farm levels at more than nine different irrigation schemes in Malawi.

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**Tables**

Table 1 Effect of application of chameleon sensors on number of irrigation and amount of water applied to Maize - bean cropping system

Irrigation/Cropping System/Nitrogen Treatments	Number of irrigations			Mean	Amount of water applied (m <sup>3</sup> /ha)			Mean
	N1	N2	N3		N1	N2	N3	
<b>Control</b>								
Maize – Bean Intercrop	12	13	13	12	6,806	7,389	7,389	7,195
Sole Maize Cropping	13	13	12	13	7,389	7,583	7,194	7,389
Sole Bean Cropping	9	8	8	8	5,056	4,861	4,861	4,926
<b>Mean (n =)</b>	<b>11</b>	<b>11</b>	<b>11</b>	<b>11</b>	<b>6,417</b>	<b>6,611</b>	<b>6,481</b>	<b>6,503</b>
<b>Green-Green-Blue (GGB)</b>								
Maize – Bean Intercrop	12	12	11	12	7,000	7,000	6,611	6,870
Sole Maize Cropping	12	14	13	13	7,194	8,167	7,389	7,583
Sole Bean Cropping	9	9	9	9	5,056	5,056	5,250	5,121
<b>Mean (n =)</b>	<b>11</b>	<b>12</b>	<b>11</b>	<b>11</b>	<b>6,417</b>	<b>6,741</b>	<b>6,417</b>	<b>6,525</b>
<b>Red – Red – Blue (RRB)</b>								
Maize – Bean Intercrop	10	10	10	10	5,833	5,639	5,833	5,768
Sole Maize Cropping	10	10	10	10	5,833	5,639	5,639	5,704
Sole Bean Cropping	7	8	7	7	3,889	4,667	3,889	4,148
<b>Mean (n =)</b>	<b>7</b>	<b>7</b>	<b>7</b>	<b>7</b>	<b>5,185</b>	<b>5,315</b>	<b>5,120</b>	<b>5,207</b>
CV (%)								9.3
Significance level								
Irrigation treatments				p<0.001				p<0.001
Cropping system				<p0.001				p<0.001
Nitrogen				NS				NS
Irrigation * Cropping system				p<0.05				P<0.05
Irrigation * Nitrogen				NS				NS
Irrigation*Nitrogen*Crop system				NS				NS
LSD								
Irrigation				0.648				377.8
Cropping system				0.427				249.1
Nitrogen				0.557				325.0
Irrigation * Cropping system				0.777				453.3

Table 2 Effect of application of chameleon sensors on total income and economic water productivity of maize-bean cropping system

Irrigation/Cropping system/Nitrogen Treatments	Total income (MK)			Mean	Economic Water Productivity (MK/m <sup>3</sup> )			Mean
	N1	N2	N3		N1	N2	N3	
<b>Control</b>								
Maize–Bean Inter.	1,507,891	1,439,300	1,549,939	1,499,043	222.4	194.2	210.7	209.1
Sole Maize Crop	1,071,630	928,861	1,052,111	1,017,534	145.8	126.8	145.3	139.3
Sole Bean crop	1,302,000	1,037,711	1,147,819	1,162,510	257.3	212.0	236.1	235.1
<b>Mean (n =)</b>	<b>1,293,840</b>	<b>1,135,291</b>	<b>1,249,956</b>		<b>208.5</b>	<b>167.7</b>	<b>197.4</b>	
<b>Green – Green – Blue (GGB)</b>								
Maize–Bean Inter.	1,559,226	1,868,367	1,488,419	1,638,671	222.7	268.1	225.3	238.7
Sole Maize Crop	1,073,833	1,064,704	1,303,019	1,147,185	149.0	130.4	177.9	152.4
Sole Bean crop	1,235,111	990,033	1,187,667	1,137,604	244.1	204.0	227.7	225.3
<b>Mean (n =)</b>	<b>1,289,390</b>	<b>1,307,701</b>	<b>1,326,368</b>		<b>205.3</b>	<b>200.8</b>	<b>210.3</b>	
<b>Red – Red – Blue (RRB)</b>								
Maize–Bean Inter.	1,276,046	1,260,207	1,630,883	1,389,045	219.9	228.3	281.9	243.4
Sole Maize Crop	1,109,407	848,457	1,190,315	1,049,393	194.2	152.3	212.5	186.3
Sole Bean crop	1,228,422	1,056,806	1,074,759	1,119,996	318.4	226.5	290.1	278.3
<b>Mean (n =)</b>	<b>1,204,625</b>	<b>1,055,157</b>	<b>1,298,652</b>		<b>244.2</b>	<b>202.4</b>	<b>261.5</b>	
<b>Significance level</b>								
Irrigation treatments				NS				0.043
Cropping system				<0.001				<0.001
Nitrogen				NS				NS
Irrigation * Cropping system				NS				NS
Irrigation * Nitrogen				NS				NS
Irrigation*N*Crop sys.				NS				NS
<b>LSD</b>								
Irrigation				105227.3				30.57
Cropping system				137566.6				25.41
Nitrogen				128447.7				27.02

Table 3 Effect of irrigation scheduling techniques on bean yield and mean height of bean plants

Treatment	Yield (ton/ha)	Plant height (cm) at harvest
T1 – Chameleon Sensor	2.643	73.47
T2 – Tensiometers	2.222	73.77
T3 – Fixed Irrigation	2.175	72.40
Grand mean	2.347	73.21
Lsd	0.5582	2.274
Cv%	8	0.8
Fpr	0.143	0.319
Sign	NS	NS
SE	0.1889	0.587

Sign = Significance, NS= Not significant, CV= Coefficient of Variation, SE= Standard Error, Lsd = Least significant difference at P< 5%, Fpr=probability value Trt = Treatment

Figures

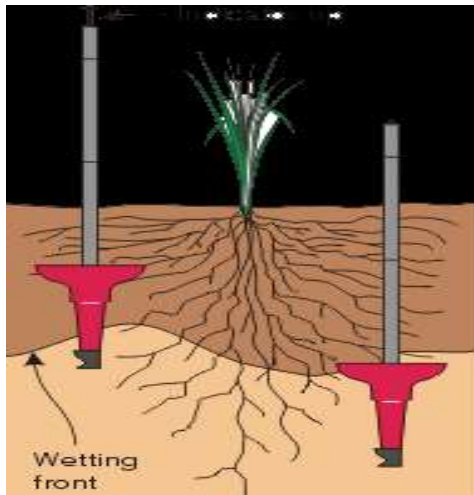


**Plate 1 - Chameleon Reader**



**Plate 2 - Chameleon Sensor arrays**

Figure1 The wi-fi chameleon reader (plate 1) and chameleon sensor arrays set (plate 2)



**Single full-stop wetting front detector**

Figure 2 Full-stop wetting front detector for monitoring nutrients and determining irrigation depth



Figure 3 Nitrate strip (4a) and Chameleon EC meter (4b) used to show how much nitrate is there within a particular soil depth and electrical conductivity respectively

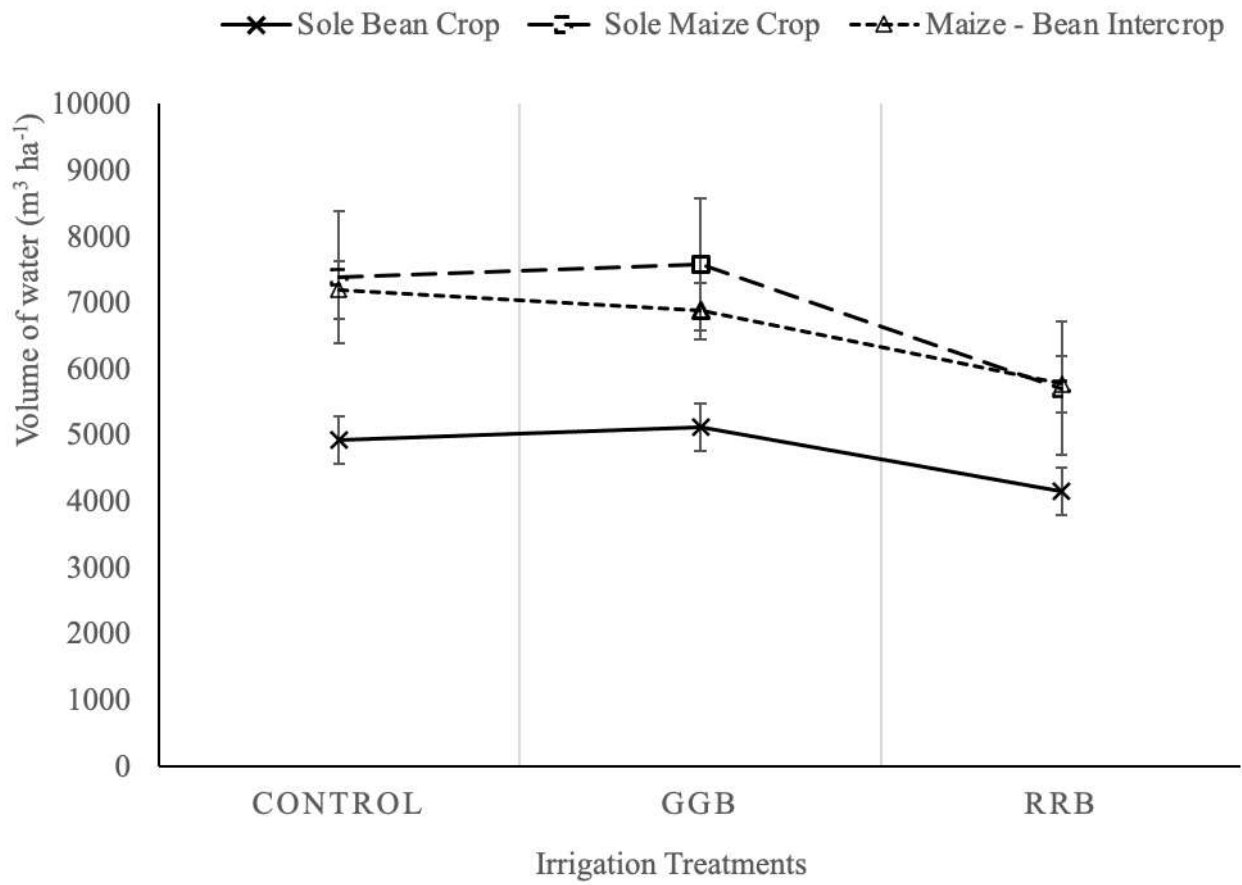


Figure 4 Interaction between irrigation and cropping system on number and amount of irrigation.

a. Soil moisture color pattern and irrigation graphs

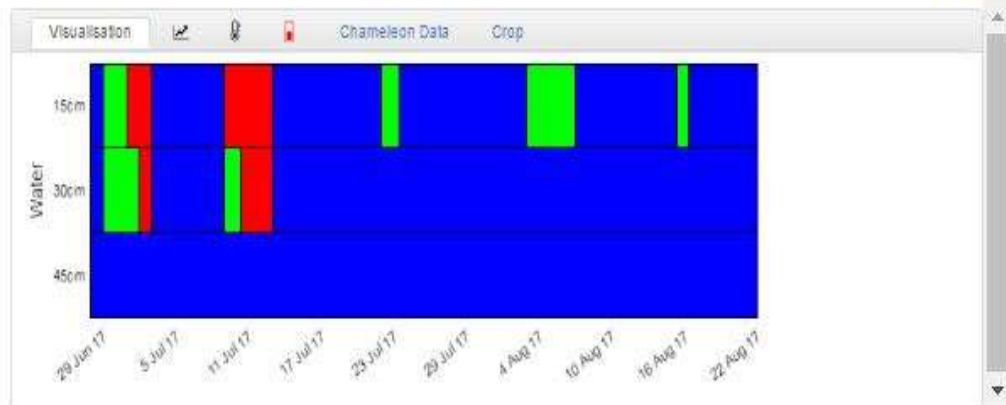
Irrigation Bay: intercropping maize and beans

Crop: Maize, Description: intercropping of maize (medium maturing variety) and beans (early maturing variety), Yield: 5.88t/ha, Planting Date: 1 Jun 17, Harvest Date: 9 Oct 17 Sensor: Jack



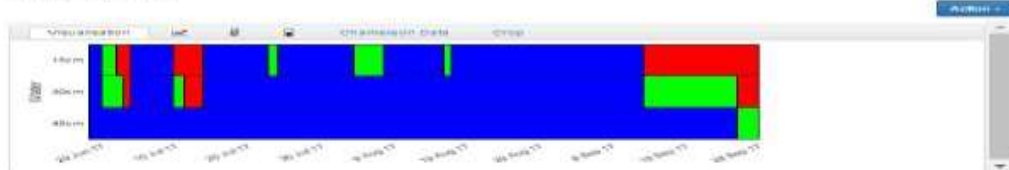
Irrigation Bay: intercropping maize and beans area #2 irrigation when first two depths shows red

Crop: Beans, Yield: 0.73t/ha, Planting Date: 1 Jun 17, Harvest Date: 29 Aug 17 Sensor: Jack



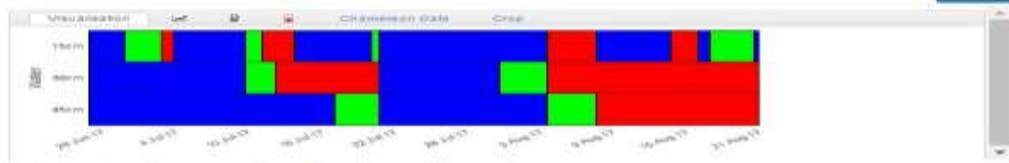
Irrigation Bay: Intercropping maize and beans area #2 irrigation when first two depths shows red

Crop: Maize, Description: maize medium variety/ beans early maturing variety, Yield: 3.45t/ha, Planting Date: 12 Jun 17, Harvest Date: 9 Oct 17 Sensor: Jack



Irrigation Bay: Intercropping of maize and beans 2

Crop: Beans, Yield: 0.96t/ha, Planting Date: 1 Jun 17, Harvest Date: 29 Aug 17 Sensor: Jack



Irrigation Bay: area #3R of bean with irrigation done when the first two depths shows red

Crop: Beans, Description: this is an early maturing variety, Yield: 2.222t/ha, Planting Date: 1 Jun 17, Harvest Date: 30 Aug 17 Sensor: Jack



Irrigation Bay: intercropping maize and beans

Crop: Beans, Yield: 0.71t/ha, Planting Date: 1 Jun 17, Harvest Date: 29 Aug 17 Sensor: Jack

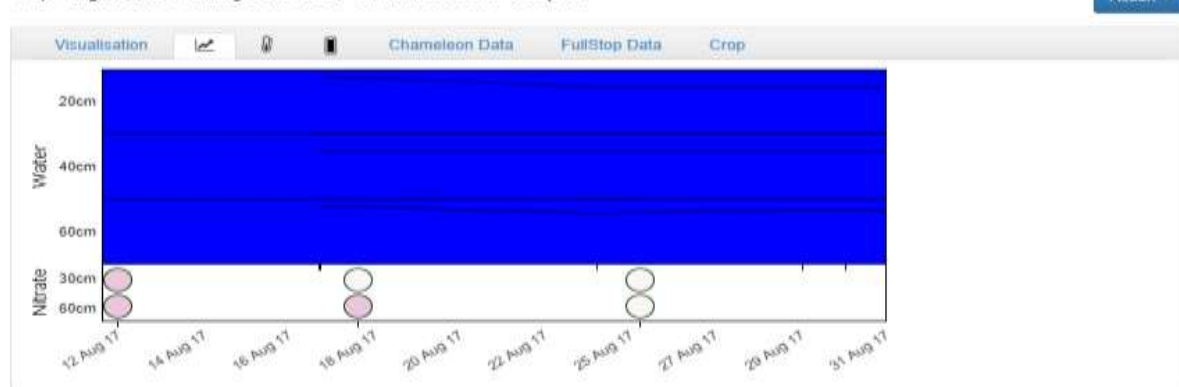


Irrigation Bay: intercropping maize and beans

b. Irrigation graphs within the pattern

Irrigation Bay: LP5

Crop: Sugarcane, Planting Date: 1 Jul 17, Harvest Date: 1 Sep 17



The visualisations from the Chameleon Sensor readings for LP5 showing nitrate readings (<https://via.farm/visualisefarm/138/past/2017/>)

Irrigation Bay: LP3

Crop: **Sugarcane**, Planting Date: 1 Jul 17, Harvest Date: 1 Sep 17

Action ▾

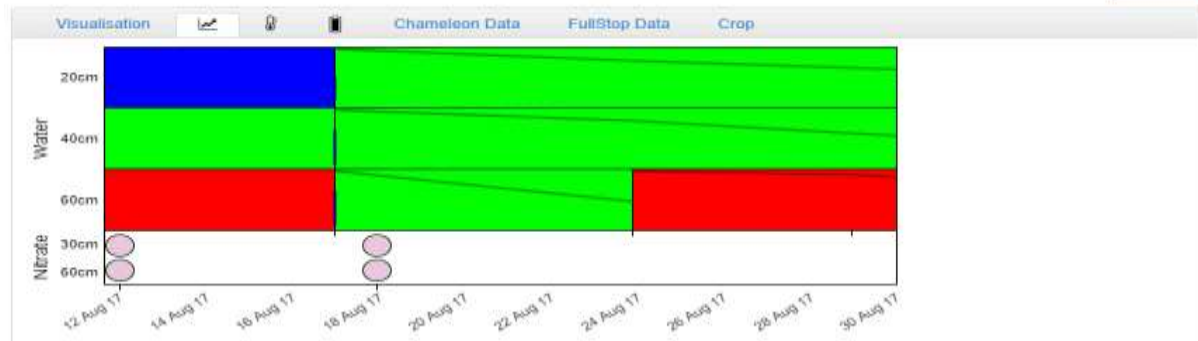


Figure 5 The visualisations from the Chameleon Sensor readings for LP3 showing nitrate readings (<https://via.farm/visualisefarm/138/past/2017/>)

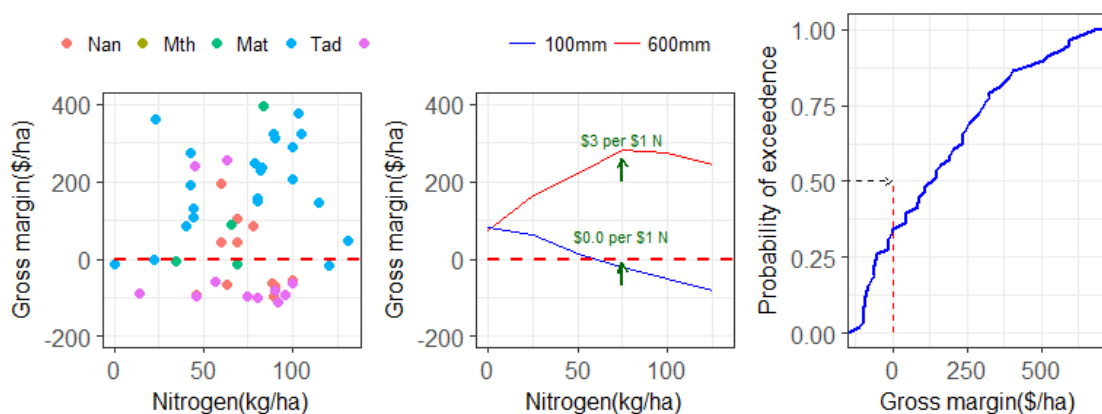


Figure 6 Gross margin analysis of Maize against fertilizer applied

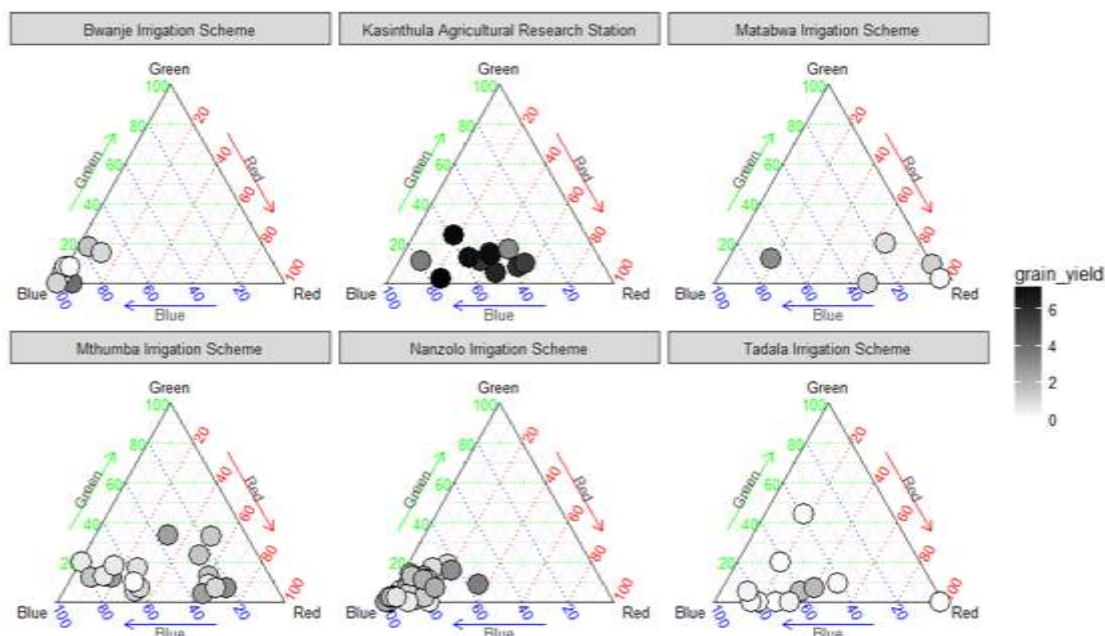
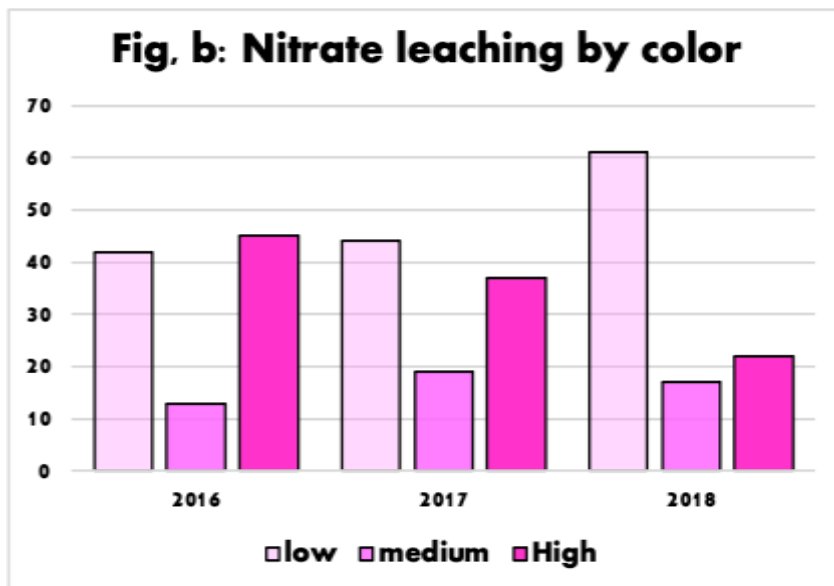
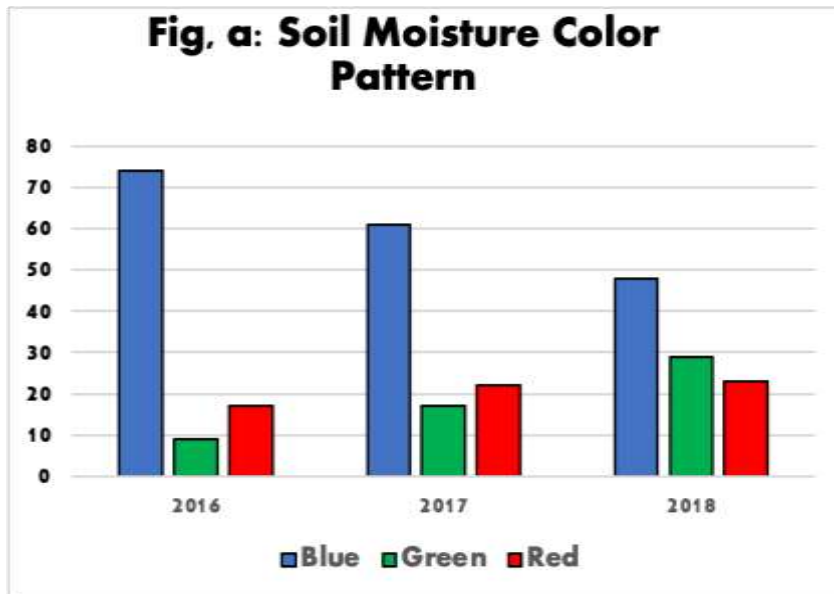
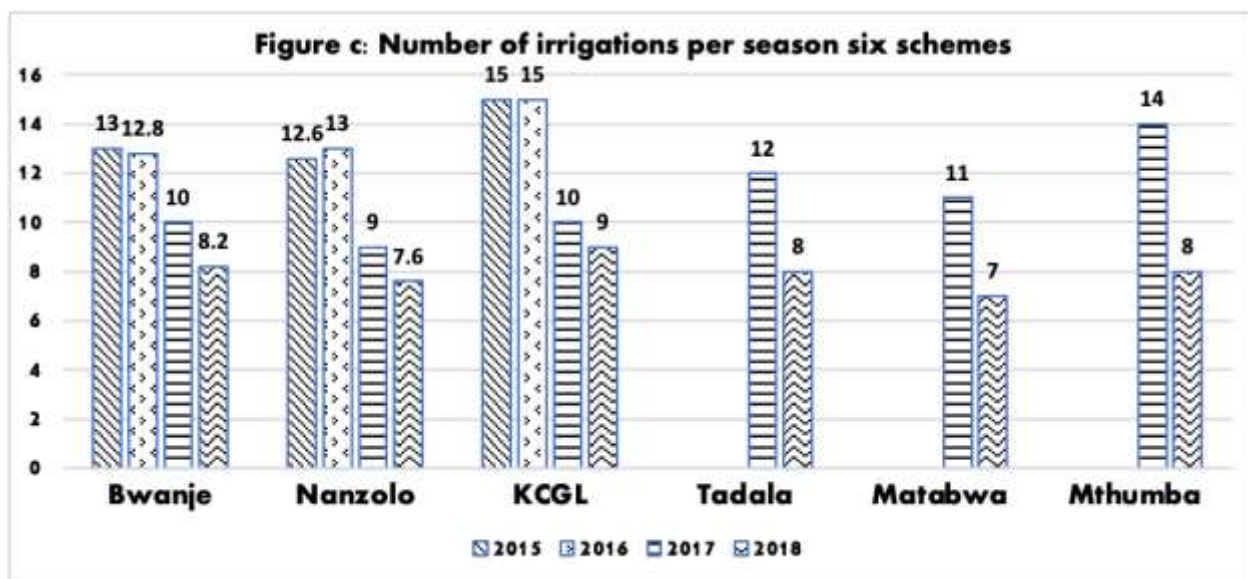


Figure 7 Triads highlighting issues of equity and governance at three irrigation schemes in Malawi.





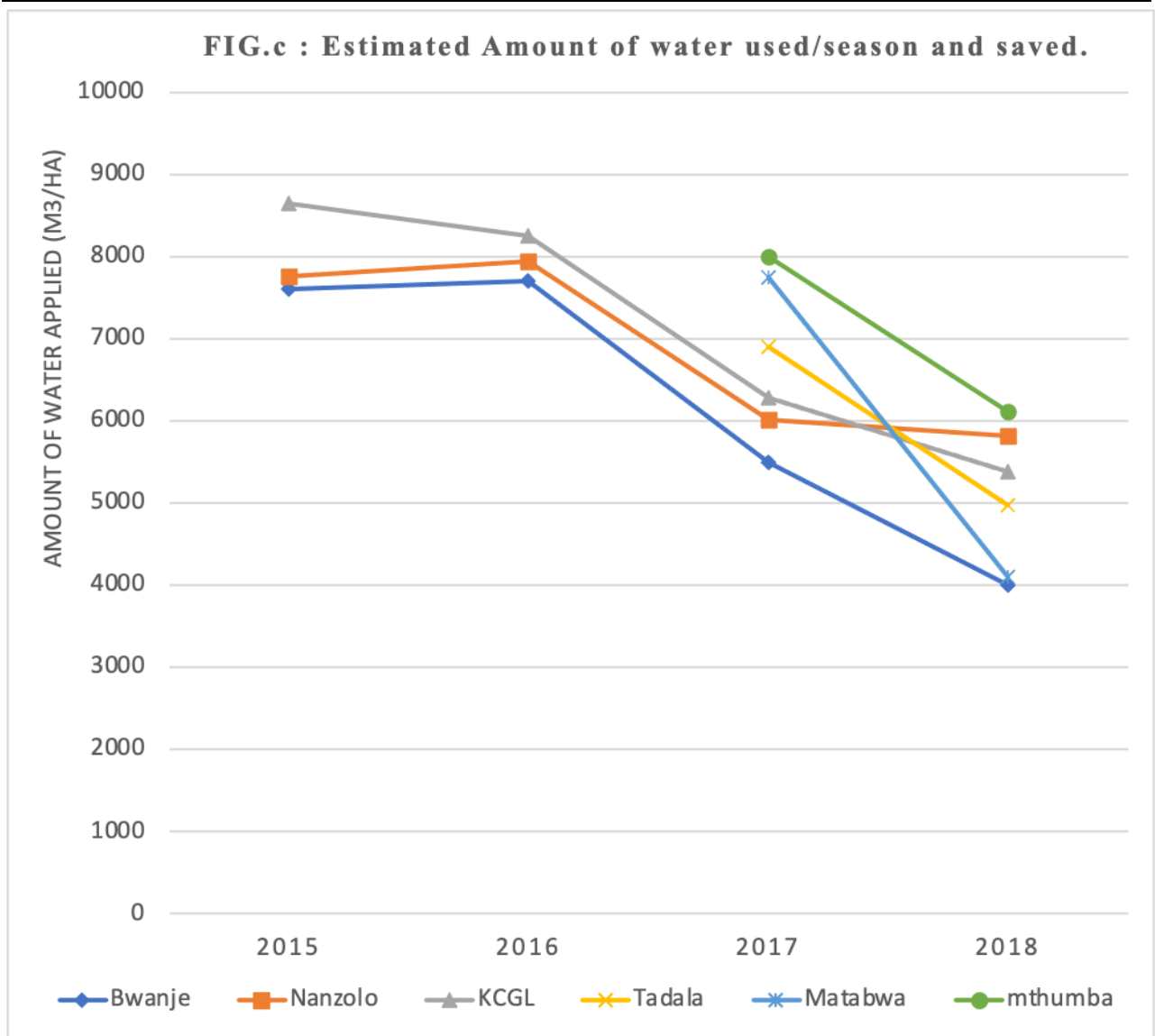


Figure 8 Influence of the tools on Water and nitrate leaching and number of irrigations among smallholder farmers in Nine irrigation schemes.

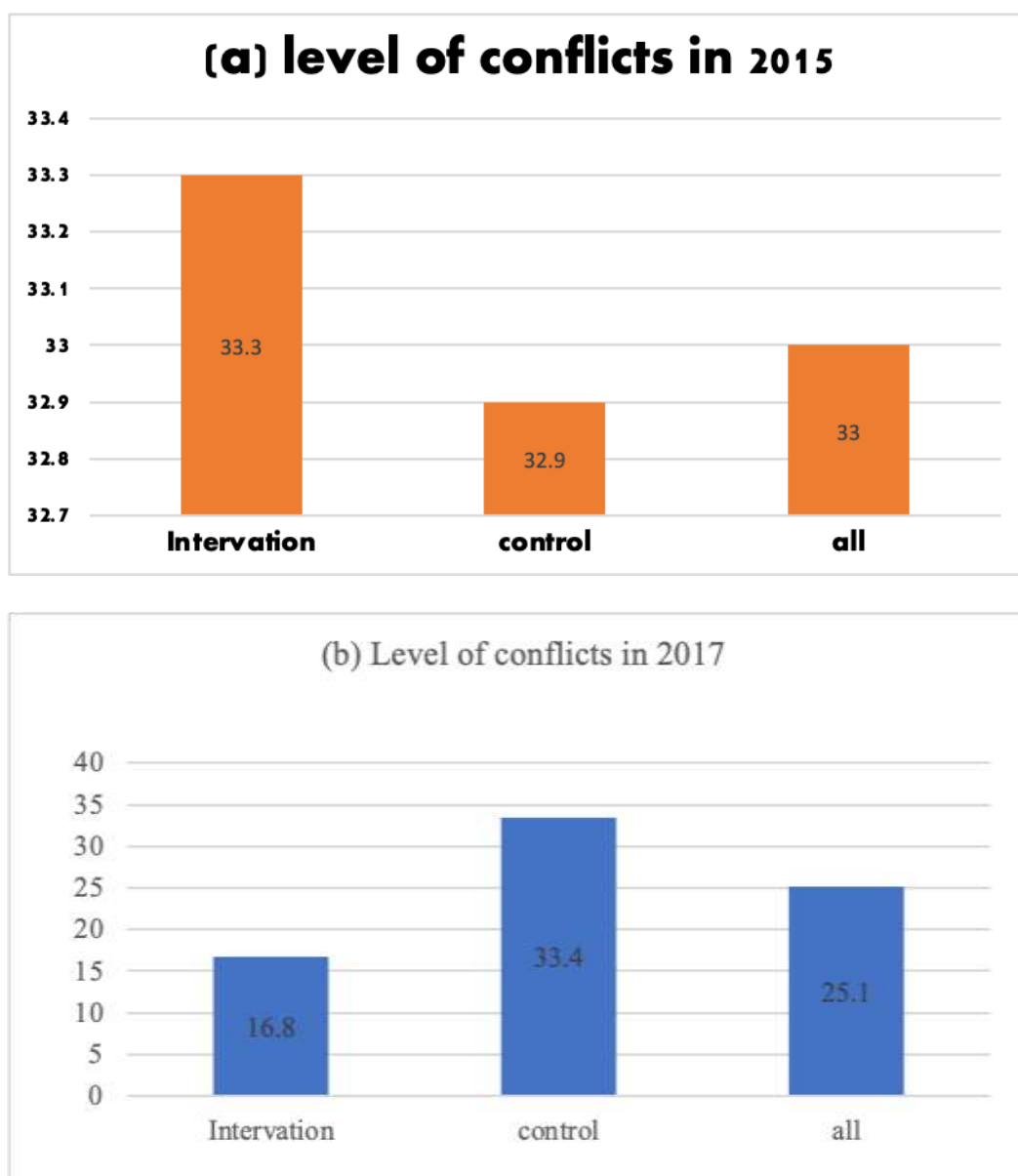


Figure 9 Influence of the tools on conflict management among smallholder farmers in Nine irrigation schemes.

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## Assessment of Quality and Safety Characteristics in Smoked *Diplotaxodon* species using Traditional and Improved Smoking Kiln in Southern Lake Malawi

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### Abstract

The study was conducted to determine quality and safety of smoked products using traditional smoking kiln (TSK) and improved smoking kiln (ISK). Multiple analyses were used to define stability of smoked products along the value chain which is a complex event. Proximate composition results show significant differences in terms of moisture content (P=0.0001), protein content (P=0.0003) and fat content (P=0.0001). Microbiological results indicated higher total viable counts from TSK were 5.9 log cfu/g than in ISK 2.2 log cfu/g. Bacteria flora isolated in TSK and ISK were specific spoilage organisms (SSO), *Escherichian coli*, *Salmonella*, *Listeria monocytogenes*, *Staphylococcus aureus*, *Clostridium perfringens*, and *Vibrio spp.* with level of 4.2 log cfu/g, 2.3 log cfu/g, 5.1 log cfu/g, 0 log cfu/g, 4.1 log cfu/g, 5.0 log cfu/g and 0 log cfu/g, 3.5 log cfu/g, log 0 cfu/g, 4.8 log cfu/g respectively. The storage life of smoked products for TSK and ISK were estimated at 3 and over 9 weeks, respectively. Total Volatile Base-Nitrogen (TVB-N) and primary oxidation increased significantly (p<0.05) with storage time in traditional smoking kiln than in improved smoking kiln, which was lower and remained below the acceptable limit throughout the storage period. Smoked products under storage from improved smoking kiln have longer storage life than traditional smoking kiln. The innovation has the potential to address issues of quality and safety of smoked fish products as it creates unavailability of ionically water molecules needed by micro-organisms in smoked products.

**Keywords:** Quality, safety, *Diplotaxodon* species, smoking kiln

### Introduction

In Malawi, fisheries sector is a major contributor to animal protein and represents a potential pathway for out of poverty for many value chain actors, due to its steady contribution role in nutrition and trade (Chiwaula et al, 2019). The high-quality protein and micronutrients in fish products plays a significant role in combating the triple burden of hunger and hidden hunger (micronutrient deficiency) (Kolding et al., 2019a). Many of the nutrients found in fish are particularly important for child growth, development and cognition (WorldFish, 2011; Jamu & Njaya, 2011). However, fish is one of the most highly perishable food products (Jeyasanta et al, 2016). During handling and storage, deterioration of fresh fish occurs rapidly, limiting its quality and shelf life (Singini, Kaunda et al, 2013; Likongwe et al 2018). Enzymatic and chemical reactions are usually responsible for the initial loss of freshness whereas microbial activity is responsible for the obvious spoilage (Saeed, 2009). The high perishability nature of fish demands for it to be processed through sun drying and smoking.

However, the use of traditionally smoking kilns requires a lot of firewood, time, and labor to smoke the fish. Improving the fishery value chain of Malawi through outscalling of modern technologies and best

practices can increase the livelihood and nutritional benefits of fish products by increasing the economic and nutritional value of traded fish products (Evance, Kapute, Tembo, Phiri, & Hon, 2019). The improved smoking kiln is one of the innovations which has potential in smoking and producing quality fish products (Chiwaula, Kawiya, & Kambewa, 2019). Using species such as *Diplotaxodon*, as a case study was designed to help understand the impact this method may have on the quality and safety of smoked fish products. It is against this background that, the present study aims at determining the effect of using improved smoked kiln (ISK) and traditional smoking kiln (TSK) on microbiological, and physiochemical changes of smoked fish products using turn over time during period of storage.

## Material and methods

Fish processing methods included processes involved in fish smoking in the traditional and improved smoking kilns (figure 1). Fresh fish was part of the treatment and acted as the reference point.



Figure 7 Improved smoking kiln L Traditional smoking kiln

## Sample analysis

About 50 kg of fresh *Diplotaxodon* species were used in this experiment. The samples were obtained from RV Ndunduma. Before the beginning of the experiments, the samples were thoroughly cleaned using portable water. Temperature degrees and time was set up accordingly, samples were smoked at initial temperature of 30°C which was drying the samples for 30 minutes. After 30 minutes, the device temperature was set on 50°C for 30 minutes this was aimed at cooking the samples. After, the second phase of smoking, the device was set at 80°C for 60 minutes this was aimed at smoking the fish.

Microbiological analyses

### Total plate count (TPC)

1 mL of 1:10 dilutions was transferred using a pipette to petri plates and melted Iron agar at 45°C poured on the plates, content mixed and allowed to solidify. After solidification, the plates were covered with a thin layer of iron agar then incubated at 22°C for 48 hours. All the microbiological analyses were conducted in duplicate, and data expressed as a logarithm of the number of colony (white and black)-forming units (log cfu/g).

### Isolation of bacteria flora from smoked fish samples

The morphological characteristics of the various bacterial isolates in vitro were noted in the agar plates, and microscopy. Representative isolates were re-plated on various selective media after staining reactions (gram staining) and several biochemical, carbohydrate (sucrose, glucose, fructose, lactose, and mannitol) to observe their habits and specific colony attributes such as colour, size, and shape.

### Physiochemical analyses

Smoked fish samples were analysed for physiochemical parameters following methods outlined by AOC (2002). The samples were analysed for crude protein, crude fat, crude ash, moisture content, total volatile basic nitrogen and lipid hydroperoxide.

### Data analysis

Microbiological data was log transformed (cfu/g) to give clear picture of the phase growth for microorganisms in smoked products during storage. Physiochemical data were analysed using the Microsoft Excel 2013 to develop graphs for clear evolutions against storage period. Level of significance for proximate content and microbial analysis data was determined using one-way analysis of variance 95% confidence value ( $P=0.05$ ).

## Results

### Quality of smoked fish products

#### Microbial load of smoked products

Table 1 shows a summary of microbiological analyses results from the two processing methods. Significant higher bacteria population was observed in traditional smoked products 5.9 log cfu/g which were above acceptable norms 5.0 log cfu/g than in improved smoking kiln log 2.2 cfu/g ( $P=0.001$ ). Pathogenic enteric bacteria species such as specific spoilage organisms, *Esherichian coli*, *Salmonella*, *Vibrio*, *Listeria monocytogene* and *Staphylococcus aureus* were present in significant numbers ( $P=0.001$ ,  $P=0.021$ ,  $P=0.000$  and  $P=0.004$  respectively) in traditional smoked fish products than in improved smoking kiln.

Table 1 Bacteria species isolates (log colony forming units per gram) from fresh and smoked products

Treatment	TVC	SSO	<i>E. coli</i>	<i>Salmonella</i>	<i>L. monocytogenes</i>	<i>S. aureus</i>	<i>C. perfringens</i>	<i>Vibrio</i>
Fresh	4.2	2.9	2.5	2.2	0	1.9	0	2.8
TSK	5.9	4.2	5.1	4.1	5.0	3.5	0	4.8
ISK	2.2	2.3	0	0	0	0	0	0
<i>P-value</i>	0.003	0.001	0.021	0.000	0.004	0.031	0.602	0.011

### Proximate composition of fresh and smoked *Diplotaxodon* species

The summary of proximate composition shows moisture content 16.11±1.34% and 11.86±0.69%, 37.02±0.03% and 40.94±0.12% crude protein and 19.21±2.78% and 16.45±0.26% fat content, 12.13±0.13% and 11.96±0.62% ash content for TSK and ISK, respectively. It was observed that moisture content, crude protein and crude fat were significantly different (p<0.05).

Table 1 Proximate composition of fresh and smoked *Diplotaxodon* species

Treatment	Moisture	Crude protein	Crude fat	Ash
Fresh	86.9±0.68 <sup>a</sup>	36.15±0.06 <sup>b</sup>	20.24±0.56 <sup>a</sup>	11.49±0.41 <sup>a</sup>
TSK	16.11±1.34 <sup>b</sup>	37.02±0.03 <sup>b</sup>	19.21±2.78 <sup>b</sup>	12.13±0.13 <sup>a</sup>
ISK	11.86±0.69 <sup>c</sup>	40.94±0.12 <sup>a</sup>	16.45±0.26 <sup>c</sup>	11.96±0.62 <sup>a</sup>

<sup>1</sup>Data represent means ± standard error of three measurements.

<sup>2</sup> Means with the same superscript along rows are not significantly different (p>0.05)

### Storage life of smoked fish products

#### Total Viable counts (TVC)

The changes in total viable counts in smoked fish products are shown in Figure 2.0. Significantly higher (p=0.004) total viable counts were observed in smoked samples from traditional smoking kiln than improved one. Total viable counts at week 3 were above acceptable norms of log 6.0 cfu/g for smoked fish products from TSK. Specific spoilage organisms were significantly higher at p<0.05 in samples from TSK than in ISK.

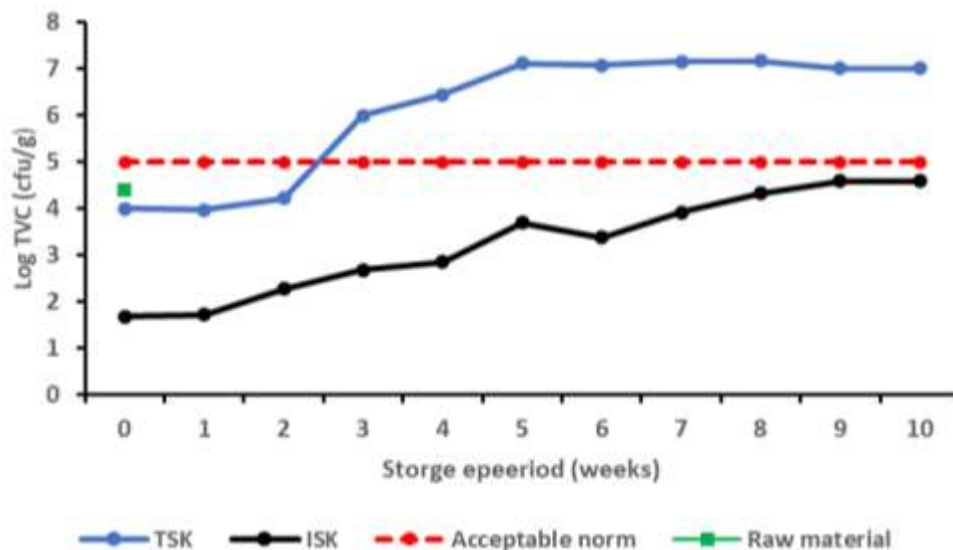


Figure 8 Evolution of total viable counts in smoked fish samples from ISK and TSK

#### Total Volatile Base-Nitrogen (TVB-N)

Level of TVB-N mg/100g from traditional and improved smoking kiln stored at room temperature range were 16.90-137.20 mg/100g and 21.20-224.90 mg/100g, respectively. The level of TVB-N from traditional smoking kiln were above the acceptable norms of 30-35 mg/100g (Jamila, Kailasam, Giftson, & Jeyasanta, 2018) for smoked fish products at week 4 and were deemed unsafe for consumption at week of storage. TVB-N increased significantly (p=0.001) with storage time in traditional smoking kiln

than in improved smoking kiln, which was lower and remained below the acceptable limit throughout the storage period.

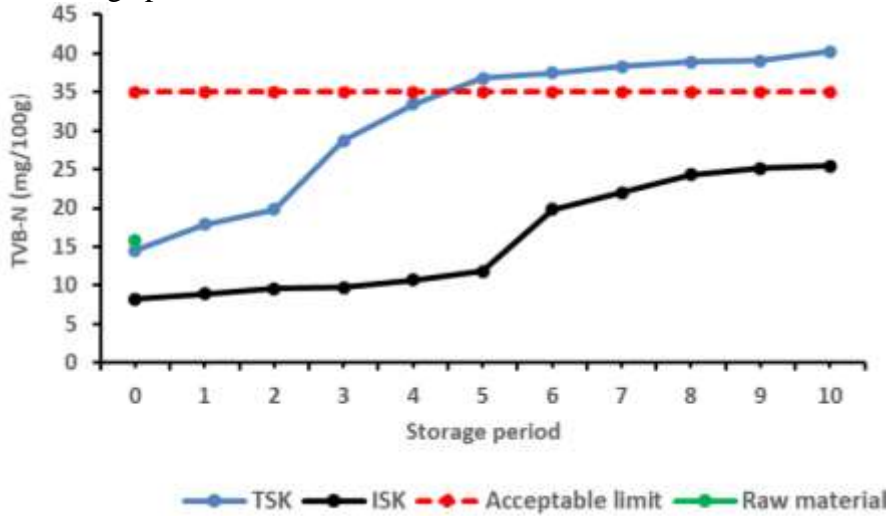


Figure 9 Level of TVB-N during storage period of smoked samples

**Lipid hydroperoxide value (PV)**

Figure 3.0 shows results of peroxide value (PV) presented as milliequivalents (meq) peroxide per 1 kg of fat extracted from the fish samples. Hydroperoxide formation, was significantly higher ( $p < 0.05$ ) in traditional smoked samples than in improved smoked kiln. Hydroperoxide production was more rapid in samples from traditional smoking kiln, and later reached the peak of above the acceptable norm of 10-20 meq/kg than in in sample from improved smoking kiln. After week 5 PV values decreased, it can be inferred that the hydroperoxides were further degraded into TBAs, which are responsible for producing the rancid taste in smoked fish products.

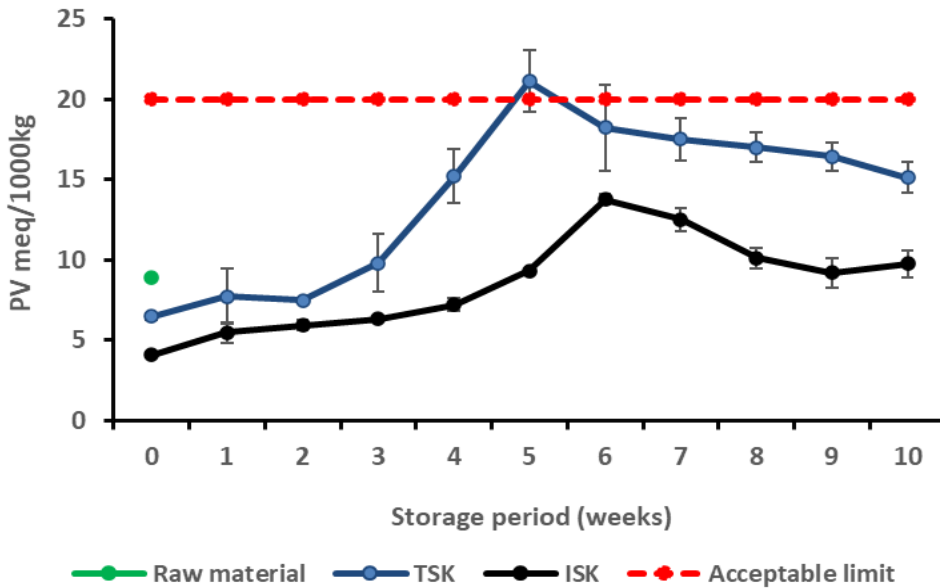


Figure 10 Level of hydroperoxide value (PV) in smoked products under storage

## Discussion

Fish is processed to reduce and prevent the level at which quality loss proceeds and to diversify fish products to suit different taste preferences of consumers. After smoking, water content of the final product sample was slightly higher in traditional smoking kiln compared with the improved smoking kiln. This increase was probably a consequence of smoking kiln process with the aspect of crossed circuit system. Inversely, protein content was increased due to the decrease in water content. The decrease in moisture content in smoked fish products was important as it helped to reduce spoilage due to bacteria activity. It describes the range of energy states of the water in fish products and the relationship of water activity to moisture content in a non-linear known as a moisture sorption isotherm curve (Romotowska, et al., 2016). Improved smoking kiln decreased significantly the moisture content and water activity in the final fish product which later became crucial for product storage.

Fish products harbours its own microflora during production and storage, and their population is a function of raw material flora, processing, preservation, and storage conditions. The proposed threshold and limit of acceptance for human consumption is  $\log 7$  cfu/g for total viable counts (ICMSF, 1986). The initial quality of the raw material used was good and fit for smoking, as indicated by the low number of bacteria (4.2  $\log$  cfu/g). The effects of smoking methods were observed after smoking. It was observed that after smoking, Total viable counts reduced in improved smoking kiln but increased significantly in traditional smoking kiln. These results would be attributed to potential of cross contamination due to multiple handling. These findings agree with the previous study of Siskos et al. (2007), where the microbial flora in smoked trout fillets was lower after the liquid smoked processing than raw material and remained stable during storage. Pathogenic bacteria were found in high numbers in products from traditional smoking kiln than in improved smoking kiln products. These bacteria flora is responsible for quality loss of smoked fish products (Ozogul & Balikci, 2016). Also, specific spoilage microorganisms were higher in traditional smoked products than improved smoked fish products.

Results for TVB-N showed a pronounced level in traditional smoking kiln than in improved smoking kiln products. Total volatile base nitrogen (TVB-N) is important compound providing a measure of the progress of spoilage that is reliant of sensory assessment (Goulas & Kontominas, 2005). The development of TVB-N as spoilage indicators in smoked fish products is due to a combination of microbiological, chemical, enzymatic, and physical events (Sigurjon, Thorarinsdottir, & Thorkelsson, 2013). Quality fish products has TVB-N values of up to 25 mg/100 g, “good quality” has values of up to 30 mg/100 g and the “limit of acceptability” goes up to 35 mg/100g, and “spoilt fish” has above 35 mg/100 g (Goulas & Kontominas, 2005). TVB-N contains total amount of volatile nitrogen bases with nitrogen which is synthesized by reaction from protein and include ammonia, monomethyl amine, dimethyl amine, sulphur compounds, and trimethyl amine (Romatowska, et al., 2016; Cakli, Berna, Tolga, & Sebnem, 2006).

Lipid hydroperoxides are primary products of lipid oxidation in smoked fish products (Nguyen, Arason, & Eikevik, 2014). There was increase in hydroperoxide value in smoked *Diplotaxodon* species from traditional smoking kiln than improved smoking kiln. The levels were above acceptable range of 10-20 meq/kg fish fat (Sigurjon, Thorarinsdottir, & Thorkelsson, 2013). The increase in hydroperoxide was due to the generation of primary products caused by the presence of oxidation initiators such as enzymes (Romotowska, Karldottir, Gudjonsdottir, Kristinsson, & Sigurjon, 2016). It is apparent that the storage of samples from traditional smoking kiln drives oxidation during early stages of oxidation process. A low and higher PV at a certain point during the storage of a smoked products indicate both an early phase of autoxidation and a late stage of a severely oxidized products, where most hydroperoxides were

broken down. These products comprise aldehydes, ketones, short chain fatty acid and others, many of which have very unpleasant odours and flavors, hence affect product sensory properties and acceptability. Their combination yields the fishy and rancid character associated with oxidized fish lipid (Sigurjon, Minh Van Nguyen , & Thorarinsdottir , 2013).

### Conclusion

The use of ISK in smoked *Diplotaxodon* species under storage increases quality and shelf life to 8 weeks than in TSK which was 3 weeks. This is due to reduction in bacteria flora multiplication, and lipid oxidation. In this regard, it is recommended for adoption and out-scaling among fish processors to produce quality and safe smoked fish products in the value chain of Malawi fishery. Also, this will be vital in meeting the matching issues of harmonizing between the quality and safety of smoked pelagic fish products as stipulated by Malawi Bureau of Standards (MBS). This has potential in developing the sustainable fish value chains which can offer important pathways out of poverty for the millions of poor fisherfoks in Malawi.

### Acknowledgement

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## **Does the same fate await them both? A tale of two fish processing technologies among small scale fisher folk along Lake Malawi.**

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### **Abstract**

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Background: The importance of fish and fishery products to the livelihood of people in developing countries need not be overemphasized. This notwithstanding fish consumption in Malawi remains relatively low, partly due to post harvest losses estimated at 40 percent. Two fish processing technologies (the improved smoking kiln and the solar tent dryer) have been developed in Malawi to reduce fish post-harvest losses. However, their uptake by small scale fishers remains low. Given the low uptake, we ask whether the same fate await these two fish processing technologies. This paper assesses factors that influence uptake of improved smoking kiln and solar tent dryer. Methodology: The paper is based on qualitative data that was collected from 20 focus group discussions and 15 key informant interviews conducted across four lakeshore districts of Malawi. Data organization was done in NVivo and thematic analysis was employed to identify relevant themes. The study's findings show that, firstly, knowledge of the technology in question plays an important role in the formation of behavior intentions. However, acting out such intentions is contingent upon one's ability to pay for the technology either using own generated resources or access to external financing. Secondly, technology promoters need to have thorough understanding of contextual issues that are unique to a community's acceptability of the technology in question. Finally, when costs associated with erection of solar tent dryers was factored in, and the need for formal lucrative markets becomes obvious, promotion of off-takers seemed to offer better solutions and benefits to small scale fishers. The fate, with regards to upscaling, of improved fish processing technologies hinges on perceived usefulness, access to financing for the technologies and perceived returns on investment. Clearly, commercialization alongside the promotion of off-takers presents the best chance for the adoption of improved fish processing technologies.

**Key words:** Off-takers, fish processing technologies, adoption, post-harvest losses.

### **Introduction**

The importance of fish and fishery products especially to people in developing countries has been well documented. Fish is one of the cheapest sources of dietary protein especially in isolated fishing communities (FAO 2010, Chidammodzi and Muhandiki 2015). Fish also offers employment to many and it is estimated that globally, the fishery sector offers employment to over 70% of people living within the water-bodies (Shettima et al. 2014). It is estimated that about 1.28 million tons of fish is harvested annually from the African lakes either through large scale commercial or artisanal (Sterner et al. 2019). In Malawi, fish is one of the most valuable food commodities that is being traded (Nagoli et al. 2010). Presently, the total annual fish landings is around 200,000 tons and approximately 25% of this total landed fish is marketed fresh while the rest is processed using traditional methods of smoking, frying, parboiling and sun drying. Unfortunately, not all the processed fish is done so out of choice i.e. while the fish is still fresh, but sometimes it is processed out of desperation, i.e. because the fish has

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already showed signs of spoilage. While the global fish consumption per capita has increased from 9.9 kg in the 1960s to a record high of 20 kg in 2014 (FAO, 2016), the situation in Malawi has remained relatively at low levels (9.1 kg lower than in 1970s) partially due to post-harvest fish losses (GoM 2011). The National Fisheries and Aquaculture Policy of Malawi, Policy Priority Area 3: Fish quality and value addition (GoM 2016) recognizes the importance of food safety and quality that includes fish products. In Malawi, fish quality and value addition are of major concern as 40% of the annual fish catch is lost due to post harvest spoilage and insect infestation. One of the policy statements to ensure improved fish quality supply and value addition is to promote the adoption of best practices that include sanitary aspects to enhance hygiene and sanitation and value addition for fish and fish products.

Therefore, the Department of Fisheries in collaboration with various stakeholders have taken a bold step towards developing technologies that aim at reducing fish post-harvest losses in Malawi. For example, a solar tent drier and an improved smoking kiln (ISK) were developed to replace the open sun drying method and open flame smoking kiln (bayala), respectively to improve fish quality, shelf-life and add value to fish and fishery products.

However, despite these various efforts, the usage of these technologies by the local fish processors remains relatively low. The solar tent drier and the improved fish smoking kiln are two fish processing technologies developed under the cultiAF's IDRC funded Nsomba Nchuma Project in Malawi that seek to modernize and add value to fish processing. The former is a modern technology that uses an enclosed wooden structure covered with a clear UV treated plastic sheet and seeks to replace the ordinary open sun fish drying racks while the latter is an improvement over the open flame bayala, a popular smoking process among fisher folk. However, the level of investment in the two modern technologies does not seem to be matched with the level of uptake. Adoption remains a pipe dream as fisher folk seem to still favor their old, trusted methods as the modern ones. This is evidenced from the structures that are seen in some landing sites either abandoned or turn to ruins. This paper, based on field observations and focus group discussions explores the reasons why adoption and up scaling the modern technologies remains a challenge.

It is a non-disputable factor that adoption of new technologies that have been developed through research and development (R&D) play a significant role in advancing agriculture (Rauniyar and Goode 1992). It is also a common knowledge that farmers or processors do not take up a technology just because it has been developed and is available because the decision to adopt a technology is complex and is influenced by several elements.

The objective of this paper is to assess the factors that have influenced fish processors in Malawi in adopting and using the newly developed fish processing technologies. We present and apply a modified analytical framework, showing the linkages and interaction between extrinsic variables and fundamental variables in the decision-making process of technology adoption.

## **Description of available fish processing technologies in Malawi**

### **Open sun drying**

The process is facilitated by natural conditions and targets all fish species (Banda et al. 2017). The fresh fish products are placed on racks raised above the ground. Drying is a complex process that involves instantaneous paired passing heat, mass, and momentum transport where heat penetrates the fresh fish muscle leading to removal of moisture (Nguyen et al. 2014). Likongwe Likongwe et al. (2018) reported that moisture content provides a dependable condition of microbial growth, lipid oxidation, non-enzymatic and enzymatic activities. Therefore, removal of moisture content is important for food

preservation along the value chain (Sigurjon et al. 2013). Ironically, Open sun drying has several limitations which include fecal contamination due to cross contamination, case hardening in which the surface of the products dries faster and form a thin layer while the underneath remains soft. This facilitates multiplication of specific spoilage microorganisms leading to degradation of the products (Mgwede et al. 2018).



Figure 1 Open sun drying

### **Kiln smoking/bayala**

Smoking processing method targets both small and big fish species including *Engraulicypris sardella* (Usipa), *Lethrinops* (Chisawasawa), *Copadichromis* (Utaka) and *Diplotaxodon* species (Ndunduma) (Samikwa et al. 2019). Horizontal and oval kilns are commonly used for smoking, but they allow an inconsistent temperature throughout the process. The importance of fish smoking is two-fold as it includes preservation, value addition through improved taste and product diversification (Goulas and Kontominas 2005, Sigurjon et al. 2013). However, the final product is compromised due to multiple handling steps (Mgwede et al. 2018). Furthermore, most smoking kilns use too much firewood for a small amount of product hence, increasing deforestation, a drawback in the fight against climate change.

### **Boiling/kufwafwadza**

Parboiling is a common processing method for *Engraulicypris sardella*. The process involves partial boiling of fresh *E. sardella* in hot water to partially break the fresh (Mgwede et al. 2018). Breaking the outer layer prevents case hardening during of the products. The partial boiled products are then subjected to open sun drying making the products prone to contamination with fecal materials and flies (Kolding et al. 2019). This makes the processed products to have high level of microbes that pose a health threat to consumers.



Figure 2 Boiling/kufwafwadza

### Deep frying

The method involves introducing fish into a hot oil to cook and remove its water content. It targets small pelagic fish species like *Copadichromis* and *Diplotaxodon* species (DoF 2018). Uncontrolled temperature of the oil it creates possibility of nutrients degradation. Furthermore, processors have the tendency of re-using the oil for process hence increasing the safety risk of the final product (Banda et al. 2017).



Figure 3 Deep frying

### Freezing/cooling (ice block business)

The freezing is ideal for super chilling of fresh fish products and maintaining a chilling temperature of +1°C (Nguyen et al. 2014). The method is important during handling of sensitive fresh fish hence extending shelf life of fresh fish products along the value chain by freezing water in tissue of fish. Water in fresh fish acts as a solvent for many organic and mineral compounds suitable environment for growth of micro-organisms and biochemical processes (Kolding et al. 2019).

### Improvements on two technologies

#### Solar tent dryer

Solar tent dryer is an adaptation for processing small fish species. It was designed and modified for processing small fish species (*Engraulicypris sardella*-Usipa, *Copadichromis* species-Utaka and

*Diploaxodon* species-Ndunduma) under Nsomba Nchuma project in southern part of Lake Malawi. A fish solar tent dryer enables fish to dry in all weather conditions and in a clean environment, and this ensures reduced quantitative and qualitative post-harvest losses (Chiwaula et al. 2018). A standard dimension of the dryer is 12m x 5m x 5.5m (length x width x height at the center) and the height at the side is 2.5m. The technology consists of air vent on the bottom and vertex with dimension of 30 cm x 30cm (Banda et al. 2017). It is made up of a UV treated polythene sheet 200 µm worn over a wooden frame. Due to its design, the technology can work and governed by the process of convection current process (Chiwaula et al. 2018). The technology is capable to provide enough amount of heat that is more than ambient heat under certain relative humidity (Banda et al. 2017). This increases the vapor pressure of the moisture kept and confined within the fresh fish products on racks and eventually decreases the relative humidity of the drying air so that the moisture carrying capacity of the air is increased (Chiwaula et al. 2018).

Solar tent drying in fish has fast drying rates and improves quality of dried products. Solar tent drying also saves energy and time, thereby making them environmentally friendly. In Malawi, the Samva Nyengo (All-Weather) Solar tent dryer is being promoted for processing small fish species as a package. The cost of a solar dryer with maximum carrying capacity of 850kg costs MK1,513,850 (US\$2100)-MK2,000,000 (US\$) to construct.



Figure 4 Solar tent dryer

### Smoking kilns

Improved smoking kiln (ISK) is an improvement of local smoking kiln. The technology works through a closed-circuit system and retain nutrients in final product. Furthermore, it is cost effective, efficient in energy use, less complex in operation, saves time and is sustainable. The products have enhanced flavor and its economic value is increased. The novel smoking method staging the thermal curing and the subsequent exposure to thick smoke within the same kiln without having to move the product has proved very convenient and effective (Likongwe et al. 2018). The innovation potentially makes smoked fish products improve on quality that meet guidelines stipulated by Malawi Bureau of Standard (MBS). It also complies with Codes of Quality Assurance (QA), Quality Management (QM) ISO-9000 (quality assurance). The improved energy efficient smoking kiln works through closed circuit air conditioning.



Figure 5 Smoking kilns

### Conceptual framework (adoption of technologies)

There are two theoretical frameworks that are used to assess technology adoption or the potential to adopt an emerging technology; the Technology Adoption Model (TAM) is mostly used to assess how people make a decision concerning a new technology (Davis 1989). On the other hand theory of planned behavior (TPB) is used for consumer acceptance to a technology especially in marketing research (Ajzen 1991). The figure 1 below provides the different extensions of the TAM model that was developed by Davis (1989), and further enhanced and presented by Holden and Karsh (2010). The model suggests that, to increase chances of users accepting a technology, there is need to determine or probe the user what purpose the technology will be used for. However, one of the limitations of TAM is that there is not enough exposure to the technology by the user before the assessment is carried out (Lee et al. 2003). Perceived usefulness (PU) and perceived ease of use (PEU) are the opinions that users of a technology have regarding the system (Dillon and Morris 1996). Davis (1989) defined PU as “the degree to which a person believes that using a particular system would improve his or her job performance “while PEOU was described as the degree to which a person believes that using a particular system would be free of effort.

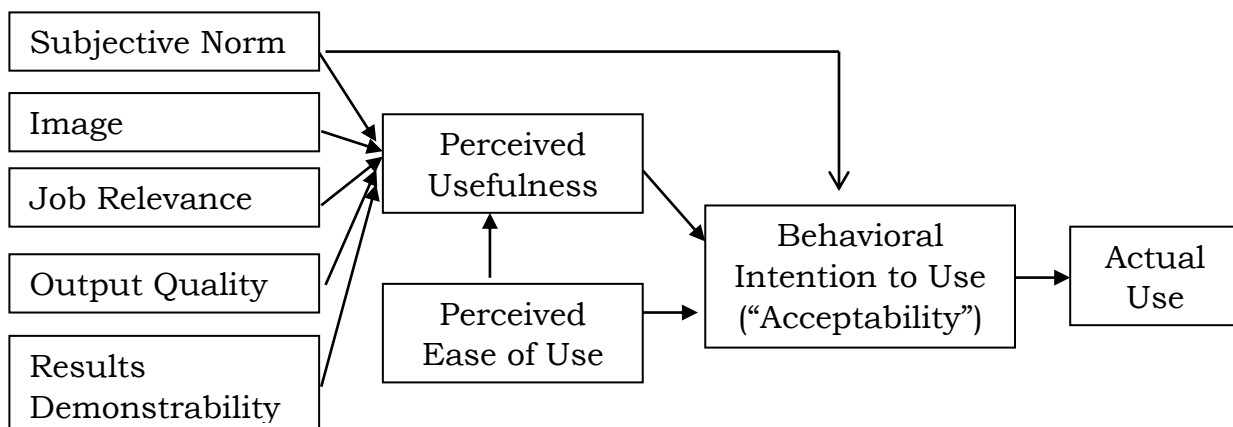


Figure 6 Extensions of the Technology Adoption Model. Adapted from Holden & Karsh (2010)

Table 1 below provides useful definitions of the extensions that are outlined in the Technology Adoption Model. Some of these variables are also used in the theory of planned behavior model modified from Holden and Karsh (2010).

Table 2 Definitions of variables in the TAM and TPB models (Holden and Karsh 2010)

Variable	Definition	Models that use the variable
Use (USE)	One specific behavior of interest performed by individuals with regard to some system	TAM
Behavioral intention to use	An individual's motivation or willingness to exert effort to perform the target behavior	TAM, TPB
Perceived ease of use (PEOU)	An individual's perception that using an IT system will be free of effort	TAM
Perceived usefulness (PU)	An individual's perception that using an IT system will enhance job performance	TAM
Subjective norm (SN)	An individual's perception of the degree to which important other people approve or disapprove of the target behavior	TAM, TPB

Within the agricultural sector, theoretical and practical approaches that aim at promoting the adoption and usage of new farming practices have been thoroughly studied (Kumar and Engle 2016). Meijer et al. (2015) indicate that theories that take into account decision-making processes should emphasize on the following three variables: characteristics of the farmer, characteristics of the external environment, and characteristics of the innovation. Pragmatic studies have also been conducted in the aquaculture sector and include the following five broad categories: (a) source of information, (b) characteristics of the technology, (c) economic factors, (d) farm characteristics, and (e) socio-demographic and institutional factors (Kumar et al. 2018). However, there are still relatively few attempts to make predictions about adoption outcomes using these factors (Kuehne et al. 2017).

### Material and Methods

This was a component of a larger mixed methods study on gender inclusive financing for scaling up improved fish processing technologies in Malawi whose qualitative data collection component was achieved through twenty (20) focus group discussions (FGDs) and fifteen (15) key informant interviews. The FGDs were split into ten each for males and females while the KIIs comprised six females and nine males.

Membership of the FGDs, which lasted between 45 and 90 minutes, ranged from six to ten per group. The KIIs on the other hand ranged from 20 to 45 minutes. Those interviewed included Beach Village Committee leaders and members, gender champions, a female boat owner, and bank loan beneficiaries.

FGDs and KIIs yielded direct quotations from participants about their experiences, opinions, feelings and knowledge (Paton, 2002) of the various fish drying technologies. These were augmented by direct

observations of objects [solar tent driers and smoking kilns] in their natural setting (Berg, 2001; Paton, 2002) to gain thorough understanding of their state of repair. These observations were captured in photographs using a smart phone in-built camera.

Thematic analysis was carried out on the transcripts to identify themes related to usage and challenges facing usage of solar tent driers and modern smoking kilns, and opportunities that exist for upscaling modern fish processing technologies. NVivo was used to organize the data.

## **Findings and discussion**

This part of the paper presents findings and their discussion. Structured based on identified themes, the focus is on two technologies, namely solar tent driers and smoking kilns.

### **Upscaling modalities and financing**

The project partnered with FDH Bank to manage the loan fund. One of the beneficiaries of the loan facility was a male fish seller, who used to belong to a cooperative in his area. His influential exposure to solar tent driers happened when he, alongside other cooperative members, visited Uganda on a learning tour. That inspired him to own his own solar tent drier. The challenge, however, was lack of financing given that the cost of erecting one was way above the means for many small-scale fisheries actors. An average solar tent drier would cost in the region of US\$2,000.00 (Chiwaula et al, 2017 & Chiwaula et al, 2020). Accordingly, the participant's direct benefit from the project's intervention was provision of access to financing as explained below:

*When we came back from Uganda, then came the Nsomba Nchuma Project which built us that tent dryer you are seeing over there for the Cooperative [The participant points to a solar tent drier that is in a state of disrepair]. That was the beginning of the Nsomba Nchuma project. Due to the interest that I had on this, I was persuaded to have my own tent dryer. So, they came and built one for me, I bought mine. I have been doing the fish business all along. The problem, however, has been shortage of fish such that at times there was literally no fish to sell. That's why I decided to search for money lending institutions to get a loan to boost my business. Nsomba Nchuma linking me up with FDH Bank for the loan was a timely intervention. In my case I already know very well the benefits of solar tent driers. The only challenge was lack of enough capital.*

The above participant's earlier exposure in knowledge in the usefulness of solar tent driers thereby establishing behavior intention to use the technology or acceptability (Holden & Karsh, 2010). The participant sheds light on a number of important issues in terms of scaling up the modern fish drying technologies.

Firstly, early adopters would already have sufficient interest or motivation to adopt (ref). As such early exposure to new technologies would facilitate formation of behavior intentions and possibilities of enacting such intentions. As can be observed from the above participant, his behavior intentions resulted in active search for opportunities to access financing.

Secondly, it is important for potential users of the technology to clearly understand the range of important problems whose solutions lie in the technology in question. The above participant clearly understood the solutions that solar tent driers would provide to his fish business such as increased shelf

life for the fish and reduced post-harvest losses (Chiwaula et al, 2017; Chiwaula et al, 2020 & Makwinja & Kapute, 2020), allowing sales to take place during times of heightened demand.

The third important issue that the participant raises is the question of ownership. As he happily narrated his solar tent drier ownership story, he seemed apprehensive while narrating the tale of the one in state of disrepair that was constructed for the cooperative:

*Yeah, that one is not working because it is for the Cooperative, it is for the group. And you know how difficult it is to handle a group property than it is for personal property. That one is for the public but what made it to get to that state is that, as I explained already, that in the process of selling fish, it reached a point where we were not making any profit because the fish dried in that tent are difficult to be sold.*

It is therefore important to empower groups with knowledge and skills on how to manage ‘pool’ resources. Ownership models, ie whether the technology is owned by a group or an individual ought to be promoted on the basis of sound foundations, including an understanding of any contextual issues with the potential to disrupt or promote uptake. According to Makwinja & Kapute (2020), multiple factors influence households’ willingness to pay for communal technologies. In their study of willingness to pay for solar fish drying technology, Makwinja & Kapute (2020) found, among other factors, that household involvement in fish processing, household social trust, and household experience with post-harvest losses influenced willingness to pay for a communal fish tent drier. Observations at most landing sites showed that communal solar tent driers faced challenges. Individual ownership of solar tent driers and smoking kilns, on the other hand, seemed to be working well. At one landing site, individual ownership was not restricted to men as one woman was in the process of constructing hers using a bank ‘materials’ loan.

#### **Local context, local knowledge and technology maintenance costs**

A thorough understanding of contextual issues is critical for adoption of technologies. In one area, a solar tent drier that was constructed for the community was damaged by wind. The participant below sheds light on the fate of a community solar tent drier:

*We were introduced to solar tent driers as a modern technology for preserving fish. It was an advanced procedure. However, it was very hard to implement it because the weather here is too hot and the plastic that was used was being burnt by the sun. And, as you can see, we are in the open. The wind pressure coming from this side of the lake is relatively different from that which blows over that market [pointing to a different part of the beach where a market is situated] because that side is shielded by the trees. Because the tent is in open air it couldn't withstand the combination of the heat from the sun and wind. Little wonder that they said they would bring stronger plastic than the original to repair the tent. As you would imagine, people used that drier for only a few days.*

The above sentiments were echoed by male participants at a different landing site when they said that:

*We were informed that they [Nsomba Nchuma Project] supply the materials in form of loans. After we studied it we realised that the solar tent drier expires and wears out overtime. Given the cost of constructing it, the wearing out happens before you even finish paying back the debt because it wasn't even for free. It was a loan. Millions of kwachas of plastic. So, in this [weather] it keeps breaking off requiring maintenance.*

Clearly, from the perceptions of the project beneficiaries, an understanding of the local context might have resulted in a different project outcome. For instance, choice of materials such as plastics to use might have considered the sun and wind elements. The images below illustrate damage to solar tent driers in two different communities:



Figure 7 Damaged Solar Tent Drier at Lifuwu



Figure 8 Damaged Community Solar Tent Drier at Malembo

As can be seen from the two images, although they suffered different degrees of damage, they share a similar fate. They were both constructed for the ‘community’ and both were never used or only partly used. Maintaining them to a state where they could be used, having never been used to generate resources, is something that the community was not eager to do. Instead, they were still banking on external funders for maintenance.

The idea of a missed local context or local knowledge was also evident in the implementation of improved smoking kiln. As the designs below show one would expect fish processors to use the ‘improved’ smoking kiln and abandon the traditional one because of the seeming advantages that the former would offer:



Figure 9a Traditional Smoking Kiln



Figure 9b Improved Smoking Kiln

However, since improved smoking kiln is partly promoted on the basis of efficiency in energy use, potential adopters felt that was not the case. They were equivocal in claiming that the ‘improved’ kiln were energy wasters because of their height. Observations at one study site corroborated the participants’ claims. Measurement of the technologies’ height showed that the traditionally constructed smoking kiln was 64cm high contrasted with 87cm for the improved smoking kiln. However, the story was different at another study site where improved smoking kilns offered dual functionality of smoking and boiling while retaining fuel wood efficiency. Study site observations showed many processors adopting the technology.



Figure 10 Improved smoking kilns

Cost of constructing the solar tent drier and smoking kiln using a loan facility [in form of materials] was a recurring theme. This was a particularly important theme because, firstly, the absence of a loan facility for the actual buying of fish appeared to be putting people off. Secondly, the amount of loan, the repayment period, and the period during which the technology would be in use without maintenance did not seem to make sense to some participants. Clearly, there was need of for a rethink of the model. Promotion of off-takers or bulk-buyers appeared to be a viable option.

### **Commercialization/marketing and promotion of off-takers or bulk-buyers**

The costs for erecting solar tent driers would require a clear business plan for optimal returns on the investment. Chiwaula et al (2020) observes that the viability of large solar fish tent driers could be enhanced by introducing fish processors to formal lucrative markets where solar dried fish are sold at stable and high prices. “*Kusunga mkute nkukhuta*”, a local idiom that means savings can only happen in the context of a surplus, was made when a study participant was discussing the use of solar tent driers and the challenges associated with the technology for small scale fisheries.

Clearly, the business model that Nsomba Nchuma sought to promote, particularly the concept of bulk-buyer or off-taker seemed to offer solutions and benefits for small scale fisher folk. The off-taker or bulk-buyer ought to have the capacity and flexibility of stocking enough fish volumes to be processed using the solar tent drier without disruption to their sales on the other end of the value chain. For that to be realized, however, there was need to provide financing specifically for bulk buying of fish to potential off-takers or bulk-buyers.



Figure 11 Personal solar tent drier and improved smoking kiln at Malembo

Promotion of individual technology adopters as off-takers and dealing with challenges associated with using technology in drying fish could be the way to go. Asmare, et al (2015) for instance, note that price for fish dried by solar tent technology is not encouraging and recommend promotion and market linkages for the quality dried fish. While other studies (Chiwaula et al; Makwinja and Kapute) found willingness to spend on technologies, findings from the present study suggest caution in interpretation of such findings. In the present study, participants were not too excited about the loans being in material form ie construction of technologies. Preference for a cash-based loan which they could inject into the actual buying of fish was a common theme across landing sites.

### **Conclusion and recommendation**

The fate of improved fish drying and/or fish smoking technologies rests in three critical and interrelated factors that influence adoption. Perceived usefulness, whose transition to actual use is enabled by the ability to meet the costs of the technologies and perceived returns on investment. Perceived returns on investment was, in turn, enabled by linkage to profitable markets which promised marked differences in incomes between those using improved fish processing technologies and those stuck in traditional

modes. Ultimately, it is clear that commercialization alongside the promotion of off-takers present the best pathway to adoption of improved fish processing technologies.

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## Isolation and Purification of *Fusarium oxysporum* for Improved Disease Screening and Development of Resistant Varieties in Malawi

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### Abstract

*Fusarium* wilt remains a serious disease in many parts of Malawi affecting various solanaceous crops including tobacco. The disease is caused by *Fusarium oxysporum*; a soil borne fungus which is most prevalent in the central and northern parts of the country. The only option for management of the disease is use of resistant varieties, as there are currently no practical chemical solutions for its control. In addition, patchy distribution of the pathogen in the soil makes on-farm evaluation of breeding lines as well as screening of chemical products difficult. In view of the foregoing, work was initiated aimed at collection, isolation and purification of *Fusarium* wilt causing fungus across the country for purposes of targeted inoculation and preliminary screening of resistant lines during development. Soil and diseased plant samples collected from various parts of the country were used to isolate the wilt causing pathogen in the laboratory using PDA media. A total of seventeen *Fusarium* wilt causing fungal isolates were isolated and are being maintained in the Crop Protection Laboratory at Kandiya Research Station in Lilongwe. The significance of these isolates lies in their use in bioassays and screening of resistant tobacco genotypes for improved disease management and sustainable crop productivity in the country.

**Keywords:** Isolation, fusarium wilt, inoculation, tobacco, tobacco productivity.

### Introduction

Tobacco (*Nicotiana tabacum* L.) remains one of the most important economic crops globally (Liu *et al.* 2013). Crop plant biotic stresses (soil and air-borne) caused by various pathogens pose serious challenges to production (Vasudevan *et al.* 2014). Some diseases of economic importance in tobacco include Bacterial wilt (*Ralstonia solanacearum*), *Fusarium* wilt (*Fusarium oxysporum*); and Angular Leaf Spot (*Pseudomonas syringae* pv. *Tabaci* Tox-) [Yabuuchi *et al.* 1995; Joshi *et al.* 2013; Li *et al.*, 2017; Oljira *et al.* 2020]. Control of diseases in tobacco is dependent on Good Agriculture Practices (GAP) through practices such as crop rotation, certified varieties and use of Crop Protection Agents (CPAs). Development of cultivars for resistance to all or some of the key tobacco diseases is an integral part of Sustainable Tobacco Production (STP) (Pedro Seambelar, 2016) as some of the diseases do not have practical CPAs recommended for their control. Screening of new tobacco cultivars in Malawi has depended mainly on natural occurrence of the pathogens. While this approach has aided in variety screening for improved cultivars, it cannot solely be relied upon due to unpredictability and unfavorable conditions such as patchy and uneven pathogen distribution, particularly soil-borne pathogens. Artificial inoculation of isolates or culture filtrates of disease-causing pathogens can improve evaluation efforts as it provides assurance of the presence of the pathogen (Portia-Puglia *et al.* 1993). In addition, use of inoculum of known pathogenic composition is recommended in order to obtain comparable and reproducible results and it allows for proper discrimination between susceptible and resistant lines (Iglesias *et al.* 2000). In view of above, there is need to develop strategies for artificial disease inoculation to aid development and evaluation of breeding lines and efficacy trials of agrochemicals for

control of soil and aerial borne pathogens. The objectives of this work therefore were to a) collect *Fusarium* wilt causing pathogens from major growing areas of Malawi; b) to isolate and purify the wilt causing agents for use in artificial inoculation of research trials.

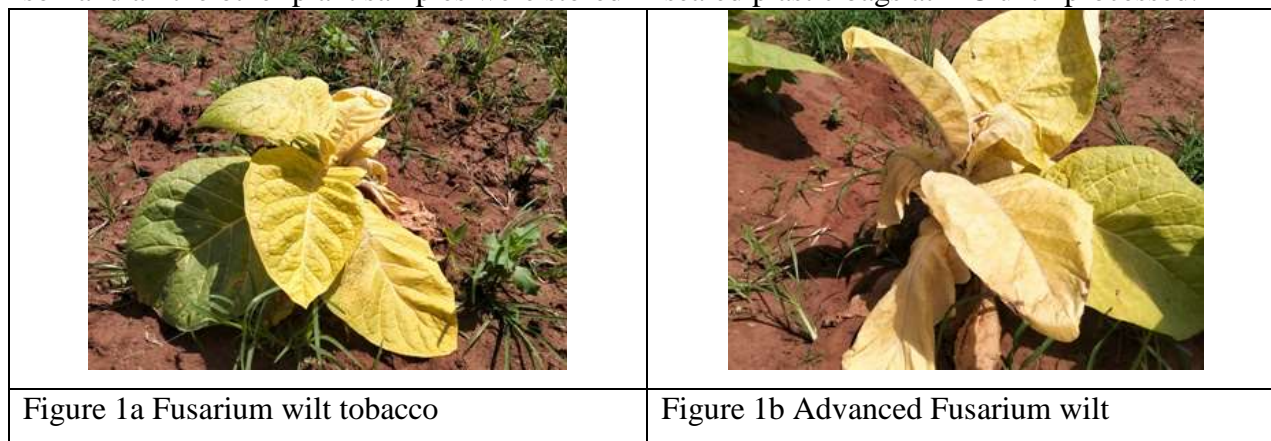
## Materials and Methods

### Collection Sites:

Samples of diseased tobacco plants were collected from sick plots located at our experimental research stations and various farmers' fields across the country.

### Fusarium Wilt Plant Sample Collection:

Rhizosphere soil (soil adhering to the roots after gentle shaking), tobacco leaves, stems, and roots from severely disease symptom-showing plants (**Figure 1**) were collected and kept separately into polythene bags, placed inside cooler boxes. The diseased plant samples were transported to the Plant Protection Laboratory of the Agricultural Research and Extension Trust for further processing and analysis. Moist soil and all the other plant samples were stored in sealed plastic bags at 4°C until processed.



### Isolation and purification of Fusarium wilt causing pathogens

*Fusarium* wilt plant samples (stems, roots) were cut into smaller pieces, and later surface sterilized in 70% alcohol for 60 s. The samples were then rinsed in sterile distilled water and transferred onto sterile towels to air dry. For isolation of *Fusarium* wilt pathogens, potato dextrose agar (PDA) - a nutrient rich medium for growing a wide range of fungi was used. The petri plates were incubated at 28°C under dark conditions for 4 days to culture the *Fusarium* fungus (Figure 2a). The four-day grown fungal hyphae were further sub-cultured on PDA amended with 300 mg/L ampicillin to inhibit bacterial growth. A colony of fungus on PDA near tobacco sample parts was selected and transferred onto fresh PDA plates using a sterilized inoculation loop and incubated at 28°C to obtain pure cultures of the isolates (Figure 2b). All the procedures were carried out in a laminar hood under aseptic conditions.



Figure 2a Fusarium culture



Figure 2b Purified Fusarium Isolate

### Results and Discussion

The results of Fusarium wilt collection and pathogen isolation are provided in Table 1. A total of 17 Fusarium wilt causing pathogens from various tobacco growing areas have been isolated and purified in the laboratory (Table 1). The isolates are being maintained at the Plant Protection Laboratory at Kandiya on agar slants and in petri plates (Figure 3). Verification of pathogenicity bioassays and re-isolation (Fig.4) of the isolates has been carried out and currently studies are underway to identify the most virulent isolates which will later be maintained for use in varietal and chemical screening experiments. The morphological characteristics of selected Fusarium wilt isolates are given in Figure 5.



Figure 3 Agar slants



Figure 4a Pathogenicity bioassay



Figure 4b Re-infection

**Table 1: Fusarium wilt fungal pathogens isolated from diseased samples collected from various tobacco growing areas of Malawi**

Isolate ID	Mycelia Arrangement	Pigmentation	Area of collection
ISOFWKRS -1	Sparse cotton white	Pale yellow	Kandiya sick plot
ISODA -0	Sparse cotton white	Pale white	Dowa
FWLIS19 -1	Dense cotton white	Pale yellow	Kandiya sick plot
FWR19 -6-1	Sparse cotton white	Pale yellow	Kandiya sick plot
FWLKBIS19-3-1	Sparse cotton white	Pale yellow	Kabwafu
FWISOR19 -3	Dense cotton white	Pale yellow	Kandiya sick plot
FWRISOKRS1	Dense cotton white	Pale yellow	Kandiya sick plot
FWSISOLKB19-1	Sparse cotton white	Pale yellow	Kabwafu
FWSKBISO19-1-2	Sparse cotton white	Pale yellow	Kabwafu
FWRKDISO19-3	Dense cotton white	Pale yellow	Kandiya sick plot

FWRISOL19-2	Sparse cotton white	Pale yellow	Kandiya sick plot
FWISOMBA -1	Sparse cotton white	Pale yellow	Mwimba
FWRU -0	Dense cotton white	Pale yellow	Rumphi
ISOFWMBA – 0	Sparse cotton white	Pale yellow	Mwimba
ISOFWMBA – 2	Sparse cotton white	Pale yellow	Mwimba
ISODZ – 0	Dense cotton white	Light brown	Dedza
FWRISMBA-0	Sparse cotton white	Light pink	Mwimba sick plot

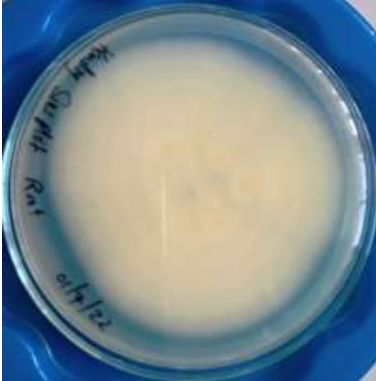


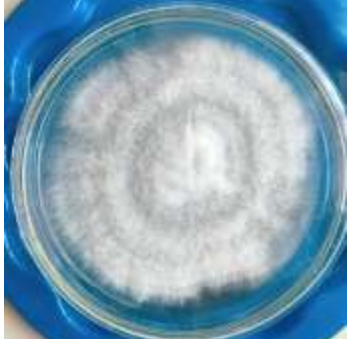


Collection site	Colony morphology	
Kandiya Sick Plot		
Dowa - isolate		
Mwimba Sick Plot		

Figure 5 Colony morphology of selected *Fusarium* wilt fungal isolates

### Conclusion

In this study, *Fusarium* wilt diseased plants were collected from major tobacco growing areas of Malawi. A total of seventeen isolates of *Fusarium oxysporum*, the wilt causing fungus were successfully isolated and purified in the laboratory. These isolates are being maintained in the laboratory. Future

research thrusts will focus gaining more insight on virulence, efficacy and resistance screening studies in the laboratory and the greenhouse under artificial inoculation.

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## Temporal and spatial changes in fish size structure, diversity and distribution in the trawlable demersal zones of Lake Malawi, Malawi

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### Abstract

A comparative study was conducted to assess temporal and spatial changes in the trawlable demersal zones of Lake Malawi. The study used data from surveys conducted in 2020 and 1998 targeting 120 stations covered in a surface area of 9,647sq. km. Trawling speed of *RV Ndunduma* was restricted to 2.5 knots (4.6km/hour). Length frequency distribution was modelled with probability density function for determining the likelihoods using the gamma distribution. Parameters for modal length and logistic modelling were guessed and Solver in Microsoft Excel 2021 was used to generate the values that best fit through iteration with GRG Nonlinear approach. The set objective for the Solver was to minimise the residual sum of squares (RSS) by adjusting the variables specific parameters. The study determined fish diversity using the Shannon and Weiner relationship. The recent survey recorded fewer fish species (149) against 158 sampled in the previous survey. The overall catch rates in 2020 and 1998 ranged from 3.8 kg/0.5 to 2003.8 kg/0.5hr and 28.7 kg/0.5 to 1,884.3 kg/0.5 hr, respectively. Overall fish density for all fish species in the two surveys was calculated at 11.7tons/km<sup>2</sup> and 7.5tons/km<sup>2</sup>, respectively representing a decline of 35.6%. The results indicated diversity indices of 3.84 and 4.06 for 2020 and 1998 surveys, respectively. The study revealed temporal and spatial shifts in the fish stock composition, distribution and abundance which necessitates urgent management interventions to prevent further fisheries resources losses.

**Keywords:** Modelling, Cichlids, catch rates, sexual maturity, management measures,

### Introduction

Lake Malawi with over 800 fish species has the greatest diversity of freshwater fishes in the world (Stauffer et al., 2018) and still counting! The latest addition to this species rich waterbody was made by Stauffer et al., (2018) where two deep-water *Diploaxodon* fish species were described. Lake Malawi fisheries provide essential socio-economic and ecosystem services to the country (Weyl et al., 2010). Fish and fisheries products contribute 4% to the Gross Domestic Product (GDP) while nutritionally about 70% of the animal protein and 40% of the total protein are derived from fish (Government, 2021). With the current annual fish landings of 170,844 metric tons having an average “beach” value of US\$1.3/kg, fisheries of Malawi are estimated at a landed value of MK184 billion or US\$ 230 million. The fishery directly employs over 80,000 people as gear owners and crew members while over 500,000 are employed in ancillary activities like fish processing, marketing, trading, boat building, repairing, net mending and fishing gear supply business (Government, 2021).

Lake Malawi fisheries are mainly distinguished by their level of mechanisation hence, are classified into small-scale/artisanal and commercial (aquarist and trawlers) components, (Banda, 2001). The

traditional fishery is known for its low investment cost, low production per unit effort, labour intensive and wide spreading across all waterbodies (Kolding et al., 2019). Aquarist or ornamental fishery in Malawi dates back to the early 1970 and is primarily appreciated for the foreign exchange earnings through global export of wild-caught cichlid fishes (Msukwa et al., 2020). The fishery takes advantage of the robust fish diversity particularly the colourful rock-dwelling species commonly known as *Mbuna*. A total of MK141 million or US\$176,250 was generated in 2020 after exporting 23, 985 pieces of live fish (Government, 2021). The total revenue was significantly reduced (more than 100%) when compared to 2019 and this was attributed to the Covid-19 cross boarder restrictions. The commercial trawl fishery on the other hand was introduced in 1968 after successful trawl trials in 1965 in the southern part of Lake Malawi (Banda, 2001; Weyl et al., 2010). Globally, bottom trawling dates back to as early as 1376 (Roberts, 2008). In Lake Victoria, the very first lake wide experimental bottom trawling was conducted from 1969 to 1970 (Mbuga et al., 1998) while a midwater experimental trawling in Lake Tanganyika was conducted in 1998 (Sarvala et al., 1999). The western African coastal (Guinea-Bissau, Guinea, Sierra Leone and Liberia) started bottom trawling as early as 1950 (Virdin et al., 2019). Lake Malawi trawl fishery is mainly categorised based on the number of trawl units hauling the net (Banda, 2001), they are stern (single boat) and pair trawlers (paired boats). Kanyerere (2018) identified the current trawling techniques in Lake Malawi as semi-pelagic stern trawling; demersal stern trawling and semi-pelagic pair trawling. Entry into the commercial trawl fishery is controlled by area specific permits issued by the Department of Fisheries.

A substantial change in the species composition as a result of the introduction of trawl fishing was observed in Lake Malawi fish stocks (Banda, M. C., Tomasson, T., 1997; Weyl et al., 2010). It was particularly noted that large demersal fish species were being replaced by smaller haplochromine species. A significant decline in one of the commercially important fish, *Oreochromis spp* locally known as *chambo* was particularly noted Weyl, et al., (2010). The decline in the bigger fish was attributed to a number of factors but the paramount reason was the increased fishing effort and non-compliance to set out management regulations (Turner et al., 2005). It was observed that vessels particularly pair trawlers routinely fish within one nautical mile (1.8km) from the shore or in less than 18m water depth, whichever comes first; mesh sizes have been reduced from the legal minimum size of 38mm to less than 20mm. Furthermore, the fishery was characterised by increasing engine horse power and the trawl nets while fishing hauls lasting more than the recommended aggregated duration of 8 hours per day (Turner et al., 2005).

Efforts to assess the status of the fish stocks of the lake have partially been there with no distinct pattern and technical consistency. The last comprehensive demersal trawl survey was conducted in 1998 by the Department of Fisheries. Kanyerere and M'balaka (Unpublished Data) assessed the demersal zone of the central part of Lake Malawi and made some investment recommendations for trawlers. The study attempted to bring solutions to decongest the over-capacitated southern part of the lake as earlier observed by Turner et al., (2005). Kanyerere *et. al.*, (2018) recently assessed the status of commercial trawl fisheries in southern Lake Malawi using time series data. Latest attempts to assess the fish stocks in the demersal zones were made by M'balaka *et. al.*, (2019) in the southeast arm of Lake Malawi. Based on the recent efforts, it is clear that Lake Malawi has not been comprehensively covered to assess the status of its stocks since the 1998 survey. It is imperative therefore that an assessment of the status of fish stocks was conducted in 2020 to generate new information for renewed perspectives of the fisheries resources in Lake Malawi. Findings of this

study culminate into a number of recommendations for sustainable management of the demersal fish stocks in Lake Malawi.

## Materials and Methods

### Study area

The study made use of data from biomass assessment surveys that were conducted in 2020 and 1998 in the demersal zones of Lake Malawi. The two surveys covered the following districts which were categorised in regions as follows; Karonga, Nkhata Bay, central (Nkhotakota and Salima), Southwest Arm (SWA) covering Dedza and Mangochi and the Southeast Arm (SEA) in Mangochi district (Figure 1).

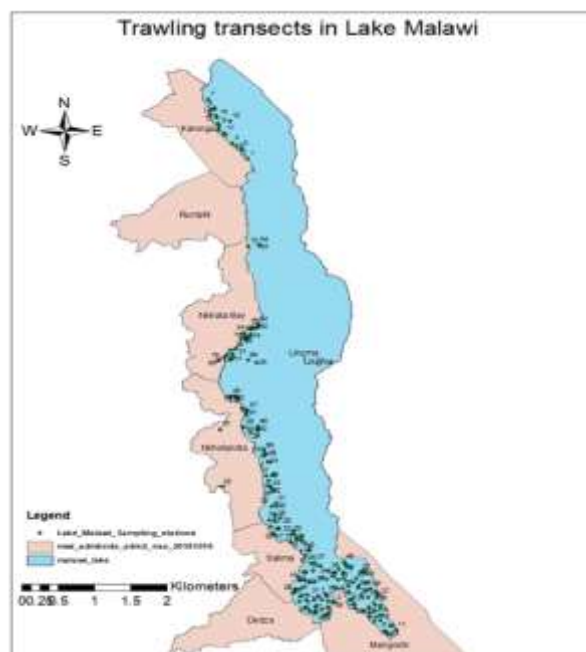


Figure1 Sampling points used in the 2020 and 1998 demersal trawl surveys in Lake Malawi

### Survey Equipment

*Research vessel Ndunduma*, a 17.5 m stern trawl, powered by a 386 Hp Caterpillar engine, was used in carrying out the surveys. The vessel used a 38mm mesh-sized codend Guttorpur bottom trawl net with horizontal and vertical openings of about 14m and 4m, respectively. An on-board Global Positioning System (GPS) receiver was used to locate the stations. The trawling speed was restricted to 2.5 knots/hour (4.6km/hour). Since catchability of species and their respective sizes depend on the trawling duration, hauls were standardised to an interval of 30minutes. The research team from the Research Division of the Department of Fisheries was involved in both designing and implementation of the surveys.

### Sampling procedure

Once the fish were moved from the net into the receiving bin, a 30% sample was randomly collected from the landed catch. Where the sample was too big for handling, a sub-sample was drawn from the

sample. The procedure was done following protocols recommended by Sparre & Venema (1989). The total catch was determined by a summation of all the number of fish containers (with predetermined weight) filled with fish. The fish sample was then sorted by species by taxonomists while making references to Fish Taxonomy Field Guides by George Turner (1996) and Ad Konings (2016). Individual total length (TL) in mm and weight in g using stainless ruler and digital weighing scale respectively were measured. Data collection form was designed and used in capturing both metadata and the catch data.

### **Data Source and processing**

Data for the two surveys was collected at Monkey Bay Capture Fisheries Research Station under the Department of Fisheries. Technical Assistants of the station were engaged in the data entry in Microsoft Excel package. Fish catch composition for the two surveys was compared through cross-tabulation using pivot tables in Microsoft Excel. Graphs of the catch composition at family and genus levels were produced in SigmaPlot 12.5 upon importing the dataset from the Microsoft Excel.

### **Size Structure and Distribution**

To determine size structure, length frequency distribution data was modelled with probability density function for determining the likelihoods for the gamma distribution (Hastings, N., Peacock, 1975)

Length frequency distributions for the top five fish species were modelled using the logistic model (Holt, 1963). The logistic model was used to determine the probability of a fish being retained by the trawl net.

### **Fish species diversity**

Fish species richness and abundance have been used broadly to describe and assess the status of fisheries ecosystems (Van Oppen et al., 1998). This study determined fish diversity in two ways; Species richness (number of species in the study area) and species abundance as a relative number of species (Gorman et al., 1978). Species diversity indices for the two time periods were calculated and compared using the Shannon and Weiner (1949) relationship.

To estimate the real diversity, Effective Number of Species (ENS) was estimated by getting the exponential of the Shannon-Weiner Index ( $H'$ ) (Van Oppen et al., 1998).

## **Results**

### **Catches sampled**

Table 1 provides a summary of the total recorded catches by region for both 2020 and 1998 biomass assessment surveys. The 2020 biomass assessment survey recorded 27,261.6kg of fish against 37,853.2kg registered in the 1998 survey thereby representing a decrease of 28%. At regional level, the recent survey recorded 713.3kg of fish in Karonga which represented a drop of 58.1% from 1,700.6kg reported in 1998. Another big decline was recorded in the SEA where catches of 9,233.1kg were registered in 2020 against 17,912kg recorded in the previous survey translating into a 48.5% drop. The central part and the SWA reported declines of 13.4% and 4.6%, respectively. Nkhata Bay was the only site that reported an increase of 12.3% between the two surveys.

Table 1 Comparative results of total fish catch and mean catch rates between 2020 and 1998 surveys

Region	2020			1998		
	No of Stations	Total Catch (kg)	Mean Catch Rates (kg/0.5Hr)	Total Catch (kg)	Mean Catch Rates (kg/0.5Hr)	Change (%)
Karonga	7	713.3	101.9±53.8	1,700.6	242.9±148.3	-58.1
Nkhata Bay	14	4,267.7	304.8±46.6	3,800.9	271.5±44.2	12.3
Central	29	7,130.0	245.9±28.3	8,234.0	283.9±37.2	-13.4
SWA	27	5,917.5	219.2±28.4	6,205.6	229.8±25.1	-4.6
SEA	39	9,233.1	236.7±52.6	17,912.0	459.3±67.8	-48.5

**Fish species composition**

The 2020 survey recorded fishes comprising 7 families, 45 genera and 149 species. The catch from the former survey on the other hand consisted of 7 families, 45 genera and 158 species. The family Cichlidae that contributed 86% in 2020 and 83% in 1998 survey was dominant in both surveys (Fig. 2). The Cichlidae dominance in the recent survey, was followed by Clariidae, Bagridae, Mormyridae and Mochokidae with 7.1%, 3.4%, 1.4% and 1.2%, respectively. The family Cyprinidae had smaller contribution of less than 1%. In the former survey, family Bagridae Clariidae, Mochokidae and Cyprinidae with 6%, 5%, 5% and 1%, respectively followed the dominant display of the Cichlids. Family Mastacembelidae and Mormyridae had insignificant contributions of less than 1% each in the earlier survey.

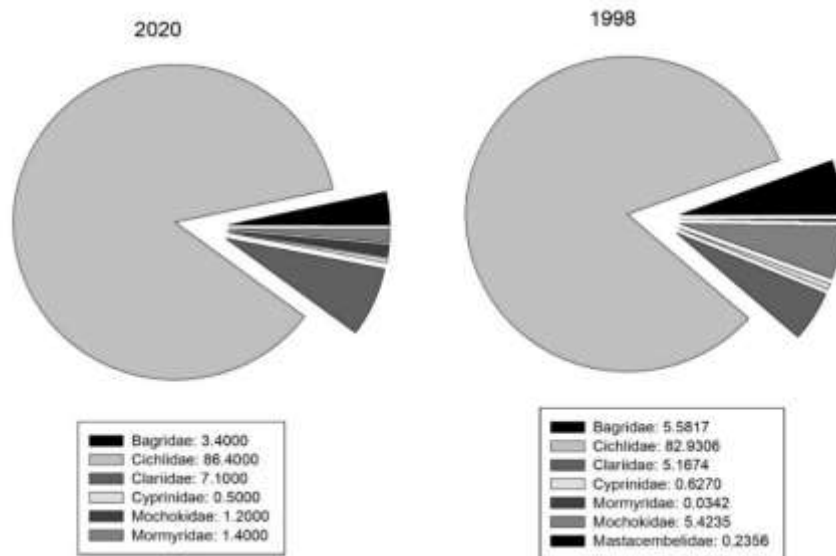
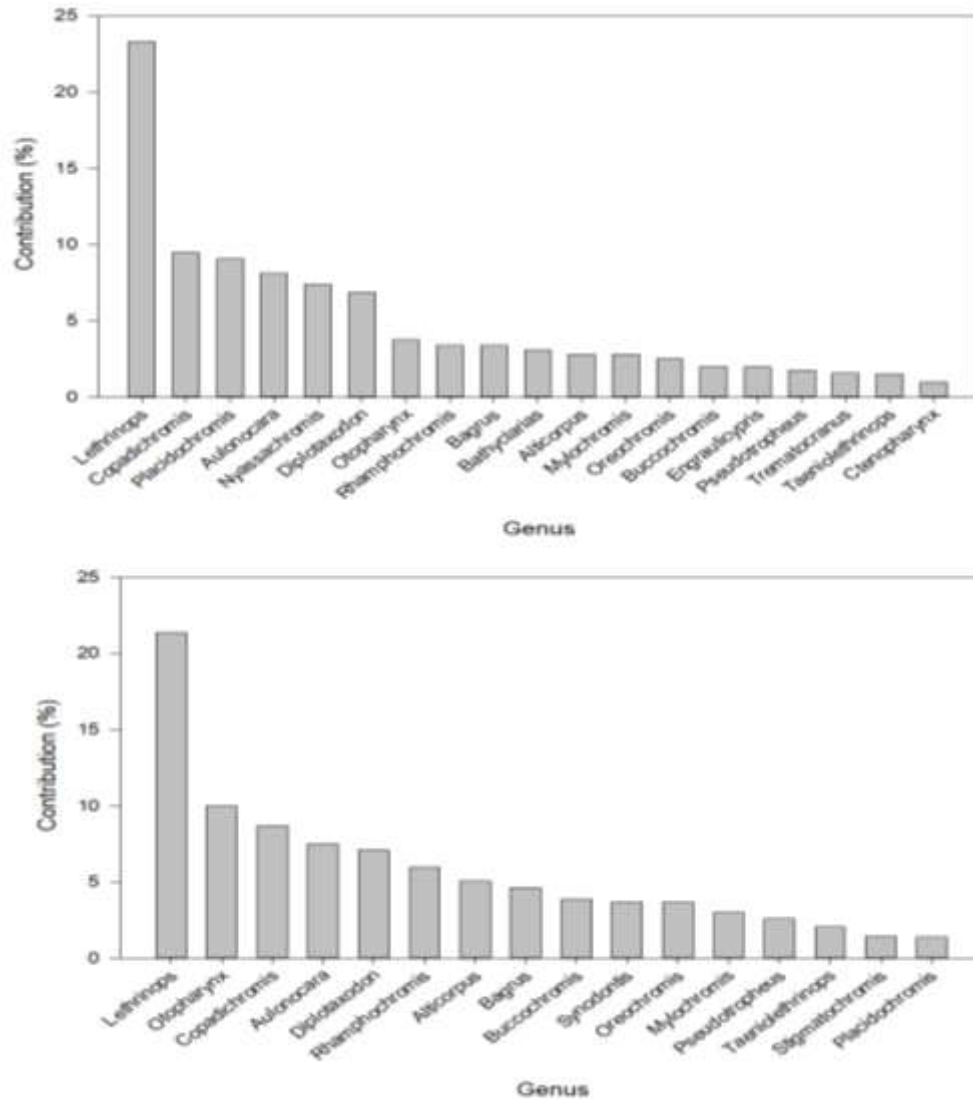


Figure 2 Catch composition at family level between 2020 and 1998 biomass assessment survey

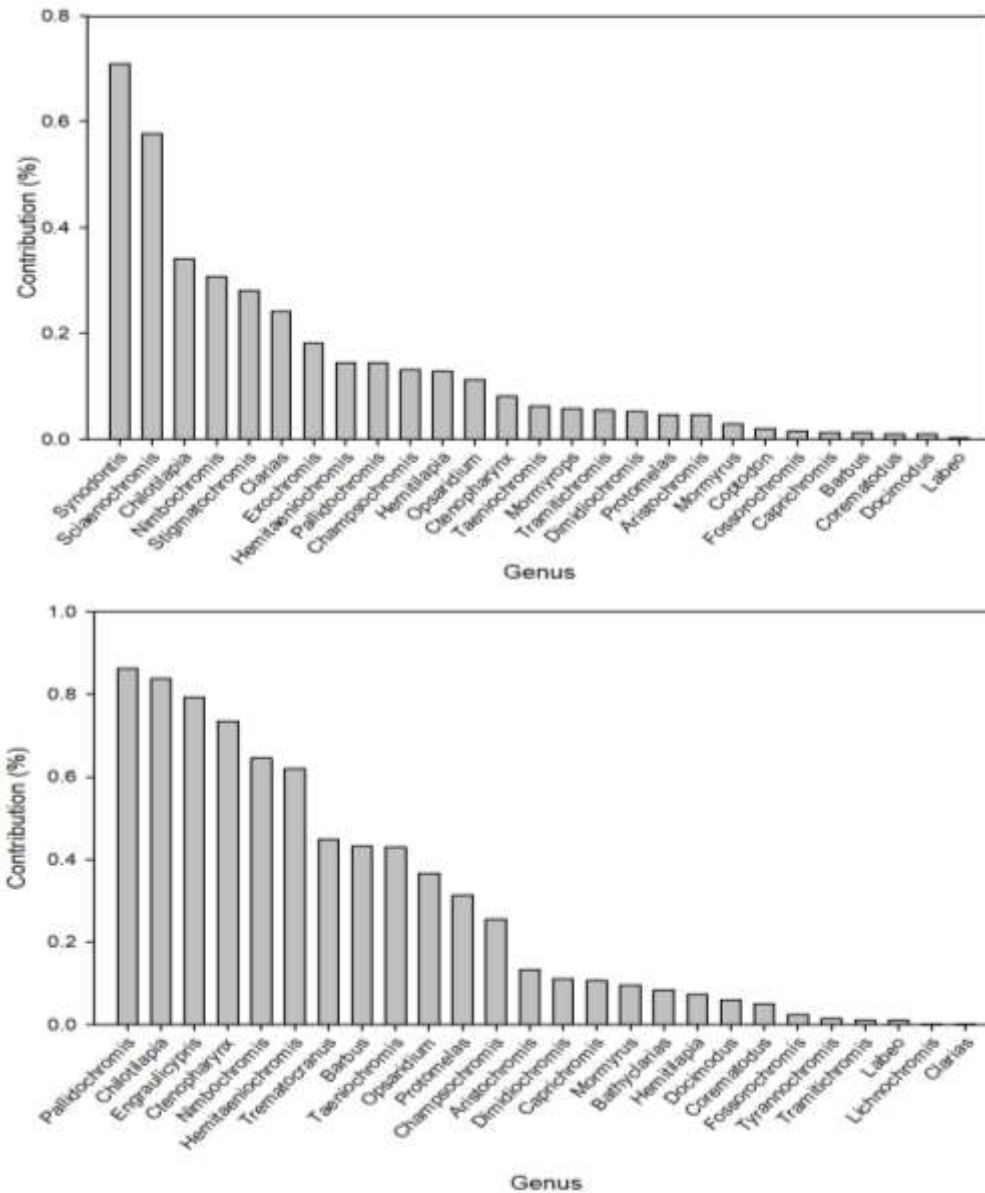
At genus level, Fig. 3 shows fish that contributed to more than 1% of the total sampled catches. The recent survey recorded *Lethrinops* (23%) *Copadichromis* (9%), *Placidochromis* (9%), *Aulonocara* (8%), *Otopharynx* (7%) and *Diplotaxodon* (7%), as the most common with a combined contribution of more than 60%. In the former survey, *Lethrinops* (22%) *Otopharynx* (10%), *Copadichromis* (9%), *Aulonocara* (8%), *Diplotaxodon* (7%), *Rhamphochromis* (6%) *Alticorpus* (5%) and *Bagrus* (4%) were the most important genera in the sampled catches. The genera *Taeniolethrinops*, *Stigmatochromis* and *Placidochromis* were the least in the 1998 survey.



**Figure 3** Catch composition by dominant fish genera that contributed more than 1% in the 2020 (Top) and 1998 (Below) surveys

In the category of fish genus that contributed less than 1% in the recent survey, the genera *Synodontis* (0.71%) and *Sciaenochromis* (0.57%) contributed more than 0.5% each (Fig. 4). The least were the genera *Barbus*, *Corematodus*, *Docimodus* and *Labeo* with 0.013%, 0.011%, 0.011 and 0.002%, respectively. The 1998 survey recorded *Pallidochromis* (0.86%), *Chilotilapia* (0.84%), *Engraulicypris* (0.79%), *Ctenopharynx* (0.74%), *Nimbochromis* (0.65%) and *Hemitaeniochromis*

(0.62%) having contributions of more than 0.5% each. The genera *Labeo*, *Lichnochromis* and *Clarias* with 0.01%, 0.002% and 0.002%, respectively were the least.



**Figure 4** Catch composition by fish genera with less than 1% contributions in 2020 (top) and 1998 (below) surveys

From the 149 fish species recorded in the recent survey, the SEA dominated with 119 species followed by central with 113 species. The trend was similar to the one reported in 1998 survey. The third highest number of fish species (92) was also registered in SWA while Nkhata Bay and Karonga on the other hand recorded 62 and 46 species, respectively. In terms of number of sampled specimens recorded in the recent survey, SEA with 14,890 was again dominant followed by SWA and central with 10,075 and 8,713 individuals, respectively. Nkhata Bay and Karonga were the last two with 3,305 and 1,104, respectively. A further assessment of the 38,037 specimens indicated that *Otopharynx argyrosoma* (2,541), *Copadichromis virginalis* (2,051), *Lethrinops oliveri* (2,011),

*Aulonocara minutus* (1,675) and *Placidochromis longimanus* (1,607) had a numerical advantage from the rest. Hence, the five top most abundant fish species were subjected to length-based analyses and Table 2 provides a summary of the parameters used.

The 1998 survey reported a total of 49,223 specimens which comprised 2,170 in Karonga, 5,882 in Nkhata Bay, 10,244 in the central, 13,987 in the SWA and 16,940 in the SEA. At regional level, the highest number of fish species was recorded in the SEA with 125 which was closely followed by the central part with 120. The third highest was SWA with 110 species whereas Nkhata Bay and Karonga were the last two with 70 and 43 species, respectively. A numerical assessment of the 158 fish species indicated that *Otopharynx argyrosoma* (3,899), *Bagrus meridionalis* (2,282), *Copadichromis virginalis* (2,136), *Diplotaxodon limnothrissa* (1,984) and *Synodontis njassae* (1,812) were among the top five fish species.

### Size Structure and selectivity of selected fish species

The top five dominant fish species were subjected to further length-based analyses to determine their size structure. The fishes were analysed at two levels; using the gamma distribution function and logistic model for gear selectivity. Table 2 shows the solver fitted parameters that this study used to plot length frequency graphs and selection ogive.

Table 2 Solver fitted parameters for Gamma distribution and Logistic Models for the top 5 fish species

Fish Species	Sample (n)	Gamma Model Parameters			Logistic Model	
		Phi	Sigma	Modal Length (mm)	L <sub>50</sub>	Sigma
<i>Otopharynx argyrosoma</i>	2,541	0.81	105.30	85	81	0.14
<i>Copadichromis virginalis</i>	2051	0.95	115.38	109	97	0.08
2020 <i>Lethrinops</i> 'sp oliveri'	2011	0.80	105.44	83	81	0.13
<i>Aulonocara minutus</i>	1675	0.72	100.40	72	67	0.20
<i>Placidochromis longimanus</i>	1607	0.83	93.45	77	74	0.20
<i>Otopharynx argyrosoma</i>	3,899	0.70	118.59	82	85	0.14
<i>Bagrus meridionalis</i>	2,282	2.95	101.97	298	290	0.014
<i>Copadichromis virginalis</i>	2,136	1.02	118.46	120	114	0.08
1998 <i>Diplotaxodon limnothrissa</i>	1,984	0.98	93.40	90	132	0.04
		2.06	78.65	160		
<i>Synodontis njassae</i>	1,812	1.1	118.54	130	122	0.11

Fig. 5 and Table 2 show modelled size structure for *O. argyrosoma*, *C. virginialis*, *L. 'sp oliveri'*, *A. minutus* and *P. longimanus* sampled in the recently survey. The study registered the smallest *O. argyrosoma* of 51mm and the largest being 121mm with a mean total length of  $83.3 \pm 0.25$ mm. The model predicted a modal length of 85mm for the fish. The smallest *C. virginialis* measured 40mm and the largest was 160mm with a mean total length of  $97 \pm 1.02$ mm. The model estimated a value of 108mm as the modal length for the fish. The 2020 survey recorded sizes of *L. 'sp oliveri'* that ranged from 32mm to 155mm with an average total length of  $83.9 \pm 0.35$ mm. The predicted modal length was estimated at 83mm. Length for *A. minutus* ranged from 40mm to 80mm with a mean total length of  $67.7 \pm 1.08$ mm. The sampled fish had a length distribution estimate of 72mm as modal length. The sizes of *P. longimanus* ranged from 42mm to 135mm with an average total length of  $75.6 \pm 0.85$ mm. The predicted modal length of *P. longimanus* was 77mm.

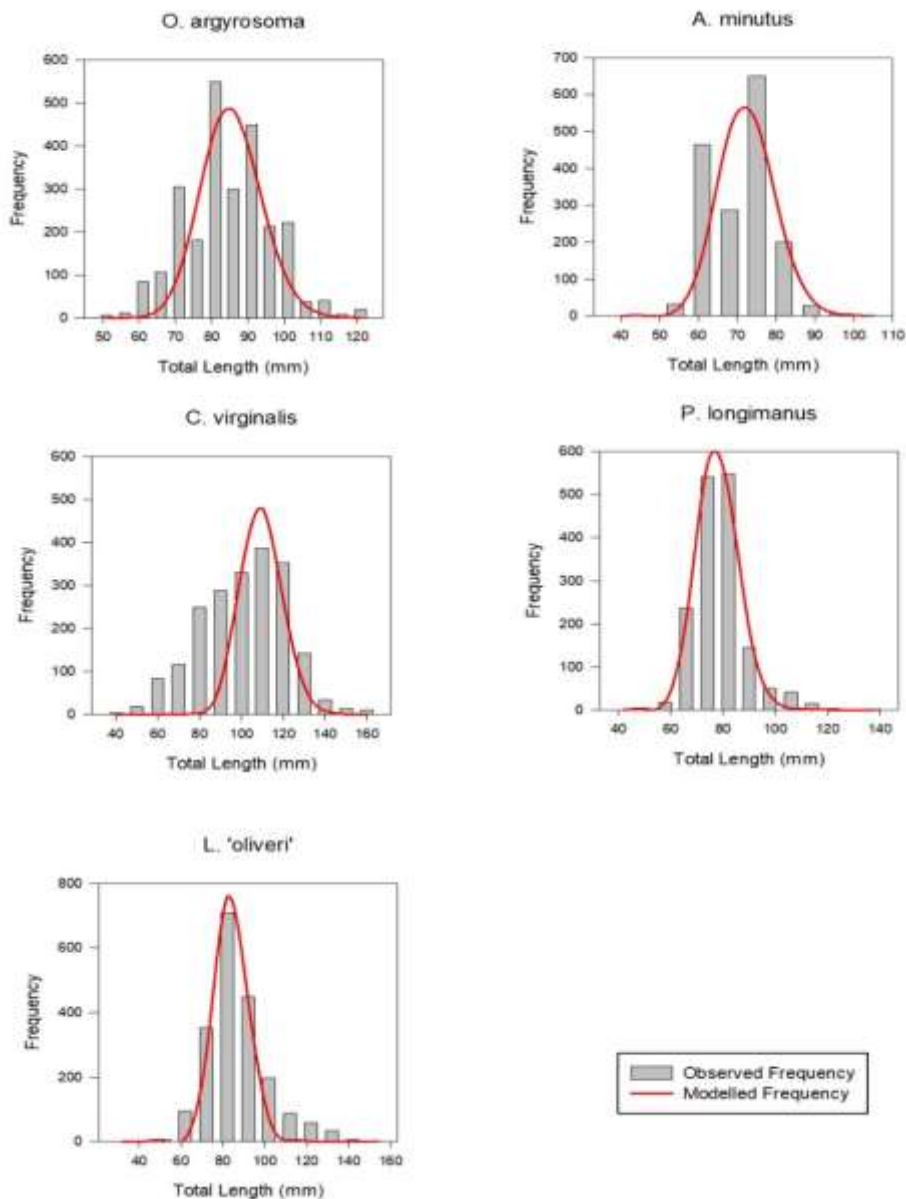


Figure 5 Modelled size structure for top 5 fish species sampled during the 2020 survey

Table 2 and Fig. 6 show the selection ogive of the five fish species. The length at which *O. argyrosoma* had 50% chance of being retained by the 38mm cod-end meshes was 81mm. The values of  $L_{50}$  for *C. virginalis*, *L. 'sp oliveri'*, *A. minutus* and *P. longimanus* were estimated as 97mm, 81mm, 67mm and 74mm, respectively.

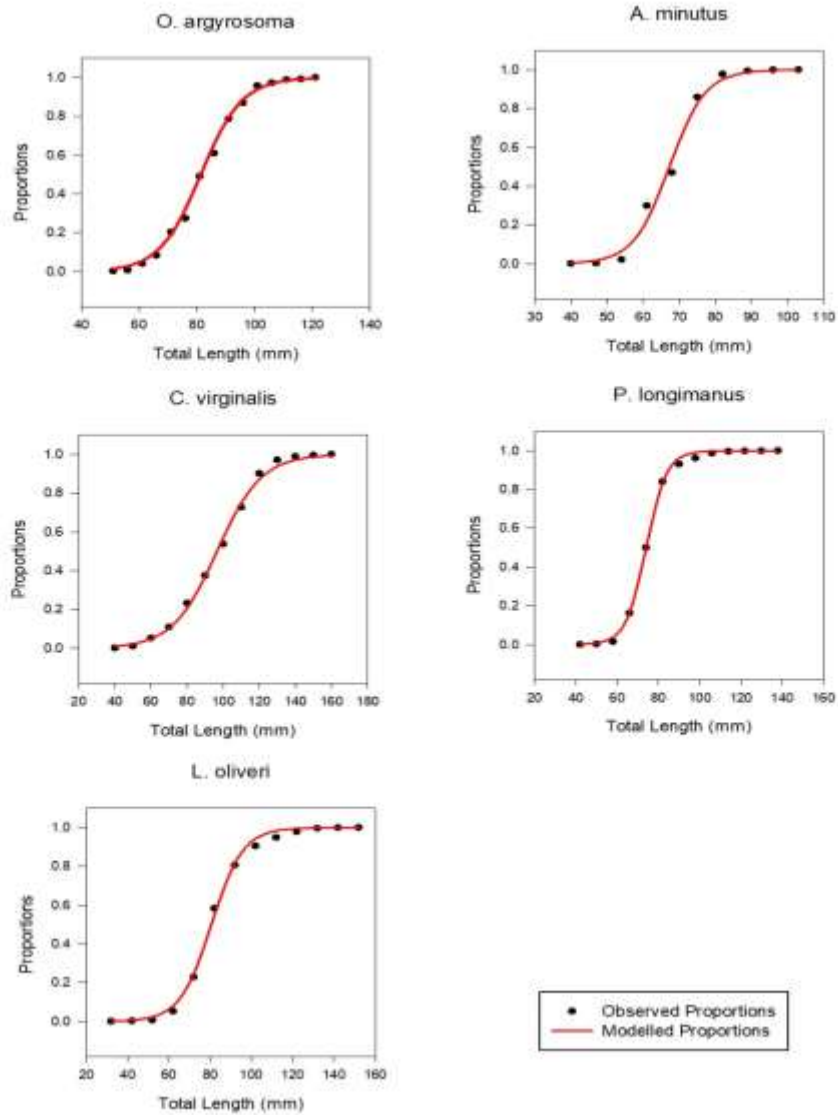


Figure 6 Selective give for top 5 fish species sampled during the 2020 survey

The modelled size structures for *Otopharynx argyrosoma*, *Bagrus meridionalis*, *Copadichromis virginalis*, *Diplotaxodon limnothrissa* and *Synodontis njassae* for the former survey are shown in Fig. 7. The survey registered the smallest *O. argyrosoma* of 35mm and the largest being 155mm. The modelled length frequency distribution clearly indicated that the study sampled most of the fish species with a total length ranging from 75mm to 115mm having a mean total length of  $88 \pm 1.01$ mm.

The model predicted a modal length value of 82mm for the fish. According to this study that recorded a total of 2,282 individual *B. meridionalis*, the smallest fish measured 50mm and the largest was 980mm. The modal length of the fish species was estimated at 298mm with a mean total length of  $306.7 \pm 2.11$ mm. The smallest *C. virginalis* measured 45mm and the largest was 195mm having a mean total length of  $114.6 \pm 0.89$ mm. The sampled fish had a modal length estimate of 120mm. The study that registered a total of 1,984 *D. limnothrissa* specimens reported the smallest fish of 30mm and the largest being 195mm. The modelled length frequency distribution showed that the sampled fish belonged to two length peaks; the first one was at 90mm while the second one was at 165mm. Because of this, the model generated two separate parameters with the first modal length at 90.2mm followed by another one at 160.2mm. The sizes of *S. njasse* ranged from 40mm to 205mm with an average total length of  $123.3 \pm 1.11$ mm. The predicted modal length from the model was 129.8mm.

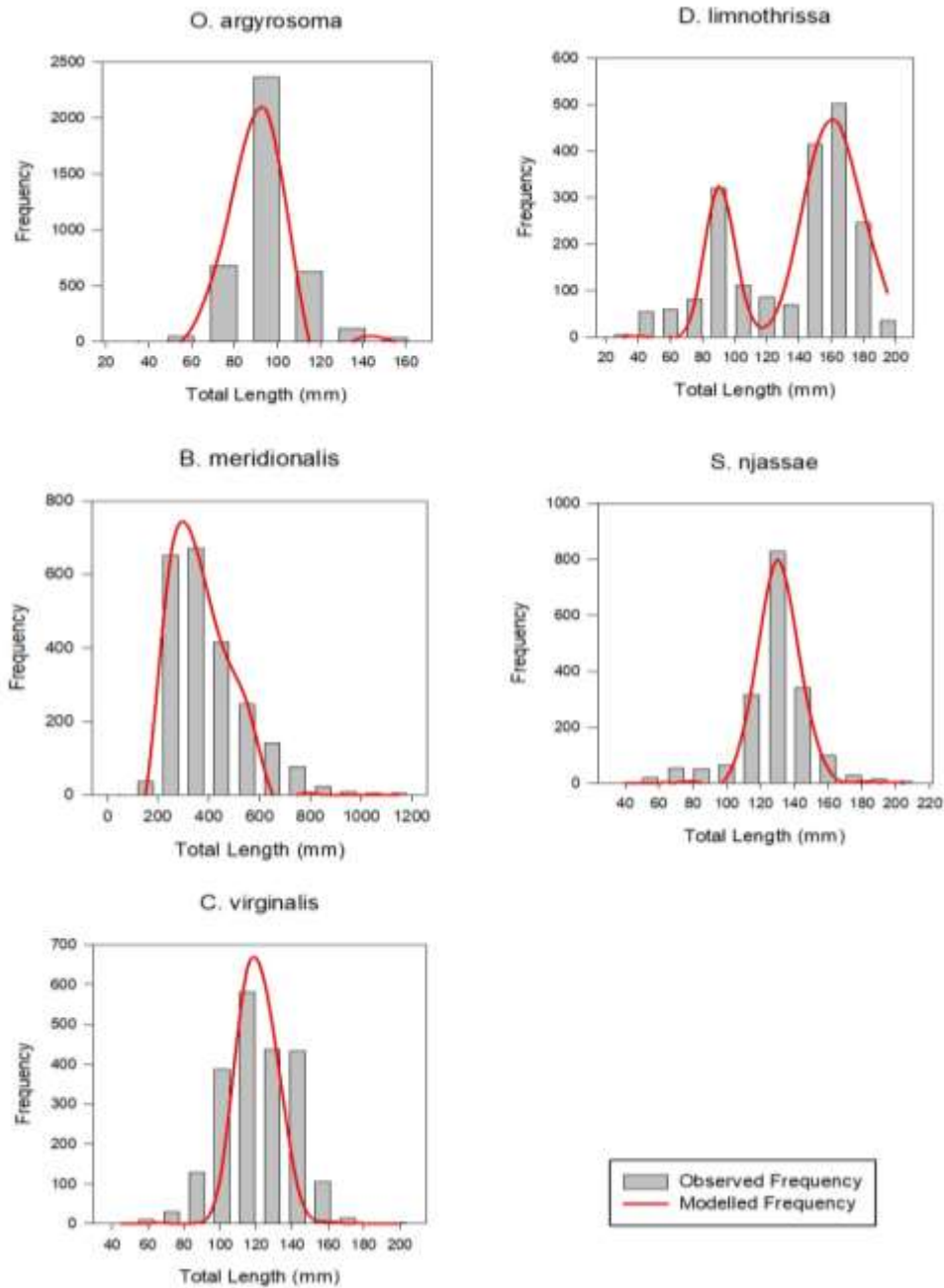


Figure 7 A modelled size structure for top 5 five species sampled during the 1998 survey

Fig. 8 and Table 2 show the  $L_{50}$  values for *O. argyrosoma*, *B. meridionalis*, *C. virginalis*, *D. limnothrissa* and *S. njassae*. The length at which *O. argyrosoma* had 50% chance of being retained by the 38mm cod-end meshes was 85mm. The value for  $L_{50}$  for *B. meridionalis* was estimated at 290mm while for *C. virginalis*, *D. limnothrissa* and *S. njassae* were 114mm, 131.8mm and 122mm, respectively.

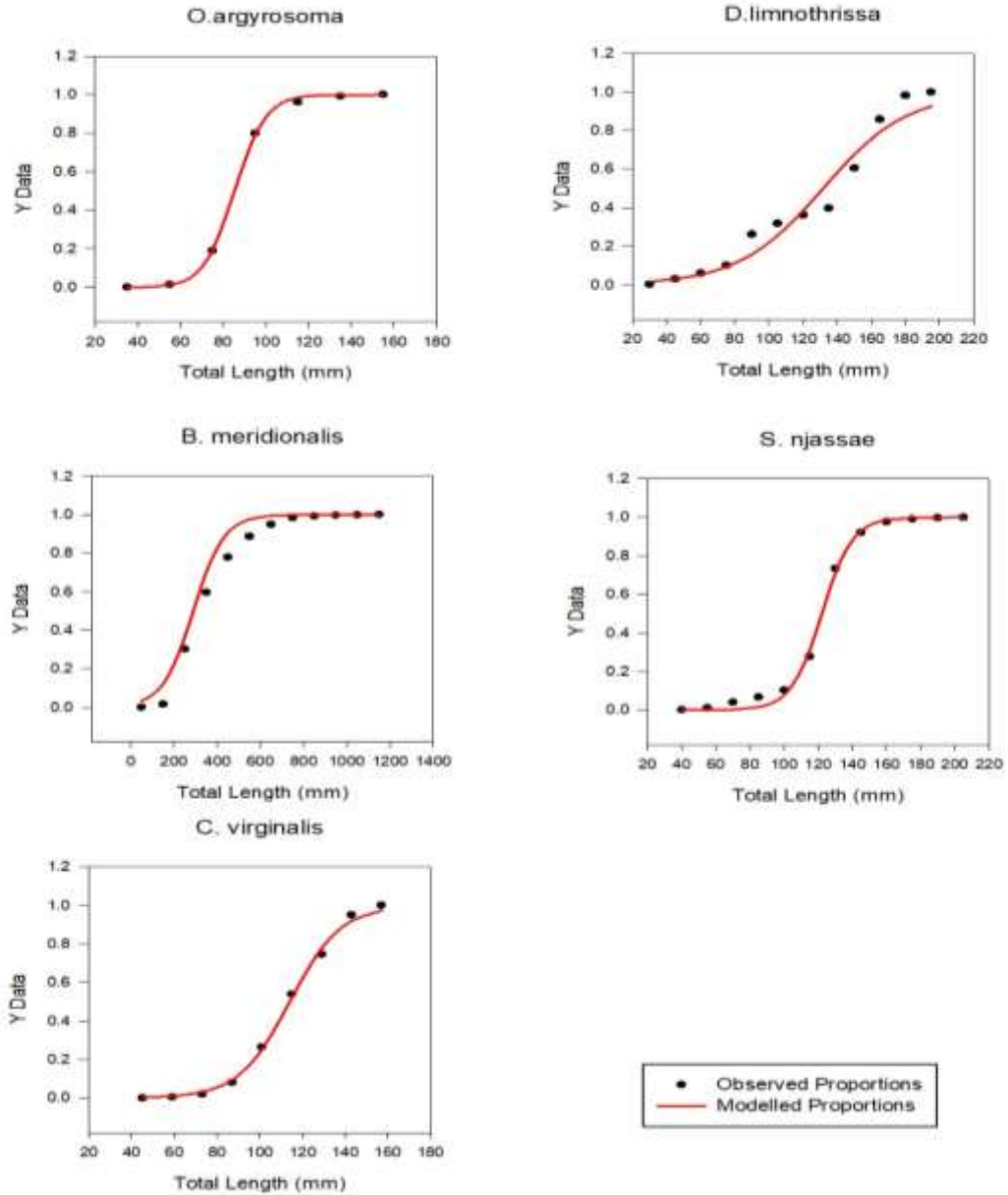


Figure 8 Selection ogive for top 5 fish species sampled during the 1998 survey

**Fish species diversity**

An assessment of the fish diversity between the two surveys was conducted and the results indicated diversity indices of 3.84 and 4.06 for 2020 and 1998 surveys, respectively. Building on the estimated indices in both surveys, the effective number of species (ENS) was estimated as 47 for the 2020 survey and 58 for the 1998 survey. Besides reporting differences in the total number of fish species, the two surveys further differed on a number of fish species in that some species were appearing either in the 1998 or the 2020 survey.

The 2020 biomass assessment survey reported fish species amounting to 36 that were not there in the former survey whereas the 1998 survey registered a total of 43 fish species that were not recorded in the recent survey. Within the fish species that were only available in the recent survey, a total of 16 genera originating from Cichlidae and Mormyridae families were recorded. Out of the 43 fish species that were exclusively available in the 1998 survey, a total of 20 fish genera formed from 3 families namely Cichlidae, Clariidae and Cyprinidae were recorded. The study recorded unusually significant quantities of Mormyrids during the 2022 biomass assessment survey. A total of 18 specimens of the rare *Mormyrops anguilloides* (Linnaeus, 1758) measuring 1,110mm to 1,215mm with an average weight of 12.4kg were caught around Luweya River mouth in Nkhata Bay.

## Discussion

The Cichlidae family continues to dominate the demersal zones of the Lake Malawi fishery as witnessed by the significant occurrence in both surveys. Similar results have also been reported in Lake Victoria (Masai et al., 2004; Okaronon, J., Muhoozi, L., Akumu, 2022) and Lake Tanganyika (Kimirei et al., 2008). The uniqueness with Lake Malawi cichlids is that more than 90% of them are endemic (Sayer, Cathelen, Palmer-Newton, Army, Darwall, 2019) and rapid radiation has produced the greatest number of these species (Albertson & Pauers, 2019). The small contribution of the larger Cyprinids in the recent survey points out to its overexploitation as it is highly targeted both in the open water seines and hooks (Department of Fisheries, Unpublished data). However, *usipa*, *Engraulicypris sardella* which falls under the Cyprinids family currently contributes significantly to the total fish landings of the country (Government, 2021; Kolding et al., 2019). Similar dominance of smaller cyprinids has been widely reported in many tropical lakes such as Lakes Kariba, Mweru, Kivu, Victoria and Tanganyika (Kolding et al., 2019) with several social-economic and ecosystem benefits being highlighted.

Significant presence of bigger genera like *Otopharynx*, *Rhamphochromis* and *Bagrus* was reported in the former survey but very little in the recent survey. Instead, these were replaced by smaller haplochromine species namely *Otopharynx* and *Placidochromis*. Similar results were reported by (Banda, M. C., Tomasson, T., 1997), later on concurred with Turner *et. al.* (2005). The study findings revealed that the replacement of larger fishes with smaller ones has not improved over the years. Unlike in the previous studies, this continued species shift could recently be exacerbated by the environmental degradation and climate change events. Kolding et al., (2019) reported of a complete takeover of smaller fishes in all inland water bodies in Africa. The scenario which primarily was created through overexploitation of larger fish fits well with the concept of fishing down the food web (Pauly et al., 2000), clearly demonstrating how fishers adjust their preferences in response to overfishing of particular large sized fish stock. Similar incidences of species shift have widely been reported in Lake Victoria where a deliberate introduction of *Lates niloticus* brought about substantial changes in the fish species particularly the haplochromines (Njiru et al., 2005; Ogutu-Ohwayo, 1990; Ouma et al., 2005).

This study further reported a dominant contribution of *Otopharynx argyrosoma* which was one of the major haplochromine species to have taken over the fisheries. The fish species, widely distributed in the southern part of Lake Malawi (Konings, 2016; Turner, 1996). The substantial presence of the fish in Lake Malombe signifies the importance of the connection between the two waterbodies through the Shire River. The dominance of *Otopharynx species* can be explained by their increased presence in deep waters (Turner, 1996) currently under-exploited by both artisanal and commercial trawl fishers. The commercial trawl fishery is dominated by the semi-pelagic trawling (Government, 2021) hence most of the *Otopharynx* species are spared as they are predominantly bottom dwellers.

Even with the few available bottom trawlers, harvesting of the bottom-dwelling fish is impinged by the nature of the lake bottom which in most cases act as ‘silent policemen.’ The nature of bottom of Lake Victoria (muddy bottom) has been reported to restrict full use of bottom trawling (Okaronon, J., Muhoozi, L., Akumu, 2022) while water depth in Lake Tanganyika is reported to serve the same purpose (Kimirei et al., 2008). The fish was reported by Turner (1996) to have a maximum length of 150mm which agrees to the length range reported by this study. However, based on the maturity information which states that the fish matures at 92mm, it was noted that the two surveys were catching most of the fish in an immature state which becomes a conservation challenge.

The zooplanktivorous *Copadichromis virginalis* and *Diplotaxodon limnothrissa* were the two pelagic fish species common in the study. Besides commonly recorded in trawlers, these two fish species are also in abundance in the small-scale gillnet fishers (Department of Fisheries, Unpublished Data) indicating that the two fisheries are exploiting the same resources. The study has revealed that the sampled *C. virginalis* were caught while sexually mature as most of them mature around 80mm to 140mm Turner (1996). Catch and effort statistics from the Department of Fisheries indicates that *Diplotaxodon* and *Copadichromis* species contribute to more than 80% of the commercial trawl landings (Department of Fisheries, Unpublished Data). The resilience of the two fish species has been noted indicating how buoyant the fish have been to fishing pressure coupled with environmental degradation in the lake and the catchment. The absence of trawlers in some parts of central and the northern region may also likely aid in the increased production of the offshore fish stocks. The study further recognised the contribution of rare fish species and a total of 13 species that contributed an individual specimen was recorded. The notable rare fish species that were recorded were *Labeo cylindricus* and *Placidochromis milomo*. The small contribution by these fish species may not necessarily mean that they are less abundant in the lake but might point out to the sampling equipment not being appropriate for the job. The unusual significant appearance of fully grown *Mormyrops anguilloides* (Linnaeus, 1758) in the recent survey in Nkhata Bay was also observed. The adult fish are reported to prefer deep and quiet waters between boulders and overhangs that are away from strong water currents (Skelton, 2001). This habitat preference concurs with where the fish were sampled as the site was characterized by the presence of artificial reefs (*Zilundu*) submerged by the communities to act as fish aggregating devices.

The lake has undergone noticeable changes in the fish species diversity and this could be attributed to the overexploitation of the fish stocks through increased fishing pressure. Of great concern is the overexploitation of shallow water fish species like *Oreochromis species* whose preference for shallow waters for breeding and nursery is further threatened by their slow growth and low fecundity (Bulirani et al., 2005). The observation of overexploitation in the shallow water zones was previously reported by Banda and Tommason (1997), Kanyerere and M’balaka (2019). Elsewhere, illegal and destruction of spawning and nursery grounds have been blamed for the fisheries resource destruction in Lake Victoria (Masai et al., 2004), Lake Tanganyika (Kimirei et al., 2008) and in many inland waterbodies (Kolding et al., 2019). The lake just like elsewhere has recently been cleared in the shores for easy operations of beach seining while poor farming practices upstream have equally brought about siltation and chemical overload in the systems (Bootsma & Hecky, 2003; Kolding et al., 2019; M’balaka, M. S., Kanyerere, 2019; Ogutu-Ohwayo, 1990). Of late, the overfishing is not only occurring in the shallow waters, as the study results have indicated that the deeper water species are similarly threatened. The threat being caused to the deeper water demersal fish species is enormous since these fishes are naturally confined to particular environments with minimum mobility (Weyl et al., 2010). The restricted movements pose threat to their existence as some gears

like trawl nets and lift nets have the potential to eliminate them in their designated habitats in a short period of time (Weyl et al., 2010). The demersal fish stocks are therefore more fragile in the sustainable fisheries management in comparison with the free-swimming pelagic fish stocks.

Fish biodiversity is associated with a number of biophysical characteristics of the habitats (Danley & Kocher, 2001; Sayer, Cathelen, Palmer-Newton, Army, Darwall, 2019). The area sampled in Karonga which reported the lowest fish diversity is characterized by shallow sandy habitats stretching from Kaporo to Chilumba (Turner, 1996). The central region (Salima and Nkhotakota) reporting high fish diversity is characterized by outcrops extending from the Chia River mouth to around Benga. The Nkhotakota District has artificial reefs installed by communities around the Nkhotakota Boma which deter active fishing operations. Mbenji Island in Salima, still managed by local leaders (Njaya, 2007) could be another site of higher fish diversity in the region. The central region is moreover well connected to three major tributary rivers namely Dwangwa, Bua and Linthipe (Sayer, Cathelen, Palmer-Newton, Army, Darwall, 2019) and lagoons (Chia and Kambindingu) having potential of enhancing fish diversity in the lake. Rivers in Lake Tanganyika are reported to provide escape routes for overfished stocks of the lake (Kimirei et al., 2008) and it is therefore believed that similar cases occur in Central Lake Malawi. The high diversity in both SWA and SEA is accredited to the increased productivity of the regions, partly because of the shallowness of the regions (Weyl et al., 2010). The two regions are equally known for having many outcrops, islands and aquatic vegetation (Turner, 1996). Community initiated fish protected areas (fish sanctuaries) established around 2017 are similarly reported to increase fish diversity through spillover and recruitment effects (FISH, 2018).

Despite several challenges being faced in the management of the fisheries resources, positive strides have recently been registered in Lake Malawi fisheries. An adoption of vessel monitoring system (VMS) to monitor compliance of vessels regarding fishing areas and fishing times is one of such interventions. The system aims to monitor activities of all trawl vessels in the waters of Lake Malawi including fishing duration which directly provide accurate estimates of fishing effort; adherence to their designated fishing areas and depth zones. Another optimistic development is the introduction of 3-month closed season for the commercial trawl fishery from December to February which commenced in the 2020/2021 fishing season (Department of Fisheries, 2020). The local fisheries management authorities (LFMAs) such as the Beach Village Committees (BVCs), Fisheries Association (FAs) and Commercial Fisheries Associations (CFAs) have been resuscitated. In line with the Chambo Restoration Strategic Plan (2005), the fisheries have also seen a rise in the establishment of community-owned fish protected areas. In most cases, these areas are installed with fish aggregating devices (FADs) and other barriers to deter any active fishing within those zones (FISH, 2018). Recently, the Government of Malawi has also banned the importation and use of the ecologically damaging monofilament gillnets.

All in all, Lake Malawi demersal fishery has not significantly changed in terms of fish species richness and abundance. As previously reported, the fishery continues to experience fish species shift; larger and commercially important fish species have been replaced by smaller haplochromines species. The fishery is also going through a growth overfishing as the dominant fish species were being harvested prematurely. To avert this trend, previous studies (Duponchelle et al., 2003; G. Kanyerere, 1999) recommended an upward adjustment of the cod-end mesh-sizes from the current 38mm. The small-scale and commercial trawl fisheries are harvesting the same fisheries resources and this was previously reported by Weyl et al., (Weyl et al., 2010), hence the need to revise the fisheries regulations that govern them particularly on the fishing areas and time of fishing.

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**EDUCATION & HUMAN CAPITAL FOR SOCIAL-  
ECONOMIC DEVELOPMENT**

## **Auxiliary Teaching Engagement and its Impact on the Quality of Education in Malawi Primary Schools: A Baseline Assessment**

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### **Abstract**

This article assesses the quality of education offered by auxiliary teachers the Ministry of Education Science and Technology (MoEST) has deployed in various primary schools across the country owing to the results of the onset of Covid19 Pandemic more especially to IPTE 13 & 14 teachers. The study uses data from selected Primary Schools in the Northern Education Division (NED) in general, and Mzimba North in Particular. Sample sizes will be taken to make a representation of the national impact. The Study finds that much that the deployed teachers are qualified after attaining a two-year training from various Teacher Training Colleges, they are demotivated for staying long as auxiliary teachers whilst some of their friends are on full employment status by the same recruiting government. This demotivation directly impacts the quality of teaching thereby affecting learners to acquire better education. The findings of the study suggest that the government should recruit all IPTE 13 and 14 teachers (including IPTE 15) so that their levels of motivation are raised and that they can deliver with confidence. In addition to this, they should create space for IPTE 16 and 17 that are about to finish or have finished their studies. Lastly, there is a critical shortage of teachers in primary Schools understudy and it is noble task of the government to recruit as many teachers as possible in order to make the agenda 2063 a real dream.

**Keywords:** Assessment, auxiliary, baseline, education, quality

### **Introduction**

Malawi adopted the Auxiliary Teaching System (ATS) in February, 2021 owing to the fact that the teacher-pupil ratio was worrisome. The rationale behind the design was to reduce teacher-pupil ratio during the Covid19 pandemic as a mitigation measure to social distance. The first pilot group was IPTE-13 (Initial Primary Teachers Education cohort 13) with the financial assistance from DODMA (Department of Disaster Management Affairs). The second phase of recruitment was in January, 2022 with the financial assistance from MERP (Malawi Education Reform Program) in conjunction with ORT (Other Recurrent Transaction). MERP targeted IPTE 14 teachers which later saw some IPTE 13 benefitting from the same scheme due to the phasing out of DODMA support.

The issue of quality education in Malawi cannot be overemphasized owing to the decline of performance of learners not only in primary schools but also secondary and tertiary institutions (Mkandawire, 1992; Chilora et al, 2003; MOE & MIE, 2007, 2009; MOE, 2022) . About two decades ago, findings from Improving Education Quality Project (IEQP) funded by USAID showed that the majority of learners who were illiterate (unable to read and write) owed to the fact that most schools were insufficient of teachers to match with the growing number of learners.

The adoption of auxiliary teaching following the outbreak of Covid19 pandemic was thought of as a way of dealing with a problem at hand affecting the educational system more especially in primary schools in Malawi (MoEST, 2019). To the contrary, the system in place has created more harm than

good. The term auxiliary on its on demotivates and disempowers the teachers and the scenario affects the intended outcomes of teaching and learning. Over two years of experimentation have now passed but it remains hazy whether auxiliary teachers make any impact in the improvement of learning. Worse enough, some IPTE 13 teachers are on permanent employment whilst others are still hanging on with auxiliary tapestries.

A recent survey conducted by the World Bank (<https://tradingeconomics.com/malawi/pupil-teacher-ratio-primary-wb-data.html>) making a projection that Malawi will attain 58:1 pupil-teacher ratio seems unattainable by December 2022 owing to the fact that there is a growing number of school-going pupils over against the number of teachers recruited to curb the situation.

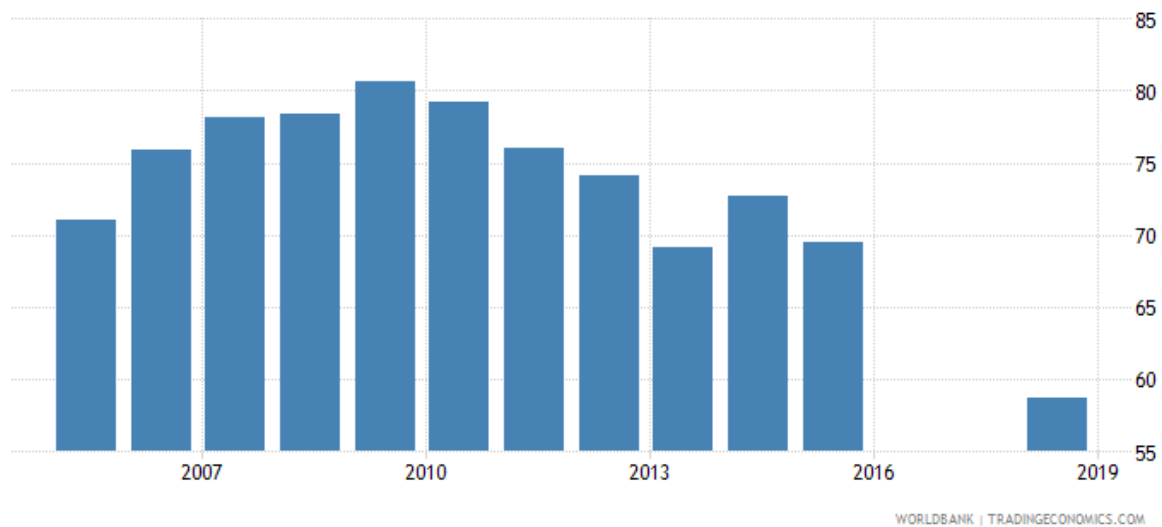


Figure 1 Number of pupils

### **Purpose of the Study**

The purpose of this study was to assess the quality of education offered by auxiliary teachers the Ministry of Education Science and Technology (MoEST) had deployed in various primary schools across the country owing to the results of the onset of Covid19 Pandemic more especially to IPTE 13 & 14 teachers.

### **Significance of the Study**

The study significantly contributes to the body of knowledge on the premise that the quality of education can be enhanced because not much has been written on the plight auxiliary teachers face in different primary schools in Malawi. To this effect, the study would be helpful in understanding issues that directly or indirectly affect auxiliary teachers which significantly contribute to the quality of education in Malawi.

Furthermore, the study would be a helpful tool to inform policy makers especially the Malawi Institute of Education (MIE) in conjunction with the Ministry of Education Science and Technology (MoEST) to modify and improve the recruitment processes so that the rationale for training teachers in Malawi is realized and achieved. In line with the above observation, it intended to inform policy makers such as the Department of Teacher education and Development (DTED) the need to train

teachers so that they don't end up as auxiliary teachers but teachers employed on a permanent basis and status.

### **Overarching Research Question**

The following was the overarching research question which guided the study:

To what extent do auxiliary teachers contribute to the quality of education in Malawian primary schools?

### **Specific Research Questions**

The following specific questions guided the study:

- a. What form of challenges do auxiliary teachers face in their teaching placements?
- b. How do auxiliary teachers cope with these challenges in their teaching placements?
- c. How can these challenges auxiliary teachers face in their teaching placements be overcome so that the quality of education is improved in Malawi?

### **Review of Related Literature**

#### **Coming to terms with the Concept**

The concept of auxiliary teaching is not a new phenomenon in Malawi. There were auxiliary teachers in the time of missionaries who were assisting them in teaching the native Malawians (Nyasaland by then). According to the Oxford Dictionary of English, the term auxiliary denotes giving help or support to the main group of workers. From the definition itself, it means that auxiliary teachers are mere helpers in the teaching and learning process. They own nothing in this regard which thereafter disempowers them

#### **Ways of addressing challenges that affect teachers on IPTE program**

Initial Primary Teacher Education is essential to develop the skills necessary for primary school teachers. Mittler (2000) argues that newly qualified teachers should be treated as the best investment that can be cherished and utilized. Despite the efforts on reforms in the recent past, the rationale of training IPTE instructors remain a subject of debate to almost all Malawians because the efficacy of the exercise still remains hazy. This concern should not be taken lightly because it has a long-lasting impact in the education sector in Malawi. Furthermore, it directly interferes with the MW2063 agenda on Human Capital Development as one of the key Enablers.

### **Research Approach**

Methodology is defined as "the rationale and the philosophical assumptions underlying a particular study" (Wisker, 2008, p.67). The study dovetailed qualitative and quantitative approaches using selected schools to make a representation. It is generally argued that literature on case studies approach provide diverse opinions regarding the nature of the cases under study. Since personal experience was crucial in understanding the topic under investigation, qualitative research was ideal as it employed an inductive research strategy that could facilitate such understanding (Creswell, 2012).

### **Research Design**

The study employed a phenomenological research design. The design was opted for because the research focused on teacher's perceptions and experiences in their placements. Furthermore, the design was selected in order to understand the research problem in detail. By design, phenomenology

is a theoretical paradigm which believes that individual behaviour is determined by the experience gained out of one's direct interaction with the phenomena. It demystifies any kind of objective external assumption. Husserl and Schutz are the main proponents of this school of thought (Wertz, 2005). During interaction with various phenomena, human beings interpret them and attach meanings to different actions or ideas, thereafter construct new experiences. Therefore, the researcher developed an empathic understanding of the process of interpretation among individuals in order to reproduce feelings, motives and thoughts that were behind the action of respondents. Phenomenology also entails a philosophical interpretive design approach which seeks to explore experiences perceived by informants (Wertz, 2005). In this case therefore, auxiliary teachers became an important aspect in understanding their situations that they are in for consideration.

### **Sample Size and Sampling Techniques**

The study used purposive sampling approach basically to understand the research problem through collecting data directly from participants who experienced the phenomenon, in this case auxiliary teachers and learners. This was based on the logic that appropriate sampling always yields appropriate data for the phenomenon under study and gives a complete picture of what is investigated (Kothari, 2004). So, in this study purposive sampling was considered appropriate because it allowed a researcher to access people who were only concerned with the research problem under study. The study targeted 11 auxiliary teachers (9 females and 2 males) from four schools in Mzimba North District.

### **Areas of Study**

This study was carried out in four primary schools in Mzimba North District where auxiliary teachers are teaching within the Northern Education Division (NED). The choice for the areas of study was based on the principle of convenience. The areas were very important to the study because the researcher easily got auxiliary teacher in their teaching placements.

### **Methods of Data Generation**

Data was collected using interviews. A total of 11 auxiliary teachers participated in the exercise via phone call discussions.

### **Ethical Consideration**

Before the process of data collection started, the researcher obtained consents from the respondents. In terms of the interviews, each auxiliary teacher was verbally informed about the information of this research project during the first contact to further make an appointment for interviewing (Kothari, 2004; Creswell, 2012). The interview guide was designed by the researcher in line with the research protocol. After being clearly informed, consents were agreeably arrived at. As regards to confidentiality, privacy and anonymity in the study (Kothari, 2004) interviews were conducted on one on one via phone call platform. The maintenance of anonymity was carried out by using school names and not necessarily the names of the respondents.

### **Research Findings, Discussions and Evaluation**

<i>Name of Headteacher</i>	: Mr. Njikho
<i>Name of School</i>	: Chaleka Full Primary
<i>Zone</i>	: Ekwendeni
<i>District</i>	: Mzimba North
<i>Year of Establishment</i>	: 2010
<i>Number of Classes e.g., Std 1 to 5</i>	: Std 1 - 8
<i>Number of Learners</i>	: 216
<i>Number of Permanent Teachers</i>	: 5
<i>Number of Auxiliary Teachers</i>	: 2
<i>Assessment &amp; Evaluation</i>	: the school has seven (7) teachers (two of which are auxiliary teachers). Even though the ratio seems to be at 1:31, it is nevertheless problematic to handle 8 classes against seven teachers. It was also known that these auxiliary teachers (receiving K80,000.00 a month) are given more subjects than those on permanent employment. These auxiliary teachers find the situation unrealistic and unhealthy, as a result, they just fulfill the lessons and filling in the schemes and records of work. This school needs more teachers in order to meet the Malawi 2063 agenda.

<i>Name of Headteacher</i>	: Mr. Andrew Mtambo
<i>Name of School</i>	:Luhawani Full Primary
<i>Zone</i>	: Engucwini
<i>District</i>	: Mzimba North
<i>Year of Establishment</i>	: 2000
<i>Number of Classes e.g., Std 1 to 5</i>	: Std 1 - 8
<i>Number of Learners</i>	: 679
<i>Number of Permanent Teachers</i>	: 6
<i>Number of Auxiliary Teachers</i>	: 4

*Assessment & Evaluation* : the school has ten (10) teachers (four of which are auxiliary teachers). The ratio of 1:68 is on the higher side if we can cross-examine this with the World Bank requirement of 1:58. As with the case of Chaleka School, it was also known that these auxiliary teachers (receiving K80,000.00 a month) are given more subjects than those on permanent employment. These auxiliary teachers find the situation deplorable and unhealthy, as a result, they just fulfill the days' requirements. The trend puts learners at risk. This school needs more teachers in order to meet the Malawi 2063 agenda as well.

*Name of Headteacher* : Mr. Emmanuel Mnthali  
*Name of School* : Chamunguma Full Primary  
*Zone* : Euthini  
*District* : Mzimba North  
*Year of Establishment* : 1938  
*Number of Classes e.g., Std 1 to 5* : Std 1 - 8  
*Number of Learners* : 630  
*Number of Permanent Teachers* : 4  
*Number of Auxiliary Teachers* : 3

*Assessment & Evaluation* : the school has seven (7) teachers (four of which are auxiliary teachers). The ratio of 1:90 is un acceptable if quality education is to be achieved. The auxiliary teachers (receiving K80,000.00 a month) are finding the work difficult. They also find the situation deplorable and unhealthy, as a result, they teach because they have nowhere to go to look for better jobs. The trend puts learners at risk. This school needs more teachers in order to meet the Malawi 2063 agenda as well.

*Name of Headteacher* : Mr. Ndilekereni Mwanza  
*Name of School* : Kamubanga Full Primary  
*Zone* : Mtende  
*District* : Mzimba North  
*Year of Establishment* : 1934  
*Number of Classes e.g., Std 1 to 5* : Std 1 - 8

*Number of Learners* : 612

*Number of Permanent Teachers* : 7

*Number of Auxiliary Teachers* : 2

*Assessment & Evaluation* : the school has nine (9) teachers (two of which are auxiliary teachers). The ratio of 1:68 is unacceptably high if quality education is to be attained. The auxiliary teachers (receiving K80,000.00 a month), as with other colleagues, are finding the work difficult. They also find the situation deplorable and unhealthy, as a result, they teach because they have nowhere to go to look for better jobs. The trend puts learners at risk. This school needs more teachers in order to meet the Malawi 2063 agenda as well.

## **Conclusion and Recommendations**

### **Conclusion**

The study has done a baseline assessment on the effectiveness of auxiliary teachers in four primary schools in Mzimba North District. It has argued that auxiliary teachers play important roles in their areas of placements not only to cushion the already existing staff but also change behaviour of learners in those institutions. The study has further discussed some of the main responsibilities of teachers in narrowing the learner-teacher gap that is at a worrying state. Teaching is an important profession because, all other professions are there because they were once trained by a teacher.

On the first specific question, it has been revealed that auxiliary teachers face a number of problems in their teaching placements ranging from accommodation to access of their little monthly token. These teachers receive their allowances not in a fixed pattern. A fixed pattern entails that some receive their allowances after a month or two, a development that puts their livelihoods at risk.

On the second specific question, the study has shown that auxiliary teachers find it hard to cope with the existing challenges they face in their placements. Lack of daily basic amenities like food makes a setback to their classroom delivery because they constantly think of where to get the next meal or other basic needs like soap and relish.

On the third specific question, the study suggests that the government should put all IPTE 13 and 14 on permanent employment and not on the contract scheme as is the case this time. It sounds unethical and unrealistic that you re-interview already qualifying personnel for the job. Secondly, Teacher Training Colleges should avoid admitting teacher trainees on a yearly basis but biannually so that teachers should not be piled up in their homes after receiving necessary and befitting training from recognized institutions.

### **The following are some of the recommendations:**

- a. Government of Malawi should employ the auxiliary teachers on a permanent basis and not the way as it is today. It has been discovered that many schools in Malawi don't have even a single auxiliary teacher to support and decongest learners in schools. The benefits that might be realized in schools if IPTE 13 and IPTE14 and of course subsequent cohorts are

- permanently recruited into the government system. If this is taken on board, the teacher-learner ratio will drastically be reduced.
- b. If the Malawi Government fails to put these auxiliary teachers on permanent recruitment, their salaries should be the same as those of the teachers on permanent status because the salary gap demotivates them. They have the same workload as those on permanent basis or even to some extent, work more hours as compared to those on permanent status.
  - c. Government should make a policy to recruit teacher trainees in various TTCs once every two years or when the Government sees to it that there is a need and not just keep the recruitment system running but fail to absorb those that have finished the two-year training into the teaching fraternity.
  - d. Recruitment of teaching staff should not be done out of convenience but that there should be a policy in place guaranteeing that all teachers who have finished their studies should straight go into their workplaces.
  - e. The government should avoid walk-in interviews for teachers who have successfully finished their studies because it doesn't make sense to train a teacher and later on interview the same teacher who went to the training institution via the interviews. The practice demotivates the job seeker.

### **Areas of further study**

The following are areas for further research:

- a. the same study but covering all the teacher training colleges.
- b. exploring the role of disability peoples' organisations (DPO's) in promoting inclusive education.
- c. teachers' perception on how the university curriculum is impacting on inclusive education practices.

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## **Exploring How Mathematics Teacher Educators Enact The Practices Of Exemplification, Explanatory Talk And Learner Participation In Teaching Number Concepts And Operations To Pre-Service Teachers**

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### **Abstract**

Pre-service teacher education is key to changing the quality of mathematics teaching in schools. How pre-service teachers learn greatly influences how they teach. But how are pre-service teachers helped to learn to enact the everyday teaching practices that happen in a mathematics lesson? This paper shares findings from a study that explored how mathematics teacher educators enacted the practices of exemplification, explanatory talk, and learner participation in teaching pre-service teachers how to teach number concepts and operations to early years learners (standards 1-4). The study was qualitative in nature, and was guided by the Mathematics Discourse in Instruction (MDI) framework. This paper is part of a larger study where four mathematics teacher educators from one public teacher training college in Malawi were purposively selected to participate. Data being reported in this paper is from two teacher educators whose lessons were observed and video-recorded. Data was analysed thematically. Findings indicated that all the three teaching practices, as analysed by the MDI framework, were present in the data. However, there were some limitations in the way these practices were enacted. For example, existence of examples that provided few opportunities for pre-service teachers to experience variation, and existence of nonmathematical word use, especially ambiguous pronouns, which appeared to hinder mathematical meanings. These findings suggest that pre-service teacher educators need to pay deliberate attention to these teaching practices for pre-service teachers to learn to enact them in their work of teaching.

to these teaching practices for pre-service teachers to learn to enact them in their work of teaching.

**Keywords:** Mathematics teacher education; exemplification; explanatory talk; learner participation

### **Introduction**

Research on learner achievement for primary school learners in Malawi has consistently shown that learners are performing below the expected achievement level in mathematics. This poor performance in mathematics begins to show from their early years of schooling (standards 1 – 4), and is seen even in topics about number concepts and operations, which make the foundation for learning more advanced mathematics (Brombacher, 2011, 2019; National Statistical Office, 2021). Different reasons have been given to explain this poor learner performance. However, recent research has indicated that the way teachers teach mathematics in early years does not fully help learners to develop mathematical competence (Brombacher, 2019; Saka, 2019). This may raise questions about the teaching practices that teachers use when teaching mathematics. It may also be an indication that pre-service teacher education may have fallen short of providing enough support to help pre-service teachers (PSTs) learn to teach mathematics effectively to early years learners. Because of the continued reports about poor learner performance in mathematics, the Early Grade Mathematics

Assessment (EGMA) recommended paying attention to teacher education as one way of strengthening the teaching and learning of mathematics in Malawian schools (Brombacher, 2011).

In most parts of the world, there has been concerns about the effectiveness of mathematics teacher education, as to whether pre-service as well as in-service teacher education helps teachers with the knowledge they need to teach mathematics effectively (Mapolelo & Akinsola, 2015). Oftentimes, teachers' mathematical knowledge and teaching practices have been blamed for learners' poor performance (Brombacher, 2019; Chikiwa et al., 2019). However, some researchers have argued that this is a misplaced blame, considering that teachers do not become teachers out of nowhere. They undergo pre-service teacher training before beginning their work of teaching. Thus, pre-service teacher education is responsible for helping teachers to know the mathematics they are going to teach and the teaching practices involved in teaching (Thanheiser et al., 2014). This necessitates the need to explore the area of pre-service mathematics teacher education, considering that it is key to changing the quality of mathematics teaching in schools.

Some researchers have argued for core teaching practices to be a focus in teacher education. Grossman (2018, p. 184) defines core practices as "Identifiable components of teaching that teachers enact to support learning." Researchers observe that focusing teacher education on core practices would help PSTs in learning to teach because these core practices are part of what teachers do regularly with their learners. As such, PSTs are expected to be competent in discharging them (Adler & Pournara, 2019; Ball & Forzani, 2009; McDonald et al., 2013). Adler and Ronda (2015) identified exemplification, explanatory talk and learner participation as part of teachers' work of teaching and significant in mathematics teacher education. These three teaching practices are the focus in this paper.

In Malawi, research is scanty on how mathematics teacher educators (TEs) enact the teaching practices of exemplification, explanatory talk and learner participation in their lessons and how PSTs are enculturated into these practices as they learn how to teach number concepts and operations, yet, research continues to indicate poor learner performance in mathematics (Brombacher, 2011, 2019; National Statistical Office, 2021). Thus, one of the areas that need to be given attention in teacher education is the enactment of these teaching practices because these are part of teachers' everyday work of mathematics teaching (Adler & Pournara, 2019). In every mathematics lesson, teachers are expected to select and use examples and tasks, provide explanations to mathematical concepts and also invite learners to participate in the lesson. However, the ability to enact these teaching practices does not come naturally to teachers. They need to learn to do it. Thus, it is from this background that this study sought to explore how these three teaching practices are enacted by two mathematics TEs from one TTC. Specifically, the study sought to answer the question: how do mathematics TEs enact the teaching practices of exemplification, explanatory talk and learner participation as they teach PSTs to teach number concepts and operations to early years learners?

### **Theoretical Framework**

This study was guided by the Mathematics Discourse in Instruction (MDI) framework developed by Adler and Ronda (2015). I found this framework suitable for this study because it provides a description of the mathematics made available for learners to learn, and it is found to be useful when exploring what TEs make available for PSTs to learn (Longwe, 2021). Also, the framework specifically targets mathematics teaching practices that teachers meet regularly in their mathematics lessons (Adler, 2017). The MDI framework considers four elements that are key to the teaching of mathematics: object of learning, exemplification, explanatory talk and learner participation.

## **Object of Learning**

The object of learning is what learners are expected to know and be able to do. In the teaching and learning of mathematics, the object of learning is brought into focus through exemplification, explanatory talk and learner participation.

## **Exemplification**

The element of exemplification concerns arrangement of examples and related tasks (Adler & Ronda, 2015). Learners often experience mathematics through examples and tasks. For learners to be able to understand the mathematical concepts under focus, they need to experience variation within and between the examples, and be exposed to tasks that vary in cognitive demand (Kullberg et al., 2017). This implies that teachers' selection of examples and tasks is influential in the mathematics that is made available to learn. For teachers to be able to provide examples and tasks that can influence learners learning of mathematics, they need to learn this practice during their pre-service teacher education, for this is a learnable practice (Adler & Pournara, 2019). The MDI framework recognizes two necessary features for an arrangement of examples that create a basis for generalization—similarity and contrast (Adler & Ronda, 2015). According to Adler and Ronda, similarity of a set of examples provides possibilities for generalizing an invariant aspect. However, similarity by itself does not draw attention to distinguish a concept from what it is not. Using contrasting examples that bring attention to a different class, therefore, offers opportunity for learners to experience generality (Adler & Ronda, 2015). On the part of tasks, the MDI framework categorizes them in terms of the level of cognitive demand. At level one are tasks that require carrying out known operations. At level two are those tasks that require application of what is known in relation to the object of learning, while at level three are those that provide opportunities for multiple connections and problem solving (Adler & Ronda, 2015). In this study, I explored the examples that were used, and whether they provided opportunities for PSTs to experience similarity and contrast. I also explored the tasks that mathematics TEs used in their teaching in relation to the level of cognitive demand they provided.

## **Explanatory talk**

Explanatory talk is talk that names and legitimates important aspects of the object of learning. Its function is to name and legitimate what is focused on and talked about, in relation to examples and tasks. Explanatory talk unfolds through how teachers refer to mathematical objects and processes (naming), and how they legitimate what counts as mathematics (legitimation) (Adler & Ronda, 2015). Explanatory talk is another teaching practice that needs to be given attention in pre-service teacher education (Adler & Pournara, 2019), if PSTs are to be able to provide relevant explanatory talk to their learners. I used the MDI framework to analyse how mathematics TEs named mathematical objects in the lessons. The focus on naming in this study was on whether the TEs and PSTs used mathematical talk, which is about formal mathematical language use, or they used nonmathematical talk which includes use of everyday language and ambiguous pronouns (Adler & Ronda, 2015).

## **Learner participation**

This is about how learners are invited to talk mathematically and verbally show their mathematical reasoning (Adler & Ronda, 2015). In a mathematics lesson, providing opportunities for meaningful learner participation is crucial for understanding the mathematical concepts made available for

learners to learn (Trocki et al., 2014). However, teachers usually find it challenging to create such learning opportunities for their learners (Trocki et al., 2014), indicating that there is need to support them to learn the practice of inviting learners to participate meaningfully in the lessons. In the MDI framework, learner participation is characterized into categories depending on the level of participation provided. Level one is where learners are invited to answer yes/no or provide one-word responses. Level two is where learners are invited to answer what/how questions in phrases or sentences, and level three is where learners are invited to participate through answering why questions, present ideas in discussion and the teacher re-voices, confirms or asks questions (Adler & Ronda, 2015). I used these categories in the present study to explore how PSTs were invited to talk mathematically and show their mathematical reasoning during the lessons.

### **Materials and Methods**

A qualitative case study approach was used in this study. Four mathematics TEs from one public teacher training college (TTC) were purposively selected to participate in the larger study. But data being reported here is from two TEs who were selected for this paper as representative cases of the four TEs. Data were collected through lesson observations. From each TE, I observed and video-recorded six lessons—two lessons on the teaching of place value and four lessons on the teaching of addition. Data were analysed by dividing the transcribed lesson data into episodes. Coding for exemplification, explanatory talk and PST participation was done by indicating beside the utterances, following the categories as characterised in the MDI framework (Adler & Ronda, 2015). At the end of each episode, I provided a descriptive summary of how each teaching practice had been enacted. The summary also included the number of occurrences of each teaching practice. This quantification guided the analysis in determining the extent to which each teaching practice was enacted.

### **Findings and Discussion**

In this section, I begin by presenting findings on how the teaching practice of exemplification was enacted, then I present findings on the use of explanatory talk and PST participation.

#### **Findings on exemplification**

In presenting findings on exemplification, I focus on the examples and tasks that were observed for each TE, and the opportunities these provided for PSTs to learn. I begin by presenting a summary of all the examples and tasks that were used as shown in the table that follows.

Table 1 Examples and tasks observed and opportunities they provided for similarity and contrast.

<b>TE</b>	<b>No. of lessons</b>	<b>No. of sections containing examples</b>	<b>Opportunities for variation</b>	<b>Kind of tasks</b>
TE1	6	17	Similarity only (6) Contrast only (1) Similarity & Contrast (3) neither Similarity nor Contrast (7)	Known operations (20) Application (2) Multiple connections and problem solving (0)
TE2	6	27	Similarity only (10) Contrast (0) Similarity & Contrast (5) neither Similarity nor Contrast (12)	Known operations (22) Application (5) Multiple connections and problem solving (0)

The findings about examples and tasks presented in Table 1 indicate that most of the examples used in the lessons were those that were categorized as providing opportunities for PSTs to experience some kind of variation, either variation in terms of similarity only, similarity and contrast or contrast only. For TE1, a total of 10 out of 17 sections provided example sets that provided opportunities for PSTs to experience variation, and for TE2, a total of 15 out of 27 sections provided example sets that provided opportunities for variation. For example, in lesson 2, TE2 provided the following set of examples: 328; 2231; 1123. With this example set, PSTs were required to identify the value of 3 in each number. This example set provided opportunities for PSTs to experience similarity and contrast in a way that 3 was kept the same, but in different positions in different numbers. This provided opportunities for PSTs to notice the change in value as its position changed. Getting exposed to such examples in pre-service teacher education might help the PSTs to learn to do the same for their learners, thereby helping their learners understand mathematics better because research indicates that varying the examples helps learners to understand the mathematics they are learning (Adler & Ronda, 2015; Kullberg et al., 2017).

Although the findings indicated that the TEs used more examples that provided opportunities for PSTs to experience some variation, it was also noticed that there was lack of deliberate attention to why the particular examples were selected for use in the lessons. This means that the issue of how to choose and use examples was not considered in these two TEs' lessons. This finding concurs with the observations of Zodik and Zaslavsky (2008) that the practice of selection and use of examples is not considered in pre-service teacher education. Selection and use of examples is a learnable practice (Adler & Pournara, 2019), and as PSTs who are being prepared for the work of teaching, they need to know what to consider when selecting examples, because not every example can bring learning gains to learners.

Table 1 also indicates that concerning tasks, the TEs mostly used tasks that required PSTs to perform known operations—20 tasks and 22 tasks for TE1 and TE2 respectively, were categorized as those that asked PSTs to perform known operations. There were few tasks that required PSTs to make application of what they know to the object of learning—2 tasks for TE1 and 5 for TE2. And there was no task that required performing multiple connections and problem solving. This implies that PSTs had limited opportunities to work with high-level tasks in terms of cognitive demand. For TEs to be able to develop PSTs' ability to construct meaningful tasks for their learners, they need to pay attention to cognitively challenging tasks (Bragg, 2015).

### **Findings on explanatory talk**

In this section, data were analysed using the element of explanatory talk as an element of the MDI framework. The focus was on whether word use was mathematical or nonmathematical. I begin presenting the findings for this section by providing a summary of all instances of mathematical and nonmathematical word use to show the extent in use of mathematical and nonmathematical word use in each lesson (L).

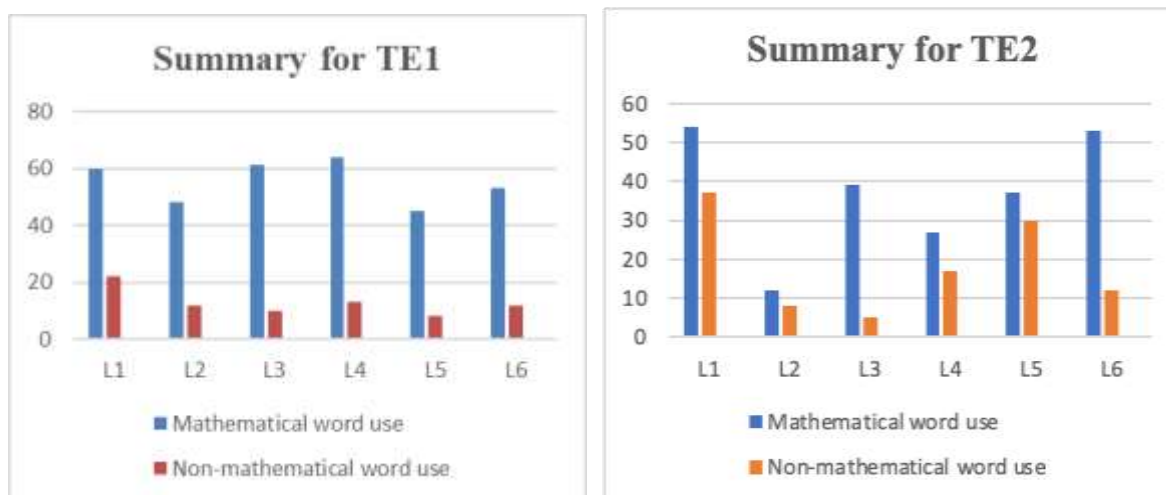


Figure 1 Summary of instances of word use.

As can be seen in Figure 1, findings indicate presence of both, mathematical and nonmathematical word use for both TEs. However, the results also indicate that there was more mathematical than nonmathematical word use across the lessons. This implies that the PSTs were exposed more to mathematical word use. In many instances, mathematical terms and definitions were named using correct mathematical terms. TEs were also observed giving modifications and directing PSTs to mathematical word use. For example, when defining the term addition in lesson 3 of TE2, some PSTs provided definitions that appeared to be correct, such as “adding numbers in order to find a total number.” Although the TE, to some extent, agreed with such definitions, he consolidated the discussion by making sure that he brought in a definition that included mathematical terms used in the concept of addition: “... a binary operation performed on two addends to get a sum.” He went on to explain the terms addends and sum, indicating that he paid attention to how mathematical terms are named in the concept of addition. This is important as it creates opportunities for PSTs to become familiar with mathematical words and learn to use them correctly in their teaching.

Although findings indicated dominant use of mathematical words in all the lessons, there were also some instances where non-mathematical word use was observed, especially use of ambiguous pronouns (Adler & Ronda, 2015). An example of use of ambiguous pronouns is shown in the following excerpt taken from TE2, lesson 2.

**PST.** ...We have the place value box here, and *this* stands for ones, *this* stands for tens. So, in ones we have zero and two *here*, so, since there is no anything *here*, we are going to add, zero, one, two, (counts up to two) which means we are going to have two *there*

This extract shows use of ambiguous pronouns. The italicized pronouns, *this*, *here*, *there* have been used in place of letters T and O as representations for place value headings, Tens and Ones. Instead of mentioning that T stands for tens, O stands for Ones, the PST repeatedly referred to them using their pronouns. This way of referring to objects of focus in mathematics can hinder mathematical meaning as it does not make clear what mathematical concepts or numbers are being referred to, and, therefore, can lead to imprecision (Leatham et al., 2016). Thus, it is important that TEs should encourage PSTs to refer to mathematical objects by their names rather than using ambiguous pronouns, as this may help them to learn to talk mathematically (Leatham et al., 2016), and eventually do the same with their learners.

### Findings on PST participation

In this section, I sought to understand how mathematics TEs invited PSTs to participate in the activities of the lessons, and how these participations provided opportunities for them to learn. The focus was on whether they were invited to provide yes/no or one-word responses, answer what/how questions, why questions, present ideas in discussions or invited to ask questions. A summary of how these forms of participation were enacted is presented in Figure 2.

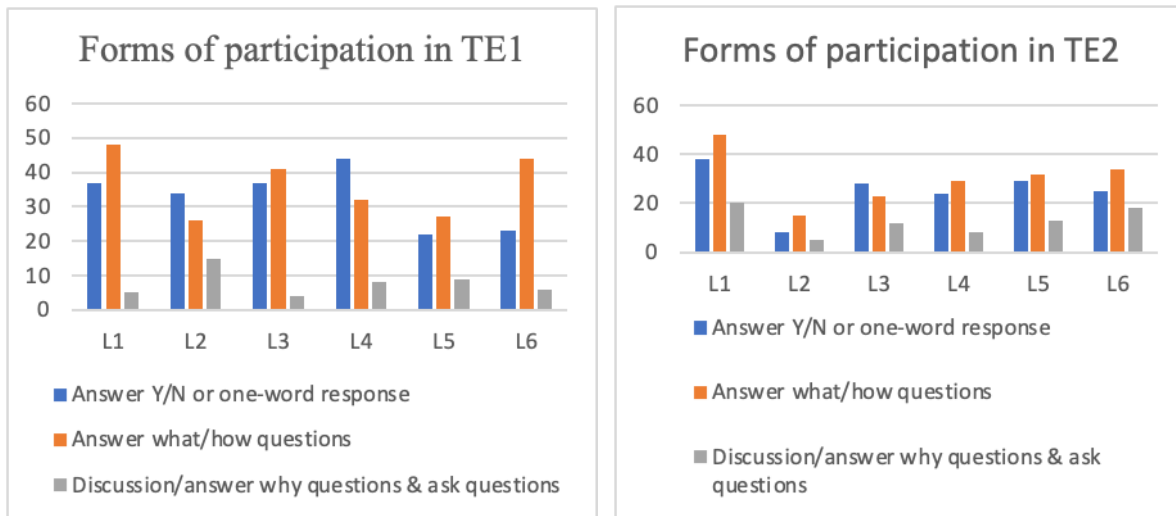


Figure 2 Summary of forms of participation.

As shown in Figure 2, PSTs were invited to participate through all forms of participation as characterized in the MDI framework (Adler & Ronda, 2015), but these forms of participation were enacted to varying degrees. It can be seen that in most lessons—4 for TE1 and 5 for TE2— PSTs were mostly invited to participate through answering what/how questions in phrases and sentences. For example, PSTs were invited to participate by defining what mathematical terms such as place value and addition mean. In these forms of participation, PSTs were provided with opportunities to go beyond offering single words and be able to express themselves mathematically (Adler & Pournara, 2019), to show what they know about the mathematical concepts being defined or explained. But the findings also indicate that PSTs were given limited opportunities to participate through discussions, answering why questions or asking their TEs questions. This implies that PSTs were not exposed much to opportunities where they could argue mathematically and show their mathematical reasoning (Adler & Pournara, 2019). PSTs need support if they are to learn to engage their learners in participations that can provide opportunities for them to reason and argue mathematically, and this support needs to be provided during their pre-service teacher education.

### Conclusion

The findings of this study have revealed that although the teaching practices of exemplification, explanatory talk and learner participation were present in all the lessons, there were some limitations in how they were enacted. For example, the findings have shown that most of the examples that were used provided opportunities for student teachers to experience variation, but deliberate attention and guidance was not provided to PSTs to learn to pay attention to what to consider when selecting examples. PSTs were mostly exposed to tasks that were categorized as of low level of cognitive

demand as they mostly required PSTs to perform known operations. The findings have also shown existence of non-mathematical word use, especially use of ambiguous pronouns that may have hindered mathematical meaning of some mathematical concepts. It has also been revealed that the forms of participation used fell short of providing ample opportunities for PSTs to argue mathematically. These findings may suggest that the challenges teachers face in teaching number concepts and operations which have been argued to have contributed to poor learner performance (Brombacher, 2019; Saka, 2019), as explained in the introduction section, might be attributed to the way teachers were prepared to teach mathematics in early years, especially how they were enculturated into the teaching practices of exemplification, explanatory talk and learner participation. Thus, as a way of addressing learners' poor performance in mathematics in Malawi, an implication from this study might be for TEs to pay deliberate attention to these teaching practices as they teach PSTs in order for the PSTs to understand primary school mathematics better and learn to enact these practices in their work of teaching.

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## **Generational Diversity In The Workplace And Its Impact On Individual Perspectives Regarding Important Career Success Dimensions.**

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### **Abstract**

This study was undertaken to analyse individual perspectives regarding important career success dimensions based on generational diversity in the workplace. Research on how individuals define a successful career is important because it brings to light the aspects that different generations value most and would strive to attain as they progress through the various stages of their careers. However, the majority of career success research has been conducted in western countries and not much research has been done in developing country contexts. Therefore, for this study, data were collected from 382 Malawians in full time employment and in three age groups, younger, middle and older. Using a structured questionnaire, respondents rated the importance of four entrepreneurship related career success dimensions on a five-point Likert Scale. To establish whether there were any variations in perspectives based on generational cohorts, a one way between -groups analysis of variance (ANOVA) was conducted. The results revealed that entrepreneurship as a career success dimension was perceived to be more important for the younger age group and the middle-age group than the older age group. These results imply that different generational cohorts in the workplace perceived entrepreneurship as a career success dimension differently. In particular, the younger individuals, although in full time employment, seemed to embrace entrepreneurship more as an important dimension of a successful career reflecting the tenets of boundary- less careers. This is important for Malawi because entrepreneurship is a key pillar in the youth led Malawi 2063. We therefore conclude that it is vital to comprehend the characteristics and values of diverse generational cohorts so that relevant strategies including human capital development endeavours can be uniquely designed to meet the needs and expectations of different cohorts in the society.

**Keywords:** Generational diversity, career success, human capital development, entrepreneurship.

### **Introduction**

Generational diversity is inevitable in the workplace because today's workforce is more diverse in age than ever before (Gutterman, 2022; Usmani, 2019). A generation is defined as an identifiable group that shares birth years and significant life events at critical developmental stages (Kupperschmidt, 2000, p. 66). These experiences influence person's feelings toward authority and organizations, what a person values from work, and how a person plans to satisfy those desires (Jurkiewicz & Brown, 1998; Kupperschmidt, 2000). Therefore, the significant life experiences of individuals belonging to each generational group tend to shape their unique characteristics, aspirations, and expectations (Cennamo & Gardner, 2008 as cited in Angeline 2011). Although, Hay Group (2015) contends that we do not define people and their needs at work by gender or cultural background, and that there is little evidence for making assumptions about the kind of work environment an employee wants based on their age, nonetheless, other researchers such as Angeline (2011); Prawitasari (2018); Usmani et al. (2019) argue that understanding diversity and using the right strategy is crucial for organizations' generational success. Failure on the part of managers to

understand and adjust appropriately to generational differences and the demands of new generations entering the workplace can result in misunderstandings, miscommunications, and mixed signals, and can affect employee productivity (Prawitasari, 2018, p. 15).

In this study, we defined career success as the experience of achieving goals that are personally meaningful to the individual, rather than those set by parents, peers, an organization, or society (Mirvis & Hall, 1994, cited in Dries, 2011). Mayrhofer et al. (2016) identify seven globally relevant dimensions of career success that people regularly consider when they evaluate their careers: financial security, financial achievement, learning and development, work-life balance, positive relationships, positive impact, and entrepreneurship. It is important to note that, although the study of career success has progressed significantly, the nature of career success is often bounded within and influenced by a country's unique context (Pringle & Mallon, 2003). Furthermore, age has been identified as one factor that influences the variability in people's perceptions (Prawitasari, 2018). In comparison to other contexts, generational diversity has been theorised in western cultures (USA, UK, and Canada) more often and not much research has been done in developing country contexts (Graeme, 2008; Prawitasari, 2018). Research on how different generational cohorts define career success is important because it brings to light the aspects that different generations value most and would strive to attain as they progress through the various stages of their careers. This study was therefore undertaken to analyse individual perspectives regarding important career success dimensions with a specific focus on entrepreneurship. Entrepreneurship has attracted a lot of attention in many developing economies such as Malawi because it is perceived as a contributor to job creation and economic growth. In such economies, systematic research into entrepreneurship as a career success dimension is central to enhance concerted efforts undertaken by relevant stakeholders to attract individuals to venture into entrepreneurship.

Specifically, the paper addressed the following two research objectives:

- 1) To establish the extent to which individuals in full time employment regarded entrepreneurship as important in their conceptualization of career success.
- 2) To establish whether there were any variations in perspectives regarding the importance of entrepreneurship as a career success dimension based on generational cohorts in the workplace.

## **Materials and Methods**

Data were collected from 382 Malawians, employed full time in four occupations: managers 31.9% (122), professionals 35.1% (134), clerical and service workers 22.3% (84), and skilled labour 10.7% (41). In terms of gender 40.2% (155) were females and 59.6% (229) were males. The study used a structured questionnaire based on insights from the broader Cross-Cultural Collaboration on Contemporary Careers (5C) research project. A total of 30 career success aspects were presented to study respondents of which 4 aspects were entrepreneurship related. These were (1) owning own company, (2) running own company, (3) being self-employed, and (4) having an opportunity to be entrepreneurial. Respondents were asked to indicate how important each aspect was to how they viewed career success on a five-point Likert Scale ranging from 1 = not at all important to 5 = very important. Responses from the 4 entrepreneurship related aspects were transformed into a composite entrepreneurship variable. Study respondents were then divided into almost three equal age groups. The younger age group born between 1983 and 1994 and were aged between 22 – 33 years, the middle - age group born between 1977 and 1982 and were aged 34 – 39 years; the older age group born in and before 1976 and were aged 40 years and above. To establish whether there were any

variations in perceptions regarding the importance of entrepreneurship based on generational cohorts in the workplace, a one way between -groups analysis of variance (ANOVA) was conducted using IBM Statistical Package for the Social Sciences (Pallant, 2010).

### Results and discussion

Table 1 results revealed that the respondents considered entrepreneurship as an important career success dimension. The mean scores of all the three age groups on a scale of 1 – 5, were above 4.0. That is  $M = 4.35$ ,  $SD = .764$  for the younger age group,  $M = 4.33$ ,  $SD = .698$  for the middle age group and  $M = 4.05$ ,  $SD = .944$  for the older age group. Furthermore, there was a statistically significant difference at the  $P < .05$  level in the mean scores for entrepreneurship as a career success dimension for the three age groups:  $F(2, 376) = 6.76$ ,  $P = .001$ . The actual difference in the mean scores between the groups was modest. The effect size calculated using eta squared, was 0.03.

Table 1 Descriptive Statistics: Entrepreneurship

Age Group	Career Success Dimension - Entrepreneurship			
	Mean	Standard Deviation	F	Sig.
Younger	4.35	.764	6.764	.001
Middle-age	4.33	.698		
Older	4.05	.944		

Entrepreneurship as a career success dimension for those in full time employment is of relevance since the concept of career has become more fluid. The traditional view of life-long careers in the same profession or organization is a thing of the past. The new concept of a career is often referred to as a protean career. That is a career that frequently changes based on changes in the person’s interests, abilities, and values and in the work environment (Noe et al., 2006). Additionally, people increasingly move from opportunity to opportunity without regard for traditional job boundaries – hence boundaryless careers (ibid. 2006). Entrepreneurship can be a vehicle for those pursuing a protean career as it offers opportunities for flexibility and self-expression (Gelderen et al., 2008, p. 539). Similarly, with the reduced constraints of boundaries as exemplified in boundaryless careers, the entrepreneur can break away from the traditional employment setting in pursuit of his or her own venture (Gelderen et al., 2008).

Table 2 Post Hoc Tests: Tukey HSD- Entrepreneurship: Multiple Comparisons

Age Group (I)	Age Group (J)	Mean Difference (I-J)	Sig.
Younger	Middle Age	.093	.973
	Older	1.233*	.007
Middle age	Younger	-.093	.973
	Older	1.140*	.015
Older	Younger	-1.233*	.007
	Middle Age	-1.140*	.015

\*The mean difference is significant at the 0.05 level.

Post – Hoc comparisons using the Tukey HSD Test as shown in Table 2 indicates that the mean score for younger age group ( $M = 4.35$ ,  $SD = .764$ ) was statistically different from the older age group ( $M =$

4.05,  $SD = .944$ ). The middle-aged group ( $M = 4.33$ ,  $SD = .698$ ) was significantly different from the older age group but did not differ significantly from the younger age group. These results clearly revealed that the different generational cohorts in the workplace perceived the entrepreneurship career success dimension differently. Specifically, the results revealed that entrepreneurship as a career success dimension was perceived to be more important for the younger age group and the middle-age group than the older age group.

Graeme (2008) argues that in each new context, work needs to be done to identify unique, local defining events, and show how these events specifically influenced the generations in that context. The distinct experience of one's upbringing during a specific time period is thus a meaningful psychological variable, rather than a mere stereotype (Twenge, 2010). This distinct experience creates a difference in values and attitudes, which each individual brings into the workplace. A comprehension of these differences is vital. In Malawi, a major event which can possibly be associated with the younger age group that took part in this study is the design of the education system. In the past, entrepreneurship was not highly emphasised. Even the education system was perceived as being designed to produce jobseekers and not job creators. It is only in more recent years that the trajectory has shifted and more emphasis is now being placed on entrepreneurship. Anecdotal evidence shows that institutions of higher learning in Malawi have already taken on board the drive to enhance the entrepreneurial skills and competencies of their students by introducing entrepreneurship related modules in a wide range of programmes of study to prepare graduates for self-employment. This paper provides empirical evidence to justify such endeavours.

Individuals in full time organizational employment represent a potential group of entrepreneurs who, based on changes in the personal interests, abilities, values and changes in the work environment, can break away from the traditional employment setting in pursuit of their own ventures as entrepreneurs. In particular, the younger age group, although in full time employment, seem to embrace entrepreneurship as an important dimension of a successful career reflecting the tenets of boundary-less careers. This generation cohort can be likened to generation Y who Martin (2005) described as technology savvy, independent, self-reliant, and entrepreneurial thinkers. Similarly, other research has shown that individuals in generation Y are making a significant move from traditional forms of employment to self-employment because they are very entrepreneurial—engaging in multiple jobs with diverse career paths (Gibson, 2013). (Prawitasari, 2018) asserts that with the increasingly transitory nature of work, the reduction in lifelong employment and the increase in part-time and contract work, generation Y is able to have multiple career paths and begin a career revolution by valuing self-employment.

Apparently, our study shows that even in an African context, Malawi in particular, this reality of the younger generation being more entrepreneurial, is manifesting itself. Therefore, the fact that in this study entrepreneurship is perceived as an important career success dimension is a great opportunity for Malawi as it forges ahead toward the attainment of the Malawi 2063. As a developing country, Malawi ranks on number 169 out of 191 countries on the human development index (United Nations Development Programme, 2022). The country faces a number of challenges including poverty, hunger and growing unemployment. Over the years, the youth unemployment rate has been increasing. For instance, in 2021, the youth unemployment rate was 9.85% with a 0.32% increase from 2020; in 2020, the rate was at 9.52%, a 1.2% increase from 2019; in 2019, the rate was 8.32%, a 0.05% increase from 2018 and in 2018, the unemployment rate was at 8.27% with an increase of 0.06% from 2017 (World Bank, 2022). Accordingly, Malawi recognizes that delivering the Malawi 2063 is a collective responsibility and hinges on a number of critical success factors.

Entrepreneurship is a key pillar for the youth led Malawi 2063. In harnessing the successful achievement of the Malawi 2063, young people are recognized as the greatest resource and source of wealth (npc, 2020).

### **Conclusion**

Entrepreneurship emerged as a more important career success dimension for the younger age group in comparison to the other age groups. This suggests that although this younger age group is in full time employment, they place much value on entrepreneurship in their conceptualization of a successful career. We therefore conclude that different generational cohorts in the workplace perceive important career success dimensions differently since their value systems also vary. Accordingly, Prawitasari (2018, p. 15) posits that “individuals from the traditional generations will tend to choose careers which provide firm loyalty as his personal accomplishment, while individual from the baby boomers will tend to choose careers which provide prestige, facilities, and positions. Additionally, the generation Y lay their personal accomplishments on freedom and balance between career and family and tend to choose careers which give them freedom and creativity to work by utilizing high technology. Similarly, the Z generation not only tend to choose careers which give them freedom and creativity but also expect feedback from the experienced people (Prawitasari, 2018, p. 15). Hence, in any human capital development endeavours, there is certainly a no one size fits all. It is vital to comprehend the characteristics and values of diverse generational cohorts so that relevant strategies including human capital development endeavours can be uniquely designed to meet the needs and expectations of different cohorts in the society.

The implication of these results is that learning and development programmes should be diverse to support the acquisition of skills, experiences and competencies required for the advancement of careers both within and beyond the formal traditional organizations to self employment.

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## **Malawi's secondary school education: a curse or a blessing?**

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### **Abstract**

Education is the reason behind social change and scientific progress. The Malawi Vision 2063 rightly notes this role of education as it posits that the thrust of any economy is its people as they are the ones that design programmes, implement strategies and create innovations. Using a qualitative design this study explored how the education offered in secondary schools in Malawi equips students with prequisite skills for bringing about economic transformation. Data were generated through semi-structured interviews and focus group discussions with teachers, students and parents in one hundred secondary schools across Malawi. Data analysis using inductive thematic analysis technique revealed that secondary education being offered in Malawi emphasises much on theoretical as compared to practical knowledge and that curriculum delivery is examinations oriented hence benefits a few who proceed to tertiary education. The education offered does not take into account the new needs confronting the people of Malawi, in particular and everywhere in the world, in general. This renders the education offered in Malawian secondary schools ineffectual in producing the human capital required for economic transformation. The most salient implication raised by these findings is that there is need for curriculum reform to ensure that secondary school graduates are equipped with the requisite skills and capabilities to support the development agenda of the country. This is critical because in order to integrate into the world economy, people must not only acquire the knowledge and tools of traditional knowledge, but above all, they must be capable of acquiring new skills demanded by a knowledge society.

**Key words:** Curriculum reform, economic transformation, human capital, knowledge economy

### **Introduction**

Education provides a foundation for development, the groundwork on which economic and social wellbeing is built. It is the key to increasing economic efficiency and social consistency. By increasing the value and efficiency of their labour, it helps to raise the poor from poverty. It increases the overall productivity and intellectual flexibility of the labor force. It helps to ensure that a country is competitive in world markets now characterised by changing technologies and production methods (Avalueva, Alekseeva, Alieva, & Fiofanova, 2022)

In the 21st century, all the countries implementing their policies of national socio-economic development place a particular emphasis on the development of human capital as one of their national priorities (Avalueva, Alekseeva, Alieva, & Fiofanova, 2022). Many countries of the world, realising the challenges of modern development, are constructing a new ideology of human development, which is based on expanding human capabilities, granting people the right to choose, recognise their creative abilities and ensure their involvement in designing changes. Such concepts of human development in the changing world become the basis of national strategies and reforms of socio-economic development, including educational reforms (Avalueva, Alekseeva, Alieva, & Fiofanova, 2022).

Fundamental to the growing interest in investment in education is the widespread notion that a nation's economic performance is linked to education and training. It is usually asserted that human

capital plays a significant role in economic development and that education is the centre-piece of human capital formation (Jill, 2016).

Malawi has not been left out in this new thinking. Through its policy documents, Malawi places education as the centrepiece in most of its development (Government of Malawi, 2008). For instance, the National Education Sector Plan 2008-2017 clearly stated that: *“the vision for the education sector is to be a catalyst for socio-economic development, industrial growth and instrument for empowering the poor, the weak and the voiceless”*. It went further to state that: *“education should enable people to acquire relevant knowledge, skills, expertise and competencies to perform effectively as citizens, workforce and as leaders of Malawi, thereby reduce poverty amongst the people of Malawi”* (Government of Malawi, 2008:1).

These aspirations have been reinforced in the current Malawi’s development blueprint, the Vision 2063. Vision 2063 posits that developing human capital through education and skills plays a pivotal role in the transformation of the economy. It goes further to state that with the capacity of our citizenry developed, Malawi will fully harness her resource potential and expeditiously achieve the agriculture productivity and commercialization, industrialization and urbanization agenda. Thus, Vision 2063 affirms that the thrust of any economy is its people as they are the ones that design programmes, implement strategies and create innovations. To this effect, Vision 2063 commits that scientific and technical skills at the secondary and tertiary education levels shall be enhanced. Again, Vision 2063 promises that education and training institutions shall be aligned with the industrial sector to produce relevant qualifications and skills for the job-market and benchmark industry skills training, assessment and certification to international standards.

Given the fact that it is generally asserted by scholars that there is a relationship between education and socio-economic development, efforts should be made to explore Malawians perceptions on the potent of the education being offered in secondary schools in bringing about socio-economic development. This study aimed at exploring how teachers, students and parents perceive the education being offered in Malawian secondary schools as prequisite for bringing about economic transformation.

The preceding statements, drawn from both Malawi’s previous and current policy documents, NESP (2008) and Vision 2063 (Government of Malawi, 2020), suggest that education planning in Malawi is mostly guided by plans that link it to development policies. While agreeing that education is key to national development, this study was particularly interested with the bearing of the relevance of Malawi’s secondary education on both human capital formation and national development (Jill, 2016).

The purpose of the study was to explore how teachers, students and parents perceive the education being offered in Malawian secondary schools as prequisite for bringing about economic transformation.

The study aimed at answering the following research questions:

1. How does the current secondary school curriculum prepare students for productive life in society?
2. What knowledge and skills should secondary school students learn to be productive in society?

## **Materials and methods**

The study employed a qualitative research design. Data was collected from 100 secondary schools that were purposively sampled. The following respondents were involved in the study: 400 secondary school teachers, 400 secondary school students and 200 parents. Data was generated using focus group discussion semi-structured interview guides. The data was analysed using inductive thematic analysis technique.

## **Findings**

In this section, findings of the study are presented according to the two research questions. These are: 1) How does the current secondary school curriculum prepare students for productive life in society? and, 2) What knowledge and skills secondary school graduate should learn to be productive in society?

### **How the current secondary school curriculum prepares students for productive life in society**

This part of the study tasked respondents to give their views on whether or not they felt that what students learn in secondary schools helps them become useful and productive members of society. The findings show that respondents had reservations on the potential of the curriculum to prepare students for productive life in society.

The respondents observed that the curriculum falls short of preparing students for a productive life after secondary school education. For instance, most of them felt that what students learn in school is not effective enough to help them become productive members of society. Specifically, the respondents faulted the content, teacher competency, how the content is taught (methodology) and the central focus that examinations have on teaching and learning.

Parents observed that secondary school graduates do not learn practical skills that could enable them to do anything productive. One parent had this to say:

*“Today’s secondary school graduates cannot create jobs. In the past, primary school learners were mastering practical skills. This time, neither primary nor secondary school students master practical skills. The curriculum does not even transform the mind of the students.”*

The parents further pointed out that the curriculum does not equip students with necessary skills such as tailoring, carpentry, cookery, craft work, drawing and music, which could help them after completing secondary education. They further observed that only those who further their education beyond secondary were at least better off.

Students too felt that what they were learning in school was falling short to help them to be productive in life and the world of work. They argued that they learn things that could hardly be used in life and that school was full of memorisation and exam-orientedness. During a focus group the students had this to say:

*“...at school we just learn to pass examinations and not to survive in life. No wonder, we end up being less productive. The problem is that when learning we do not conduct practicals say, on ‘electric current’; we just learn theoretically such that we cannot even do basic electrical installations.”*

Another set of students explained that:

*“What we learn in school will not help us because we only learn theory. As such it will be difficult for us to apply anything in everyday life. Again, some subjects and topics are irrelevant....”*

Teachers too had reservations on the potential of the secondary school curriculum in preparing students for productive life. One teacher had this to say:

*“The subjects I am teaching do not equip students with required skills, knowledge and values to be productive members of the society. This is because for the students to be productive they need a certain level of knowledge that they can use to solve various problems. I do not think the current curriculum is providing enough knowledge to help the students solve various problems. This is because there is too much theory as compared to practical knowledge. The practical aspects featured in the curriculum are too basic to properly help the students to be productive members of the society.”*

The findings show that the secondary school curriculum does not prepare students for life because it has limited practice-based activities and more theory than is relevant. This denies the students the opportunity to develop practical skills for immediate use after school life. This renders most of secondary school graduates less productive.

#### **What knowledge and skills should secondary school students learn?**

The respondents were also asked to suggest what knowledge and skills should secondary school students learn so that they are productive in society. The respondents raised a number of expectations. For instance, members of school management teams expected the graduates to model agricultural skills in areas of fertilizer-making from local materials, manure making and improved methods of farming. Graduates were also expected to exhibit positive values in the society such as integrity (i.e., avoiding corruption), inter-personal relationship, care for natural resources, hardworking spirit, self-reliance, patriotism, good citizenship skills and self-discipline. They also expected secondary graduates to display technical and scientific skills such as wood work, metal work, brick laying, and computer skills. On the quality of thinking processes, school management members expected the graduates to display critical thinking, decision-making, problem solving, conflict resolution, and open-mindedness.

On entrepreneurship, the school management teams expected graduates to be investors in their communities, display creativity and productivity in their engagements such as designing water pumps. They also expected them to have skills on how to manage small scale business, how to wisely spend money, ability to come up with income generating activities and self-employment.

Parents too presented their views about what they would have loved students to be learning in secondary school. Apart from the content they already learn, most parents wished the students to be learning practical things they could easily make use after school for a living even if they would not be employed. The emphasis was on the content to deal with practical skills such as carpentry, metal work, computer studies, and gadget repairing. For example, one parent had this to say:

*“It is very unfortunate that our schools do not offer vocational training. We know there are those subjects like woodwork, metalwork and home economics in the curriculum. However, not every school does offer those subjects. By not offering such subjects, we are killing some students who may not go very far with their education but who would otherwise live independent life if they had*

*acquired those vocational skills. We should not wait until they go out of secondary school level for them to acquire the vocational skills”.*

The findings of this study revealed that respondents had high expectations on the students after completion of the secondary school than what the students actually demonstrate. Practical, entrepreneurial and innovative skills were consistently observed as lacking in the graduates. These were, however, deemed as very critical for their survival and development of the country. It was very clear that parents, teachers and school management teams wanted the curriculum to front skills development than putting emphasis on knowledge acquisition. This points to an approach where knowledge comes in to support targeted skills, and not skills developing as a result of knowledge. Skill based learning could also be supported by having more skill intensive subjects than cognitive ones, bearing in mind that progression rate to tertiary education remains very low leaving most of the students joining the society.

### **Discussion of the findings**

The core argument in this study is that it is essentially the relevance rather than the quantity of education that highly stimulates a nation's socio-economic development. The study examined the relevance of education being offered in Malawi's secondary schools in developing the human capital necessary for Malawi's socio-economic development. The main finding is that the secondary education being offered in Malawi emphasises much on theoretical as compared to practical knowledge and that curriculum delivery is examinations oriented hence only benefits a few who proceed to tertiary education. The education offered does not take into account the new needs confronting people in Malawi, in particular and the world, in general. This renders the education offered in Malawian secondary schools ineffectual in producing the human capital required for economic transformation.

This finding concurs with Malik (2018) who observes that society is changing at an alarmingly accelerating pace but schools remain lethargically stuck with structures that took place in the 19<sup>th</sup> Century. Malawi as many other developing countries is struggling to change her pedagogical practices. Secondary schools teach obsolete skills that are not needed in the digital era. Too many students are leaving school without mastering a minimum set of skills for a productive life in society (Malik, 2018).

This is despite the shared understanding that the core changes brought by Information and Communications Technology and globalisation call for new forms of learning and epistemological issues regarding how learning occurs and how knowledge emerges beyond the borders of traditional systems of education. Knowing how we learn, how to turn information into knowledge, and how to document and analyse life-long learning are essential in the 21st century (Malik, 2018). These findings show that in Malawi, teachers and students are stuck with a curriculum that is highly outdated and of very little use in their future lives.

No wonder, Kwengwere (2010) cited in Jill (2016) sees the curriculum in Malawi schools as being English middle class, elitist, highly selective, economically wasteful, and largely irrelevant to Malawi's developmental needs. It is largely a kind of education system that does not adequately prepare students to participate in national development but is geared towards getting graduate jobs in spite of high unemployment rate. Thus, educational outcomes have failed to meet developmental objectives at national level and have largely become a drag to socio-economic development as opposed to a stimulus.

Therefore, if Malawi is to achieve the aspirations of its Vision 2063, she has to align her curriculum and learning to a whole new economic model based on an emerging global knowledgebased workforce. To accomplish this, it is imperative to transform children's learning processes in and out of school and engage them in acquiring 21st century skills and knowledge (Dede, 2008). The fact is that the old lecture-centric, one-size-fits-all approach to education cannot prepare students for today's challenges, let alone those that will emerge in their lifetimes (Malik, 2018). The new paradigms for education in 21st century demand a holistic transformation of education by creating a comprehensive roadmap that covers curricular and assessment reform, new teacher recruitment and training strategies, leadership development and the integration of collaborative technologies.

### **Conclusion**

Clearly the educational provisions within any given country represent one of the main determinants of the composition and growth of that country's output and exports and constitute an important ingredient in the country's capacity to adopt and adapt foreign technologies effectively (Jill, 2016). This study explored how the education offered in secondary schools in Malawi equips students with prerequisite skills for bringing about economic transformation. The findings of this study have demonstrated that the secondary education offered in Malawi remains wanting.

The most salient implication raised by these findings is that there is need for curriculum reform to ensure that secondary school graduates are equipped with the requisite skills and capabilities to support the development agenda of the country. This is critical because in order to integrate into the world economy, secondary school students in Malawi must not only acquire the knowledge and tools of traditional knowledge, but above all, be capable of acquiring new skills demanded by a knowledge society. Ensuring that all citizens are educated and numerate, that many possess a wide range of problem-solving skills beyond the basic level, and that some have world class professional skills will necessitate new curricula, improved teacher programs, and academic methods that encourage higher order cognitive skills (Jill, 2016).

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## **The students' competencies in the use of online databases at Saint John of God College of Health Sciences in Malawi**

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### **Abstract**

Information and Communication Technologies (ICTs) are broadly utilised in various sectors like Agriculture, Commerce, Tourism, Environment, Engineering among others, and the education sector has not been spared. In Malawi, National Council for Higher Education, Medical Council of Malawi, and Nurses Council of Malawi encourages universities and colleges to be providing access to online databases to their students and staff. However, despite offering access to online databases to its students, low utilisation of these databases at Saint John of God College of Health Sciences has been observed. The aim of the study was to investigate the use of online databases by students at Saint John of God College of Health Sciences in Malawi. A mixed method design was used. Census method was used to select all the 188 students and one assistant librarian out of two was selected using purposive sampling. Quantitative data was collected using a questionnaire from 181 students out of 188 students and interviews were conducted with the assistant librarian. The results show that 178 (98.3%) students were aware of online databases available at the college. Ninety-one (50.3%) students indicated average competency in using online databases. The students enjoyed five key benefits in using online databases namely: 139 (76.8%) convenience, 147 (81.1%) time saving, 97 (53.6%) remote access, 112 (61.9%) full text article access, and 65 (35.8%) 24 hours access. The study also established the following key factors that encouraged students to use online databases: 169 (93.4%) students reported usefulness in their studies; 165 (91.2%) students indicated quick tasks accomplishment while 157 (86.7%) reported influence by library staff. The study also established that between 41 (22.6%) and 129 (71.2%) students were discouraged from using online databases by the following factors: slow internet connection, lack of skills, complicated passwords, and limited subscription. Online databases have proven to be very important in institutions of higher learning as they promote research culture among scholars. The study makes the following recommendations: Crafting relevant promotional and marketing strategies; management should collaborate with ICT team and Library staff to improve ICT infrastructure and the library information systems.

**Keywords:** Online databases, Information and Communication Technology, Electronic journals, Saint John of God College of Health Sciences, Malawi.

### **Introduction**

Malawi Vision 2063 (MW2063) emphasizes on the need for the education system to be re-designed to respond to the current and future skills of the different industries and sectors by promoting advances in science, technology and innovation (Nation Planning Commission, 2020,p.20). Online databases are the current information technology that need to be utilised in higher education institutions by students, lecturers and researchers to achieve quality research and innovations. In this study, online databases are limited to following: Health InterNetwork Access to Research Initiative (HINARI), PubMed, BioOne, Cambridge University Press Journals, EBSCOHost, Sage, Taylor and Francis, Oxford Reference Online, Wiley, and African Journals Online (AJOL). In Malawi, National Council for Higher Education (NCHE) requires universities and colleges to provide access to online databases (National Council for Higher Education, 2022). However, despite offering access to online databases to its students, low utilisation of these databases at Saint John of God College of Health Sciences has been

observed. It is this problem of resource under-utilisation that necessitated this study to understand students' utilisation of these online databases. The rationale for undertaking this study was to unearth evidence-based reasons for the low utilisation of online databases by students at the institution.

Saint John of God College of Health Sciences is a private institution of higher learning which was established in 2003. It is located in Mzuzu City in the north of Malawi (Saint John of God College of Health Sciences, 2022). The institution is affiliated to three Malawian public universities which include Mzuzu University, University of Malawi and Kamuzu University of Health Sciences. The College offers four academic programmes, namely Diploma in Nursing (Registered Nurse), Diploma in Psychosocial Counselling, Bachelor of Science in Clinical Medicine (Mental Health), and Bachelor of Science in Mental Health Psychiatric Nursing. The College has library which provides access to a wide range of print and electronic information resources (Saint John of God College of Health Sciences, 2022).

### **Methodology**

A mixed method design was used. Census method was used to select all the 188 students and one assistant librarian out of two was selected using purposive sampling. Quantitative data was collected using a questionnaire from 181 students out of 188 students and interviews were conducted with the assistant librarian. The quantitative data was analysed using SPSS version 20.0 while qualitative data was analysed thematically. The research was approved by Mzuzu University Research Ethics Committee (MZUNIREC).

### **Research Question**

- What are the students' competencies in the use of online databases at Saint John of God College of Health Sciences?

### **Theoretical Framework**

This study was guided by the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh *et al.*, 2003). Generally, this theory assesses whether the user is able to accept and use the new technologies. In this study, online databases are the referred technology to be thoroughly investigated.

The UTAUT model has four main variables which are performance expectancy, effort expectancy, social influence, and facilitating conditions, and these serve as direct determinants of usage intention and behaviour (Venkatesh *et al.*, 2003). Gender, age, experience, and voluntariness of use are posited to mediate the impact of these constructs on usage intention and behaviour. Performance expectancy is the degree to which an individual believes that using the system will enhance job performance (Venkatesh *et al.*, 2003). Whereas, effort expectancy is the degree of ease associated with the use of the system (Venkatesh *et al.*, 2003). This means that online databases will be adopted or rejected by its users depending on its levels of difficulty or easiness when using it. Social influence is another main construct, which is defined as the degree to which an individual perceives and believes in the importance of others towards his or her desire to use the new system (Venkatesh *et al.*, 2003). The other main variable is facilitating conditions, which is defined as the degree to which an individual believes that organisational and technical structures exist to support his or her use of the system (Venkatesh *et al.*, 2003). The components of the UTAUT are shown in Figure 1 below.

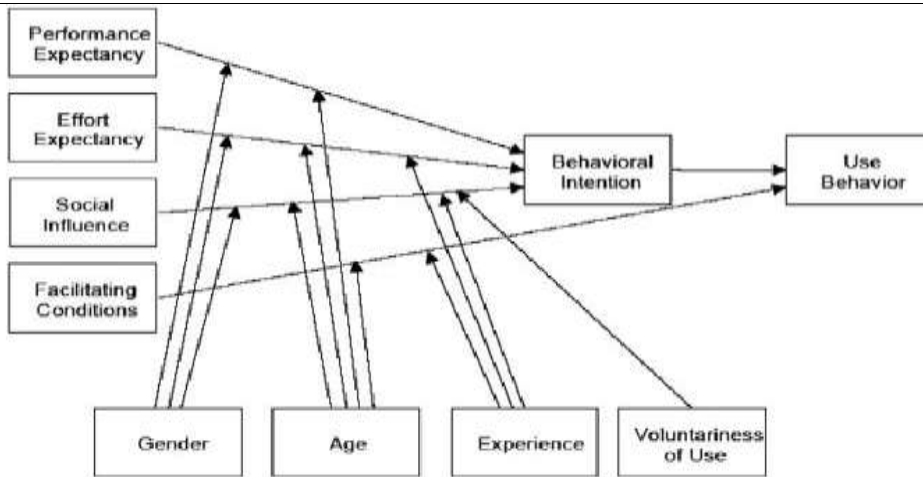


Figure 11: UTAUT model (Venkatesh et al, 2003, p. 447)

### Brief Literature Review

#### Students' Competencies in The Use Of Online Databases

Students digital competencies are the necessary skills required for them to use digital tools and work in computerised environments like electronic library infrastructures and services (Khan and Bhatti, 2017). Ridwan et. al (2019) defined ICT competencies as being able to handle a wide range of varying computer applications for various purposes. Information competency, sometimes referred to as information literacy, "is the ability to access, evaluate, organise and use information from a variety of sources" (Feather and Sturges, 2003, p.261). In an electronic environment, computer literacy is seen as the basis for information literacy (Feather & Sturges, 2003). However, it should be noted that being computer literate does not guarantee being information literate.

Ankrah and Atuase (2018) argued that online information literacy is important for students to successfully use online databases. It is essential for students to have competencies in computer skills in order to effectively access information from different sources such as World Wide Web (WWW), online databases, e-journals and CD-ROMs. Apart from accessing information, Ankrah and Atuase (2018) further argue that online information literacy skills are needed for users to successfully locate, retrieve, organise, evaluate, and apply information in their academic work.

Saulus (2017) conducted a study on the usability of the institutional repository by faculty and postgraduate students at the University of Swaziland. A mixed methods approach was used and questionnaires and interview schedules were used to collect data. Respondents were asked to rate their levels of skills in searching and retrieving documents from the repository. The majority of students reported that their levels of skills in searching and retrieving online information were low.

Different findings were obtained in a study by Adeleke and Nwalo (2017) who examined the relationship between information literacy and the use of information resources by postgraduate students from the university of Ibadan in Nigeria. The study adopted a descriptive survey design, and a sample of 300 postgraduate students were selected using simple random. Data were collected using questionnaires designed to elicit response from respondents. The study reported that a lot of students lacked search techniques skills to access the intended information in online databases. Others reported that they lacked general IT skills.

Chipeta (2008) conducted a study on the teaching and learning of Information Literacy in institutions of higher learning in KwaZulu-Natal province and Malawi using qualitative and quantitative methods. Data was collected using questionnaires, observations and interview guides. The study targeted 422 students as follows: Durban University of Technology, 229

students, University of Zululand 103 students and Mzuzu University 18 students. The study revealed that students from University of Zululand and Mzuzu University who received formal information literacy training had the perception that they had the right skills to independently identify, locate, retrieve and use information sources. This means that training boosts the confidence and skills of students in online information literacy. This may also entail that in cases where students are trained, they can be highly competent in using the online databases.

## **Results**

### **Competencies in the use of online databases at Saint John of God College of Health Sciences**

This section addressed the research question on the competencies in the use of online databases at Saint John of God College of Health Sciences.

#### **Level of agreement on the relevance of online information literacy skills to use online databases**

Respondents indicated their level of agreement to the relevance of online information literacy skills to successfully use online databases. A four-point Likert scale was used for respondents to select the extent they agreed that online information literacy skills are important to successfully use online databases. Results are presented in Table 1 below. These results demonstrate that 111 (61.3%) respondents strongly agreed and 50 (27.6%) agreed that online information literacy skills were important to successfully use online databases. In contrast, 2 (1.1%) responded that they strongly disagreed while 18 (10%) of the respondents were neutral. An analysis of the results clearly shows that a good number of the students were of the view that online information literacy skills are important to successfully use online databases.

**Table 1: Relevance of online information literacy skills to use online databases (n=181)**

<b>Online information literacy skills</b>	<b>Frequency</b>	<b>Percentage</b>
Strongly Agree	111	61.3
Agree	50	27.6
Neutral	18	10
Disagree	0	0
Strongly Disagree	2	1.1

#### **Level of competency in using online databases**

Respondents were asked to rank themselves in terms of their level of competencies in using online databases. Results presented in Table 2 below show that 91 (50.3%) of the respondents ranked themselves that their level of competency in using online databases was average; 41 (22.7%) of the respondents indicated high; 14 (7.7%) indicated very high; 22 (12.2%) indicated low; 6 (3.3%) indicated very low, while 7 (3.8%) of the respondents did not respond to the question. These findings reveal that a lot of students at Saint John of God College of Health Sciences can be ranked on average in terms of their level of competencies in using online databases.

**Table 2: Level of competency in using online databases (n=181)**

<b>Level of competency</b>	<b>Frequency</b>	<b>Percentage</b>
<b>Very High</b>	14	7.7
<b>High</b>	41	22.7

<b>Average</b>	91	50.3
<b>Low</b>	22	12.2
<b>Very Low</b>	6	3.3
<b>No response</b>	7	3.8

### Effort expectancy

Effort expectancy was measured using four statements presented in Table 3 below to see the competency of students in using online databases. Calculating subtotal of those that strongly agreed and agreed, the findings reveal that between 106 (58.5%) and 129 (71.3%) of the respondents indicated that their interaction with online databases was clear and understandable, it was easy for them to become skilful in using online databases, they found online databases easy to use and they realised that learning to use them was easy. These findings mesh well with the UTAUT's construct of 'effort expectancy' which assumes that students' competence in using online databases can be increased through easiness in finding and using online databases.

**Table 3: Effort expectancy (n=181)**

<b>Effort Expectancy</b>	Strongly Agree f (%)	Agree f (%)	Neutral f (%)	Disagree f (%)	Strongly disagree f (%)	Neutral f (%)
My interaction with online databases is clear and understandable	13 (7.2%)	96 (53%)	60 (33.1%)	9 (5%)	3 (1.7%)	0 (0%)
It is easy for me to become skilled in using online databases	44 (24.3%)	85 (47%)	36 (19.9%)	12 (6.6%)	2 (1.1%)	2 (1.1%)
I find online databases easy to use	25 (13.8%)	85 (47%)	52 (28.7%)	14 (7.7%)	4 (2.2%)	1 (0.6)
Learning to use online databases is easy for me	19 (10.5%)	87 (48%)	54 (29.8%)	17 (9.4%)	3 (1.7%)	1 (0.6%)

### Students' competencies in the use of online databases

Results obtained from students indicated that almost half of the respondents had an average level of competency. Interviews with the Assistant Librarian also showed that students competency levels in the use of online databases was average. See the Assistant Librarian's comments below:

*As a matter of fact, I would rank them moderate or average. At times, despite the awareness of online databases, the students have difficulties to fully access these online databases due to poor internet connectivity and lack of computer skills.*

The responses given by both the students and Assistant Librarian concur as they both agree that students' competency levels are on average.

### Discussion

#### What are the students' competencies in the use of online databases at Saint John of God College of Health Sciences?

From an analysis of the results, it was evident that the majority of the respondents agreed that online information literacy skills were important for them to successfully use online databases.

Online information literacy skills were important for users to successfully locate, retrieve, organise, evaluate, and apply information while using online databases in their academic work. This correlates with a related study that was done by Ankrah and Atuase (2018) on the use of electronic resources by postgraduate students at the University of Cape Coast in Ghana. The study affirms that online information literacy skills are important for students to successfully use online databases.

On students' level of competencies required in using online databases, it was established that slightly above half of the students indicated that their level of competency was average. The study also found out that few students had high to very high competency levels in using online databases. This may imply that these students were confident users of online databases. This may also mean that these students can independently search, retrieve, classify, assess, and use information while using online databases in their education. The present study results can be equated to that of Mawindo (2005) who conducted a study on the evaluation of students' use of print and electronic resources at the University of Malawi, College of Medicine. The study found out that the majority's level of online information literacy skills was average while few were competent in using online databases.

This correlates well with a related study by Saulus (2017) on the usability of the institutional repository by faculty and postgraduate students at the University of Swaziland (UNISWA). The study found out that the majority's levels of online skills were low, while fewer individuals indicated that their levels of skills were relatively high.

On the other hand, a study by Adeleke and Nwalo (2017) examined the relationship between information literacy and the use of information resources by postgraduate students at the university of Ibadan in Nigeria. They discovered that a lot of students had high to very high skills in accessing electronic information resources, while only a few had skills ranging from low to very low. The high-level skills in online information literacy were attributed to the trainings offered by the library staff. Chipeta (2008) emphasizes the need for formal information literacy training among library users as it gives them the ability to independently identify, locate, retrieve and use information sources. This implies that imparting skills in using online databases has to be intensified by the library staff so as to increase the level of competency among students at Saint John of God College of Health Sciences. This means that training boosts the competency of students in online information literacy.

Findings of this present study show that the majority of students' interaction with online databases was clear and understandable. Besides that, it demonstrated that it is easy for students to become skilful in using online databases, they find them easy to use, and realise that learning to use them is easy. These results correlate well with the effort expectancy construct of the UTAUT model which argues that the degree of ease associated with the use of the system, have a huge influence on the levels of adoption and use of that system (Vanketesh, 2003). In this study, the easiness in becoming skilled in using and learning to utilise online databases translates into the competency levels in using such online databases.

The implication is that the effort expectancy construct of the UTAUT model has a direct link to the use of online databases by students. This is because the use of online databases by students is likely to be influenced by how easy or complex it is to retrieve relevant information within the shortest time. Hence, if students realise that it is very easy to use online databases and retrieve the intended information for assignments, research and other needs, they will be motivated to use them.

## **Conclusion**

The study further established that online information literacy skills are needed for students to use online databases effectively. Such skills help students to find, retrieve, organise, evaluate,

and use information in the course of using online databases. Online databases are essential in tertiary education as they provide valid, reliable and updated information.

### Recommendations

The researcher makes the following recommendations based on the study findings:

- The librarian should consider crafting other promotional and marketing strategies that will increase in-depth knowledge of specific online databases. For instance, targeted emails, messages, posters, flyers, guides, workshops and class visits to augment the broad-based strategies they are currently using.
- Intensive library user education training programmes should be made compulsory for students. This can be done by introducing an online information literacy course at first year of the curriculum for all the academic programmes.

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## **The Culture of Primary Schools with Outstanding Learner Achievement: A Case of Schools in Phalombe District**

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### **Abstract**

The national curriculum is developed to meet the needs of the society like among others, to have human capital for socio-economic development. The interplay among the intended, implemented and attained curriculum is a crucial one. Unless learners' attained curriculum is in sync with the intended curriculum, national curriculum development efforts are in vain. The attained curriculum is usually seen through assessment of learning outcomes. At national level, this is done through national examinations. It has been observed that the Malawi National Examinations Board has been ranking Phalombe Educational district as the best performing at Primary School Leaving Certificate of Education (PSLCE) examinations for the past five years except in 2017 when it got the third position. The PSLCE is the national exam written after eight years (8) of primary schooling in Malawi. No systematic study has been conducted so far to establish the secret behind the success of the district. It is against this background that this study was designed to explore the culture of the schools in the district can be linked directly to the consistent good performance of the district at primary school leaving certificate examinations. The study therefore set out to answer the following research question: What is the culture of primary schools in Phalombe that contributes to the consistent good performance of learners during primary school leaving certificate examinations? This study used a case study design with an ethnographic stance to understand the culture of the primary schools in the district. Researchers spent the whole week at each of the eight primary schools which were purposively sampled. A conceptual framework informed by literature on school culture guided the study. The study among others showed that Institutional environment, curriculum implementation, leadership and interpersonal relationships contributed to learners' good performance at PSLCE. The findings of the study are very crucial in informing the implementation of the intended curriculum.

**Key words:** curriculum, school culture, learning achievement

### **Introduction**

The Malawi Government recognises the role education plays in socio-economic development of the nation. Education and skills development is one of the focus areas under the human capital development enabler in the Malawi 2063. Under this enabler, Malawi would like to have a highly knowledgeable people with relevant quality education that incorporates a strong element of academic excellence and technical and vocational skills fit for the labour market (Government of Malawi, 2021).

To achieve this, the primary education sector has a great role in providing the requisite foundation for learners. The primary education sector however continues to face several challenges like high repetition rate which eventually leads to dropout and low completion rate. Repetition is said to be linked to lack of school readiness for primary entry, absenteeism and low learning outcomes by learners; and lack of knowledge and skills for teachers to address diverse needs of learners (MoE 2020: 16).

The vision of the education sector is to be a catalyst for socio-economic development and industrial growth. In the next ten years, the vision of the education sector will be translated through the following three thematic objectives (MoE: 2020:36): Increase access, enhancing quality of learning outcomes, strengthen effective, efficient and accountable governance and management

It is clear that seeing quality learning outcomes is at the heart of the nation. It is against this background that this study was designed to explore why Phalombe has had the consistent good performance at primary school leaving certificate. According to Malawi Broadcasting Corporation and Malawi Voice, Malawi National Examination Board ranked Phalombe as the best performing district at Primary School leaving Certificate of Education (PSLCE) examinations for the past five years except in 2017 when it got the third position. There has however been not a systematic and comprehensive study to understand the secret to the success of the district. This study will therefore bridge this gap. The study intended to answer the following research question:

- What is the culture of primary schools in Phalombe that contributes to the consistent good performance of learners during primary school leaving certificate examinations?

### **Literature review**

In general discourse, the word “culture” refers to the stream of “norms, values, beliefs, traditions, and rituals built up over time” (Peterson & Deal, 1998). It encompasses a set of common values, attitudes, beliefs and norms, some of which are explicit and some of which are not (Peters and Waterman, 1982). It has a wide range of influences on how people behave in organisations, communities and even nations.

Again, Best Practice Briefs (2004) explains that school culture is based on past experience which provides a template for future action based on how an organization views things as done. But Overseas Trained Teachers Organization (n.d.) mentions that realizing what makes up a school’s culture is not straightforward. Members of the school community are not always aware of the assumptions, beliefs and practices that they hold in common because they take for granted that things will be done, or people will behave in certain ways. These underlying assumptions, beliefs and practices become clearer the longer a person becomes part of a functioning school.

The culture of a school can be described as a way of living and working in it, the impact of history and tradition of the school and its success on the behavior of teachers, staff and all school employees. Culture gives meaning to teachers on how to behave in the entire educational process and to students on how to develop a positive climate in the classroom so they can fully use the potential that helps them to quickly and efficiently learn lessons and gain the necessary competences (Reezigt, 2001).

School culture develops as staff members interact with each other, the students, and the community. It becomes the guide for behavior that is shared among members of the school at large. Culture is shaped by the interactions of the personnel, and the actions of the personnel become directed by culture (Hinde, 2014).

### **Characteristics of effective school culture**

It has long been observed that successful organisations attribute their success to their cultures (Peters and Waterman, 1982). Peters and Waterman, (1982) found that excellent companies possessed distinctive cultures and were passed on through story, slogan and legend and served to motivate employees by giving meaning to their work. They wrote “without exception, the dominance and coherence of culture proved to be an essential quality of the excellent companies.” They showed too that poor-performing companies had either no detectable culture or a dysfunctional culture. Such companies usually focused on internal politics rather than on the customer, or they focus on the ‘numbers’ rather than on the product and the people who make and sell it.

Taylor and Fratto (2012) state the following six characteristics that describe a positive school culture: the level of students’ engagement in their personal learning and in the classroom, the extent to which principals and teachers collaborate in determining challenges and

opportunities, the setting of goals to improve the school, action plan through shared vision and strong communication, the review of attitudes of all staff members and engagement of openness in giving inputs, accepting changes and trying new things.

Brown (2004) presents the following as characteristics of an effective school culture: an inspiring vision, backed by a clear, limited and challenging mission, a curriculum, modes of instruction, assessments and learning opportunities that are clearly linked to the vision and mission and tailored to the needs and interests of the students, sufficient time for teachers and students to do their work well, a pervasive focus on student and teacher learning, coupled with a continual, school-wide conversation about the quality of everyone's work, close, supportive teacher-student, teacher-teacher and student-student relationships, many opportunities and venues for creating culture, discussing fundamental values, taking responsibility, coming together as a community and celebrating individual and group success, leadership that encourages and protects trust, on-the-job learning, flexibility, risk-taking, innovation and adaptation to change, data-driven decision-making systems that draw on timely, accurate, qualitative and quantitative information about progress toward the vision and sophisticated knowledge about organizational change and unwavering support from parents.

### **Importance of effective school culture**

The culture of a school can be a positive influence on learning or it can seriously inhibit the functioning of the school. School culture affects everything that happens in schools including the way their staffs are attired, conversations, their readiness to change, teaching practices and the focus given to the students. Overall, culture affects all aspects of a school (Deal and Peterson, 2009). Therefore, there are several benefits that accrue to effective school culture.

Student achievement is the ultimate goal of a school and studies show evidence that student achievement is directly related to the school's culture (O'Brien, & Ghazarian, 2009). Gruenert, (2005) studied extensively how the presence of a positive school climate impacts student achievement. His findings point out that to improve student achievement, the focus has to be on building a collaborative, positive climate and culture. When schools focus on building an effective culture, student achievement/test scores improve.

### **Conceptual framework**

A study of the available literature on school culture points out elements of school culture. The works of Fyans and Maehr (1990), Brown (2004), and Cohen and Pickeral (2008) have been used to develop the conceptual framework that guided this study. The literature on school culture points to several elements that constitute the culture. These elements have been summarised below.

The first element is **Institutional Environment**. This element includes such issues as physical location, usage of the school environment, innovativeness, autonomy, school connectedness or engagement, safety, and established norms. The second element is **Curriculum Implementation**. This element mainly focuses on the quality of teaching and learning at the school. The third element is **Leadership**. This element focuses on how school leaders motivate teachers and students, goal setting, and involvement of others in decision making. Lastly, there is the element of **Interpersonal Relationships**. This focuses on the established ways of relating among members of the school community. Figure1 depicts the conceptual framework that guided this study.



Figure 12 Conceptual framework

### Methodology

The study used a mixed methodology research design. Data was collected from 8 primary schools that were conveniently sampled. The following respondents were involved in the study; 100 Learners, 6 Primary Educational Advisor (PEA), 150 Teachers, 8 Headteachers and 1 District Education Manager. The study used the following instruments; questionnaires, lesson observation schedule, school checklist, general observation guide and FGD guides. Quantitative data was entered into SPSS and percentages and means of variables were computed. The qualitative data was first coded. Then categories and themes were generated through inductive thematic analysis. Since we had a multiple case study, as Merriam (2011) suggests, there were two stages of analysis – the within-case analysis and the cross-case analysis. For the within–case analysis, each case was treated as a comprehensive case in and of itself. Once the analysis of each case was completed, a cross-case analysis was done.

### Findings and discussion

In this section, findings of the study are presented according to the four elements of the conceptual framework. These are institutional environment, curriculum implementation, leadership and interpersonal relationships.

#### Institutional environment

The study sought to find out the type and nature of institutional environment in which sample schools operated. Institutional environment in this case includes physical location, usage of the school environment, innovativeness, safety, and established norms.

A checklist was used to rate institutional environment in areas such as presentability, usage of the environment and surrounding of the schools. Table 1 below presents the findings:

Table 1: Physical environment

Items	Rating (%)		
	Very good	Average	Unsatisfactory
Presentability	62.0	38.0	0.0
Usage of environment	57.0	29.0	14.0
School surrounding	62.0	25.0	13.0

According to table 1 above, all the schools were rated either very good or average in terms of presentability of their environment. Some of the schools had planted flowers and trees to make their schools presentable. In all the sampled schools, learners played a big role in making sure that the presentability of the environment was maintained through planting of trees, watering of flowers, slashing grass and sweeping the surroundings.

In terms of school environment, the study established that the schools used the environment for various teaching and learning activities. In some schools, the environment was mostly used for studying purposes by the learners. Learners could be seen in the school yard conducting discussions, asking each other questions and studying. At a certain school, rocks in the hills were used as sitting spaces for group work and discussion. Che Mohd Zaid, Zawawi Ishmail (2019) reported that the physical learning environment positively and significantly influenced students' achievement and that a conducive learning environment acted as a catalyst for fostering intellectual activities, collaborations and supportive activities that encouraged students development and learning.

In terms of school safety and security, headteachers were asked to rate between 1 and 5 (with 5 being strongly agree, 4 agree, 3 uncertain, 2 disagree and 1 strongly disagree) to show how safe their schools were. Table 2 depicts the results.

Table 2: Advancement of security and safety in schools

Statement		Rating (%)		
		Very good	Good	Unsatisfactory
1	Instilling discipline	87.5	12.5	0.0
2	Reinforcing school rules regularly	75.0	25.0	0.0
3	Following school norms	62.5	25.0	12.5
4	Social emotional security	75.0	25.0	12.5
5	Health promotion activities	62.5	37.5	12.5
6	Encouraging caring and sensitivity spirit	37.5	50	12.5
7	Pyscho-social support from school	62.5	37.5	0.0
8	Reinforcing respect for diversity	62.5	37.5	0.0
9	Collegiality	87.5	12.5	0.0
10	Presentability of physical environment	62.5	37.5	0.0

Table 2 above shows that the majority of the statements were rated either very good or good which confirm the findings that there is promotion of safety and security in schools.

Furthermore, findings from FGD with parents confirmed these findings. This is what one of the parents said:

*“There is no abuse here because there is cooperation between teachers, learners and parents so that we focus on our children’s learning. Even teachers ensure that no learner victimises another learner. Teachers do not even beat learners. As parents we have never received any complaints of abuse. Even children from far off places come to enroll at this school because it offers a violent free learning environment”.*

The findings show that the schools promote safety and security for the learners to perform well. Studies originating from educational sciences, social psychology and sociology have shown that, in order for learners to be able to focus on learning, school environments need to be safe, secure and nurturing (Zullig, Ghani, Collins, & Matthews-Ewald, 2017)

### Curriculum implementation

The second element of school culture is Curriculum Implementation. This element mainly focuses on the quality of teaching and learning at the school. The study established that both teachers and students of these schools exhibited strong commitment to work. Most of the respondents pointed out that hardworking is the secret behind their good performance. This is what one learner said:

*“Teachers work very hard to make sure they finish the syllabus and they mostly have extra classes in the morning and after classes”*

Another learner had this to say:

*“Teachers at this school work hard. They conduct additional classes even on holidays, Saturdays and Sundays - all for free. Even learners come from far off places to attend this school”*

Another established norm that the study established from the schools was punctuality. Both teachers and learners were rarely late for both academic activities. In all schools it was noted that once bell goes to mark the end of one activity and the start of another, teachers and students were seen rushing to the next activity. It was established that in all these schools, every morning, teachers had to sign arrival time in a timebook which was in the head teacher office.

Through general observation, the study established that the spirit of team work and cooperation pervaded the schools` way of doing things. In most of the activities teachers and learners were observed working as teams. In most of the lesson observations that were conducted, it was noted that teachers were also supporting one another in a lesson in several activities such as marking, distributing materials and disciplining learners. Teachers were always seen in groups discussing issues or chatting. Yahya & Arumugam (2019) also found out that many advantages and benefits are obtained when the individual is able to work in a team.

Head teachers were asked to assess if it is a norm at their schools for learners and teachers to strive for excellence and table 3 presents the findings.

Table 3: Excellence in performance of the learners according to head teachers

Ratings	Percentage
Strongly agree	75.0
Agree	25.0
Disagree	0.0
Strongly disagree	0.0
Uncertain	0.0

Table 3 shows the majority of head teachers (75%) rated strongly agreed and the remaining (25%) rated agree.

The study also established that strict adherence to discipline was one of the norms in the schools. Through general observation it was established that both teachers and learners were very disciplined in doing things. Researchers observed both learners and teachers were very punctual in each and every activity which demonstrated their adherence to discipline in the schools.

Further more the study established that hardworking is one of the norms behind their success. It was found out that teaching and learning takes place more than the normal working hours of 7:30am to 2:00pm from Monday to Friday. Parents pointed out that teachers work beyond the

normal working hours and days. Others indicated that Standard 7 and 8 learners attend extra classes from 6am and after normal classes up to 4pm.

### Leadership

The third element of positive school culture is leadership. It focuses on how school leaders motivate teachers and students, goal setting, and involvement of others in decision making. The study established that there was an emphasis on involving other people in decision making by school leaders. Respondents were asked to rate the involvement of community members in decision making. Table 4 below presents the findings.

Table 4: Involvement of community members in school affairs

Respondents	Rating (%)				
	strongly agree	Agree	Uncertain	Disagree	Strongly disagree
PEA	16.7	50.0	33.3	0.0	0.0
Longest serving Teacher	42.9	57.1	0.0	0.0	0.0
Head Teacher	75.0	12.5	12.5	0.0	0.0

Table 4 above shows that the majority of the respondents (PEAs = 66.7%, longest serving teachers = 100% and head teachers = 87.5%) rated the statement on community involvement either agree or strongly agree. These findings indicate that community members were involved in decision making for the schools. These findings concur with Yahya & Arumugam (2019) who pointed out that responsibility in finding solutions and making decisions can be reduced when headmaster or principal is able to give some authority to other members such as teachers or staff in making some decisions. In so doing, the burden is lightened.

The study also found out that the way the schools organize learners shows how goal focused the leadership in the schools were. Learners were always directed towards hard work with the goal of achieving the best results during national examinations. One of the head teachers also attested to the fact that their learners had embraced the culture of being goal oriented. He had this to say:

*‘We teach learners during weekends. We start classes at 6am and finish at 4:30pm. We also encourage learners to study hard at home’.*

Similarly, a learner from one of the schools had this to say

*‘Teachers encourages learners living close by the school to come to school in the evening to study. Standard 8 learners camp at the school so that they concentrate. Teachers supervise the learners and ensure that they make use of the camping time’.*

The study sought to find out the extent to which the sampled schools display autonomy in their management and decision making. According to the findings, 62% of the schools showed very good and 38% showed good performance in showing autonomy. Both the school management and teachers showed flexibility in decision making and their day-to-day work.

Furthermore, the study established that motivation of teachers and learners in these schools is highly emphasised. During FGD with community members, one of the parents had this to say:

*“Those teachers who produce good grades are rewarded by parents, even the MP recognize them.”*

Similarly teachers also confirmed that teachers and learners are highly motivated in the schools. One of the teachers had this to say:

“By Giving performing learners rewards such as pencils, pens and exercise books. I also give them extra books to read e.g resource books.”

These findings concurs with Filgona *et al* (2020) who stated that high motivation and engagement in learning have consistently been linked to reduced dropout rates and increased levels of student success.

### Interpersonal Relationships

The fourth element of school culture is interpersonal relationships. This focuses on the established ways of relating among members of the school community. The study established that good relation among stakeholders at school is one of the factors behind the success of these schools. This is what one of the learners said:

*“We work together and there are no quarrels among us. We report to teachers when some learners fight or steal from each other, but these cases are very rare”*

The learners further reported that when one gets sick, they help each other. They share food during break time and work together on academic issues. Through a school checklist and lesson observation forms, the researchers verified what the parents and learners said about the interrelationship among learners. It was established that the relationship among learners was very good. All schools were rated either very good or good relationships between and among stakeholders including learners, teachers, school managers and parents/communities. In all the eight schools, parents were available for FGD including those with leadership positions.

Similarly, Yahya & Arumugam (2019) found out that relationship among humans is important in all organizations including schools, where principals must close relationship with teachers. This relationship enables the two sides to share information and carry out the work as a whole. Thus, this can improve the performance of work.

Another element of interpersonal relationships that was studied was the school connectedness. The study sought to find out how connected schools were with various stakeholders. Table 5: presents the findings:

Table 5: Headteacher response to school connectedness

Statement	Rating (%)				
	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
Relationships with local community and business organisations in the interest of improving learners' outcomes.	50.0	25.0	25.0	0.0	0.0
Engaging stakeholders in a variety of evaluative strategies to ascertain how well the school is achieving its goals.	25.0	62.0	13.0	0.0	0.0

Table 5 above shows that most of the head teachers (75% for the first statement and 87% for the second statement) rated the statements either strongly agree or agree which shows that there was connectedness between the schools and other organisations and stakeholders. Poster (1992) pointed out that schools are increasingly urged to establish good relations with those outside the profession like parents, forging links with other phases of education, involving themselves with the community.

### **Discussion of findings**

This study sought to find out the school culture of 8 schools from Phalombe Educational District following the good performance of the district in the PSLCE examinations. The study used an adapted conceptual Framework for school culture. The framework has four elements namely, institutional environment, curriculum implementation, leadership and interpersonal relationships. According to findings presented above, the study found out that all the eight schools had positive results in the four elements of school culture according to the conceptual framework. They had good and conducive school environments that were safe and promoted learning. Both teachers and learners worked hard to implement the curriculum. They used to extend learning time, encourage independent studies after school and teachers provided extra classes beyond working hours for free. School managers worked well with teachers and community leaders to ensure smooth running of schools. It was also observed that there were good interpersonal relationships among all stakeholders at the schools.

However, it was observed that the schools operated in the same typical Malawian rural schools. These include lack of or inadequate teaching and learning resources, limited numbers of teachers, large classes, leadership structures and implemented the national curriculum. In most lessons observed by the researchers, learners had no or very few textbooks to work with and this affected their reading especially in lower classes. The classes were large with as many as 100 learners in one class with one teacher. Other issues of concern that the study observed were: poor selection of students to secondary schools due to limited numbers of secondary schools in the district and limited numbers of spaces within the secondary schools. Some students are forced to repeat Standard 8 after passing the PSLC examinations if they are not selected to go to secondary schools.

### **Conclusion**

The purpose of this study was to investigate the culture of primary schools in Phalombe district. The study addressed the following research question:

- What is the culture of primary schools in Phalombe that contributes to the consistent good performance of learners during primary school leaving certificate examinations?

We used convenient sampling to select 8 schools from Phalombe education district. At school level, the researchers interact with learners, teachers, Head teachers, parents and other community leaders. Data was also collected for Primary Education Advisors and the District Education Manager. An adapted conceptual framework with the four elements of institutional environment, curriculum implementation, leadership and interpersonal relationships was used to analyse the findings.

Findings of the study showed positive results in all the four elements of conceptual framework in all the schools. It was observed that despite of being rural schools with minimal teaching and learning resources, schools had cultures that encouraged teaching, learning and academic achievement of learners. It was also observed that there were good interpersonal relationships between all the stakeholders including learners, teachers, school managers and communities. Schools were working hard to keep the school environment safe and secure.

We therefore conclude that Phalombe Educational District is a good case for other schools with similar conditions to learn from.

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**ENVIRONMENT & NATURAL RESOURCES  
MANAGEMENT AND CLIMATE CHANGE**



## Greenhouse Gas Emissions and Mitigation Measures within the Forestry and Other Land Use Subsector in Malawi

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### Abstract

Analysing past trends of greenhouse gases (GHG) emissions remains indispensable to the understanding of current GHG emissions as it enables prediction of future emissions as well as development of their mitigative pathways. This study quantified GHG emissions within the Forest and other Land Use (FOLU) subsector in Malawi for the period 2011 to 2020. Results indicate that Malawi's GHG emissions in the FOLU subsector fluctuated and eventually decreased by 0.84 MtCO<sub>2e</sub> (13%) from 2011 to 2020, averaging to -1.3% annually. The GHG emissions of different categories within the subsector were highly significant ( $P < 0.001$ ) and contributed the highest (99.72%) of the total variation. Forestland contributed the highest (74%) of the subsector category emissions, followed by biomass burning (19%). The uncertainties for the estimated GHG emissions were low (<15%). This shows that the estimated GHG emissions within FOLU subsector were significantly minimised. Notable interventions that have abated the emissions include: afforestation and natural/assisted regeneration; protection and conservation of protected areas through REDD+ mechanism; establishment of seed banks for raising drought-tolerant tree species; breeding of fast growing and drought-tolerant tree species; as well as screening of disease and pest resistant species and promotion of biological control.

**Keywords:** GHG emissions, FOLU, Forestland, Grassland, Biomass burning, REDD+, Uncertainty, UNFCCC.

### Introduction

Climate change, largely attributed to anthropogenic activities remains a critical global phenomenon that attracts the attention of policy makers as well as researchers in all dimensions. This challenge has triggered a nexus of problems and constraints that hinge on societal, cultural, gender and ecological dynamics. Precisely, these have culminated to a plethora catastrophe associated with ecological imbalances, global warming and extreme weather conditions (rise in sea level, floods, hurricanes, droughts, heatwaves, cyclones, hailstorms) resulting to poor economic growth, insecurity and retrogressive technological advancement [1–4]. Increasing concentration of greenhouse gas (GHG) emissions is considered as a key cause for these issues [1,2]. Recent studies have specified and quantified three main greenhouse gases which significantly impact the environment namely; Carbon dioxide (CO<sub>2</sub>) at 407.8±0.1 ppm, Methane (CH<sub>4</sub>) at 1869±2 ppb, and Nitrous oxide (N<sub>2</sub>O) at 331.1±0.1 ppb [3,5]. Accordingly, reducing GHG emissions has become a key agenda of the global community.

The paradox about reducing GHG emissions is that developing countries still remain disadvantaged due to limited access to funding and technologies, a predicament that jeopardises understanding and estimation of the emissions [4]. In the Tropical Dry Forestlands of Southern Africa Development Community (SADC) region, most country member states have embraced reducing emissions from deforestation and forest degradation (REDD+) as a remedy to the Climate Change effects [6]. Malawi, a SADC associate categorises key sectoral sources of GHG emissions as follows; (i) Industrial Processes and Product Use (IPPU), (ii) Waste, (iii) Energy, and (iv) Agriculture, Forestry and Other Land Uses (AFOLU) [7]. While the AFOLU sector is the key contributor of GHG released into the atmosphere, and the Forestry and Other Land Uses (FOLU) subsector activities are not only affected by climate change, but also contribute to the phenomenon [8, 9]. GHG emissions and removals from FOLU consist of CO<sub>2</sub> and non-CO<sub>2</sub> gases (methane and nitrous oxide) [4].

In Malawi, primarily although not exclusively, the FOLU subsector's contribution remains the most significant. The contribution of FOLU to the total Malawi emissions has been documented in a number of technical reports [7,10]. It has been estimated that FOLU alone accounts for 56% of the total Malawi GHG emissions (in the year 2011) [7]. Within the FOLU subsector, emissions from forestland contributed 70% of the sector emissions [10]. On the other hand, forests in Malawi play significant roles within the economic, social and ecological domains. These forests cover 23677 km<sup>2</sup> (25%) of the total surface land area. Out of the entire forest area, the Miombo woodlands cover 22857 km<sup>2</sup> while plantation forests take up the remaining 820 km<sup>2</sup>. Pine and Eucalyptus are dominant in the plantations, while *Brachystegia* is the most prevalent tree genus in Miombo woodlands [11]. It is estimated that more than 96% of Malawi's population use wood fuels (charcoal and firewood) for household cooking and heating. Apart from energy, forests provide timber and non-timber forest products as well. In addition, forests contribute 6.9% to Malawi's GDP through domestic and export product sales, employment and tourism [11,12]. While demand for forest products is expected to continue increasing, a recent study has projected that between 2019 and 2025 Malawi's demand for wood fuel will exceed the sustainable supply [12]. Therefore, actions have to be taken to satisfy this demand while at the same time controlling adverse effects on the environment.

It is indicated that analysing past trends of GHG emissions has become a useful tool towards the understanding of current GHG emissions and aid in predicting future emissions as well as in development of emission mitigation pathways. It is further predicted that if proper focus is not given to GHG emissions, the current trend is likely to increase even further in the nearby future [13-16]. In this context, Malawi's past scenarios of GHG emissions were only documented from 1990 to 2011 [10]. The challenging problem arising in this domain is that the trend from 2011 to 2020 has not been documented thereby creating a scientific knowledge gap that would have helped in developing GHG emissions mitigation. It is against this background that this study was conducted thus, to quantify the GHG emissions within the FOLU subsector in Malawi for the period 2011 to 2020. Specifically, the study was executed to: (1) determine the trend of GHG emissions from 2011 to 2020 within the FOLU subsector in Malawi, (2) determine the contribution of GHG emission within the FOLU subsector and (3) discuss their emission mitigation measures.

## **Materials and methods**

### **Study Area**

Malawi is located in Southeast Africa. It is bordered by Mozambique on the east and southwest, by Tanzania on the north and northeast, and by Zambia on the west and northwest. Malawi has a sub-tropical climate and it is categorized into three seasons. Namely: hot-dry, warm-wet, and cool-dry seasons. Hot-dry season is evident from September to October with an average temperature range of 25 to 37 °C. Warm-wet season lasts from November to April with an annual average rainfall range of 725 to 2500 mm. This is the season during which 95% of the annual rainfall occurs. In alternation, the cool-dry season stretches from May to August with an average temperature range of 4 to 10 °C. In the cool-dry season, especially in June and July, frost may occur in isolated areas [17].

### **Data Collection**

Records of National Forest Monitoring System (NFMS) kept by Forestry Research Institute of Malawi (FRIM) and Department of Forestry Headquarters, GIS Unit Section for the period January 2011 to December 2020 were used for this study. The records were collected monthly during the stated period and comprised of area burnt by forest fires, land cover change, wood and fuelwood removals. The datasets obtained were manually populated into IPCC Inventory software version 2.691 to estimate GHG emissions and uncertainties. The IPCC Inventory software implements the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The software can be used for the whole inventory or just individual categories. It allows different sectors of the inventory to be developed simultaneously and it gives users the flexibility to use their own country-specific information [18].

### Data analysis

Datasets on GHG emissions and uncertainties were tested for normality and homogeneity with Kolmogorov-Smirnov D and normal probability plot tests. After the two criteria were met, the datasets were subjected to analysis of variance (ANOVA). Variance components for the sources of variation were also estimated. Statistical analysis was performed using GenStat 18.1 for Windows. Differences between treatment means were separated using Fischer's least significant difference (LSD) at the 0.05 level. Graphs were plotted using Microsoft Excel 16. The data were analysed using the following model:

$$Y_{ijk} = \mu + T_i + C_j + (TC)_{ij} + e_{ijk}, \quad (1)$$

where:

- $Y_{ijk}$  is the response variable (GHG emissions or Uncertainties) of  $j$ th observation in the  $i$ th treatments;
- $\mu$  is the overall mean;
- $T_i$  is the fixed effect of time in years ( $i = 2011, 2012, 2013, \dots, 2020$ );
- $C_j$  is the fixed effect of categories of FOLU subsector ( $j = \text{biomass burning, cropland, forest land, grassland}$ );
- $(TC)_{ij}$  is the effect of the interaction between time in years and categories of FOLU subsector; and
- $e_{ijk}$  is the random residual effect,  $e_{ijk} \sim N(0, \sigma e^2)$ .

### Results and discussion

#### *Trend of GHG Emissions within the FOLU Subsector in Malawi (2011-2020)*

Summary of the results on the trends of GHG Emissions within the FOLU subsector in Malawi (2011-2020) are presented in Table 1 and Figure 2. The findings indicate that there were significant differences ( $P < 0.05$ ) in GHG emissions among different years. However, years contributed only 0.12% to the total variation (Table 1). The emissions fluctuated, but more prominently decreased by 0.84 MtCO<sub>2e</sub> (13%) from 2011 to 2020, averaging to -1.3% annually (Figure 2). The present results in the decrease of GHG emissions in the FOLU subsector are slightly higher compared to the previous results (1990-2011) of -0.6% annually [10]. The continuous decrease of GHG emissions in the FOLU sector may have been driven primarily by changes in the forestland category [19]. Nevertheless, Malawi's forest resources face large pressure from deforestation and forest degradation. According to Malawi's SNC [7], the major proximate and underlying causes of deforestation include; high population growth, forest fires, increased fuel demand, infrastructure development, not to mention agricultural expansion.

Table 1 Variance components for GHG Emissions and uncertainty

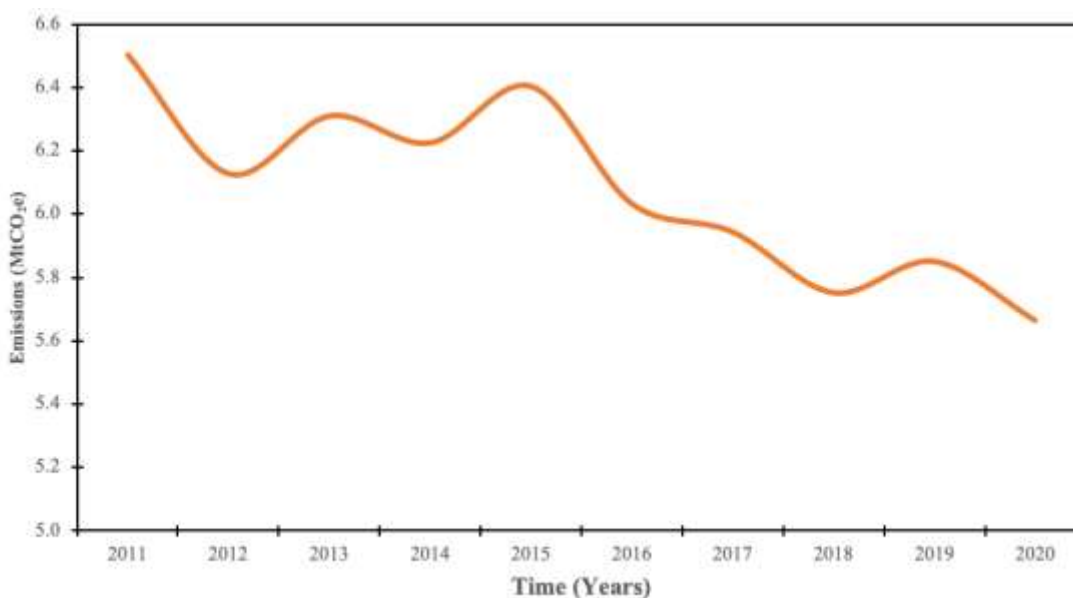
Source of variations	df	GHG Emissions		Uncertainty	
		P-value	Var %	P-value	Var %
$T_i$	9	0.035	0.12	0.372	24.79
$C_j$	3	<0.001	99.72	0.280	9.75
$(TC)_{ij}$	27	0.500	0.15	0.501	65.42

$T_i$  is time in years;  $C_j$  is categories of FOLU subsector;  $(TC)_{ij}$  is the interaction between time in years and categories of FOLU subsector.

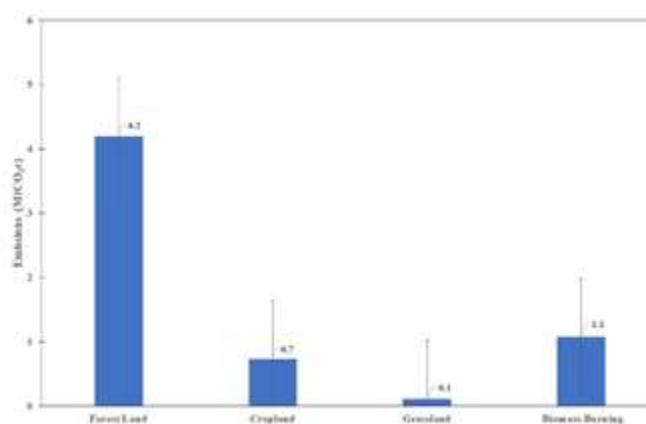
**Categorical Contributions of GHG Emissions within the FOLU Subsector in Malawi**

Results on the contribution of GHG emission within the FOLU subsector are presented in Table 1 and Figure 3. GHG emissions within different categories of FOLU subsector were highly significant ( $P < 0.001$ ) and contributed the highest (99.72%) of the total variation. Within the FOLU subsector, Forestland contributed the highest (74%) thus among the category emissions, followed by biomass burning (19%), then cropland (5%). Grassland contributed the least (2%) of the category emissions. The present findings agree with those reflected in the literature following a number of studies [7,10]. USAID [10] and Malawi’s SNC [4] which reported that within the FOLU subsector, land category contributed 70% of the entire emissions in 2011. The slight increase (4%) of GHG emissions from Forestland could be attributed to the population’s heavy reliance on biomass energy for cooking and heating [12]. According to USAID [12], it is estimated that more than 96% of Malawi’s population use wood fuels for household cooking and heating.

**Figure 2:** Average annual change in GHG Emissions in FOLU subsector of Malawi (2011-2020)



**Figure 3** Malawi’s GHG Emissions by FOLU Subsector (2020)



**Uncertainty Analysis by Year and FOLU Subsector**

Uncertainty estimates for GHG emissions within FOLU subsector are presented in Table 2. Results indicate that the uncertainties were low (<15%). This shows that the estimated GHG emissions within FOLU subdomain in the present study were significantly minimised. GHG emission estimation is always associated with uncertainties and it is essential to minimise them [20]. Sources of error in the estimation of GHG emissions are associated with calculation methods, and modelling [20-23]. Calculation method error was minimised by employing the 2006 IPCC software version 2.691. Appropriate use of the software leads to calculation method errors which are normally distributed and have minimal effect on the final GHG emission determination [23]. The use of site-specific allometric model in the present study also helped to minimize the uncertainties. The site-specific allometric models significantly ( $P<0.001$ ) differed from the default allometric model used by other researchers [18] in the same site. The uncertainties for the default allometric model were high (>22%). The recommended uncertainty for REDD+ mechanism is less than 15% at 95% confidence interval [18].

Table 2 Uncertainty by year and FOLU Categories

Year	Uncertainty (%) by category				
	Forest Land	Burning Biomass	Cropland	Grassland	Mean
2011	9.77	9.23	8.76	8.93	<b>9.17</b>
2012	8.92	8.93	9.34	9.01	<b>9.05</b>
2013	9.29	9.99	8.03	9.05	<b>9.09</b>
2014	8.67	9.56	7.99	8.67	<b>8.72</b>
2015	9.23	10.2	9.54	9.06	<b>9.51</b>
2016	9.06	8.93	8.77	8.93	<b>8.92</b>
2017	8.95	7.98	9.43	7.92	<b>8.57</b>
2018	8.94	8.95	9.24	9.45	<b>9.15</b>
2019	9.87	9.31	8.97	9.13	<b>9.32</b>
2020	9.06	9.78	9.89	8.36	<b>9.27</b>
Mean	<b>9.18</b>	<b>9.29</b>	<b>9.00</b>	<b>8.85</b>	

**Climate Change Mitigation Measures**

Classified as one of the least developed countries in Africa, Malawi is not obliged to reduce its GHG emissions. However, the country continues to explore innovative measures to abate GHG emissions that emanate from FOLU through technological and policy interventions in order to mitigate and adapt the impacts of Climate Change. Some of the key interventions that have contributed to the gradual decrease of GHG emissions within the FOLU subsector include:

**Afforestation and Natural/Assisted Regeneration**

The mitigation actions that enhance afforestation and natural/assisted regeneration are projected to result in the unconditional sequestration of approximately 1 million tCO<sub>2</sub>e annually, through planned afforestation in plantations and on customary land [24]. The projection is based on the recent afforestation rates. Since 2011, 50 plus million trees have been planted each year in Malawi (Table 3). Planting of different tree species has been done entailing all land tenure categories of Malawi that include; state-owned forest plantations and reserves, customary lands and private-owned lands and or estates. As of date, a substantial 60% survival rate has been reported [25].

In addition, Malawi has an international target of conserving and managing a total of 3.5million hectares that it pledged to contribute to the African Landscape Restoration Initiative (AFR100). The target was is committed to pan-African, a country-led effort to restore global 100 million hectares of degraded and deforested landscapes by 2030. Malawi seeks to build on past and current efforts to conserve and manage forests, among others, through the National Forest Landscape Restoration Strategy (NFLRS) [11]. Under this initiative, the country has identified and mapped degraded sites in every district to address vulnerability to climate change, adapt and mitigate through integrated landscape management approaches to forest landscape restoration. The NFLRS has developed the following forest-based restoration interventions; (i) Establishment and management of community forests and woodlots; (ii) Forest management (forest reserves and plantations) and (iii) Rehabilitation of stream and river banks.

Table 3 Annual Tree Planting Trends in Malawi, 2011 to 2019

<b>Year</b>	<b>Quantity Planted</b>	<b>Area planted (Ha)</b>
2011	53,941,221	21,576.0
2012	52,334,642	20,934.0
2013	57,507,938	23,003.0
2014	63,196,846	25,279.0
2015	52,395,006	20,958.0
2016	52,343,450	20,937.0
2017	63,912,740	25,565.1
2018	62,531,346	25,012.5
2019	63,876,257	25,550.5

Source: [26]

### ***Management and Conservation of Protected Areas***

In addition to the routine management of forest reserves, national parks and wildlife reserves, Malawi established a national framework/policy on REDD+ that ably guides, monitors and informs future actions on GHG emissions emanating from forestlands and associated land uses. After her formal acceptance as an UN-REDD partner country in March 2014, Malawi continues to estimate carbon and other GHG emissions from other categories including FOLU. This forms part of the national GHG accounting and reporting system that, as a signatory to the Kyoto Convention, obliges the country to report to United Nations Framework Convention on Climate Change (UNFCCC).

### ***National Forest Reference Level-2019***

In recognition of Decision 1/CP.16 adopted at the UNFCCC Conference of Parties (COP) in 2010, identifying national Reference Emissions Levels (REL)/Reference Levels (RL) has become an integral prerequisite for Parties aiming to undertake activities under the REDD+ umbrella. In this vein, Malawi conducted her own National Forest Reference Emissions Level (FREL) study in 2019 and submitted its report to the UNFCCC. The report serves as an interim document, detailing the proposed FREL activities. These includes; historical period it represents, associated activities, methodologies applied for deriving the estimates, and key assumptions and rationalisations that underpin the decisions made [26]. More importantly, it explains the role of

Malawi's NFMS, a structure tasked charged with the responsibility of tracking and regularly reporting greenhouse gas emissions and removals from REDD+ activities. Strikingly, it serves as an entry point through which mitigation and adaptation interventions can be integrated. Indispensably, this also ensures that accounting methods and procedures are compliant with Intergovernmental Panel on Climate Change (IPCC) principles and guidelines of transparency, consistency, comparability, completeness and accuracy [26].

### ***Establishment of Seed Banks for Raising Drought-Tolerant Tree Species***

Tree seed banks remain key to development of the forest sector in as far as the regeneration and sustainability of tree species is concerned. In response to the call on the need to develop drought resistant species, FRIM in conjunction with the Mulanje Mountain Conservation Trust (MMCT) has within the period in question established tree nurseries and seed research plots of *Widdringtonia whytei* (Mulanje Cedar) in Mulanje, Dedza and Viphya Plantations. Indigenous to Malawi, this particular *W. whytei* germplasm serves to suit the dynamic climate that is becoming warmer and drier in Malawi. In other words, the species has been developed to adapt trees to the low and marginal rainfall conditions that are being experienced in the country. Additionally, FRIM through other initiatives like Millennium Seed Bank Project, Kew Garden, UK, has also engaged in conservation of the country's rare, endangered and endemic tree species' seeds for future replanting exercises [27].

### ***Breeding of Fast Growing and Drought Tolerant Tree Species***

Malawi's SNC [7] recommended a coordinated research approach to tree breeding and indicated the need for developing suitable species for the predicted warmer and drier environments in the future. In response, FRIM outsourced fast-growing hybrid pine seeds (*Pinus patula*, *Pinus kesiya*, *Pinus oocarpa*). These were geno-typically improved breeding material of the 4th and 5<sup>th</sup> generation which mature faster compared to the earlier generations. The germplasm is also high yielding, drought and disease tolerant. It has been planted on a trial basis in Zomba, Dedza and Viphya Forest Plantations as a response to the climate change phenomenon that Malawi continues to experience.

### ***Screening of Disease and Pest Resistant Species and Promotion of Biological Control***

Threatening the forest carbon sink in Malawi has been disease and pest infestation. Of late, *Eucalyptus species* have been adversely infested by *Glycaspis brimblecombei* nymphs and adult pests that cause damage by sucking plant phloem sap [28]. In spite of this, *Eucalyptus species* are highly preferred due to their robust growth and their multiple uses and nature, i.e., firewood, poles, medicine and being resistant to fire and drought spells. Locally, these attributes render their management key to climate change mitigation and adaptation. On-going research by FRIM to establish the relative susceptibility of some of the *Eucalyptus species* to other pests, precisely the *Leptocybe invasa*, indicates that there is less susceptibility of the pest for adoption in tree planting initiatives [29, 30]. As a mitigation measure, biological control research is also underway for *L. invasa* infestation and FRIM procured *Selitrichodes neseri* as a biological controller of the pest. The natural controller was released in October, 2016 but the results on its effectiveness have not yet been documented. Another option recommended is the planting of higher resistance tree species such as *Eucalyptus citriodora* [28].

### **Multi-sectoral approach**

USAID [12] through a synthesis of statistics generated from various government surveys observed a general increase in the proportions of households using firewood and charcoal in both urban and rural areas. The Malawi Government acknowledges high dependence on biomass energy, with a focus on charcoal that is relatively more destructive. Charcoal production is believed to have contributed to impeccable levels of deforestation and degradation throughout the country. In response, the Government developed the National Charcoal Strategy (NCS) in 2017 that caters for both medium- and long-term scheme [31]. It aligns a multi-sectoral framework and approach that focuses on pillars defining opportunities to incrementally address problems of charcoal production and demand. [31]. The ultimate goal is to arrest and reverse the rate of deforestation and forest degradation that will eventually mitigate emissions that originate from the use of tree biomass as energy.

The NCS has proposed plans of action, otherwise known as pillars for the period 2017-2027, which serve to mitigate GHG emissions that emanate from the FOLU domain. These are also interrelated to the Energy Sector and they primarily but not exclusively include; promotion of alternative household cooking fuels, sustainable wood production and adoption of fuel-efficient cook-stove technologies such as the Chitetezo Mbaula. The stove is locally made in Malawi and it is designed to consume less amount of wood biomass compared to other stoves thereby contributing to reduction of emissions from woody biomass at a lowest level.

### **Conclusion**

The present study has shown that Malawi's GHG emissions in the FOLU subsector fluctuated and eventually decreased by 0.84 MtCO<sub>2</sub>e (13%) from 2011 to 2020, averaging to -1.3% annually. GHG emission within the categories of FOLU subsector was highly significant and contributed the highest (99.72%) of the total variation. Forestland contributed highest (74%) of the category emissions, followed by biomass burning (19%), then cropland (5%). Grassland contributed the least (2%) of the category emissions. The uncertainties for the estimated GHG emissions were low. This implied that the estimated GHG emissions within FOLU subsector were significantly curtailed during the period under study. Some of the interventions that have helped the continuous decrease of GHG emissions in the FOLU subsector include: afforestation and natural/assisted regeneration; protection and conservation of protected areas through REDD+ mechanism; establishment of seed banks for raising drought-tolerant tree species; breeding of fast growing and drought tolerant tree species; as well as screening of disease and pest resistant species and promotion of biological control.

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## Comparison of The Nutritional Quality Of Open Sun Dried And Solar Tent Dried Usipa (*Engraulicypris Sardella*) Of Lake Malawi Along The Value Chain

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### Abstract

The nutritive quality of fish may be affected by several factors among which are methods of processing and preservation. Changes in the nutritional quality of open sun-dried (OSD) and solar tent dried (STD) Usipa (*Engraulicypris sardella*) along the value chain were examined. The proximate composition was analyzed using AOAC methods and peroxide value method and Thiobarbituric acid method to assess lipid oxidation in samples collected from four nodes along value chain. Protein, ash, zinc, calcium, and iron contents did not change significantly ( $p < 0.05$ ) for each technique along the chain. Zinc and iron content was 13mg/100g and 15mg/100g in the dried Usipa, respectively. The main changes were in moisture and fat content. The moisture decreased significantly in OSD and STD Usipa after staying 3 days on the market. Similarly, there was a decrease in fat content in both samples. Analysis of peroxides a by-product of lipid oxidation increased as the product was kept longer on the market ranging from 6.7 to 8.27 (Meq O<sub>2</sub>/Kg fat) and 5.3 to 6.82 (Meq O<sub>2</sub>/Kg fat) in OSD Usipa and STD Usipa, respectively. A similar trend was observed in TBA values, ranging from 0.76 to 1.11 (Mg MAD/Kg) in OSD and 0.63 to 1.06 (Mg MAD/Kg) in STD Usipa. In STD Usipa PV values and TBA values were lower than in OSD, and increased more after 3 days on the market. The main changes in nutritional quality were in moisture content and lipid content due to lipid oxidation affecting product quality. Lipid oxidation was minimal in STD Usipa than in OSD Usipa. The use of a solar tent dryer has the potential to reduce the loss of nutrients and quality and should be promoted among fish processors. Dried Usipa is a potential source of zinc and iron, which are micronutrients of public health concern in Malawi.

**Keywords:** Solar tent dryer, open sun drying, *E. Sardella*, Value chain, Lipid oxidation

### Introduction

Fish is a valuable food item in the diets because it provides high quality proteins with essential amino acids, polyunsaturated fatty acids and dietary minerals such as calcium, iodine or selenium (Majumdar, (2017). Pelagic species, smaller ones like sardines, are rich in Omega-3 fatty acids mainly eicosapentaenoic acid (EPA, 20:5  $\omega$ 3) and docosahexaenoic acid (DHA, 22:6  $\omega$ 3) (Pestana, 2007). There are many fish species in Lake Malawi, which include both large and small ones. Small fish species available in Lake Malawi are: *Engraulicypris sardella* (Usipa), *Diplotaxodon* species (Ndunduma), *Copadichromis species* (Utaka).

Fresh fish is highly perishable due to high moisture contents (70%) which accelerates microbial and enzymatic activities leading to spoilage (Pal et al., 2016), hence the need to process and preserve them. Varied processing techniques have been employed by fish processors, the common ones among fish processors in Malawi are drying (open sun drying (OSD) and solar tent drying (STD)) and smoking. Solar tent drying technique was recently introduced as an

alternative method to open sun drying (Chiwaula et al., 2017) to address some of the challenges, including high post-harvest losses and fish quality. According to Banda, et al., (2017), drying fish in open sun leads to microbial contamination due to exposure to insects, dust, and other foreign particles, thus low microbial levels were found in solar tent dried usipa ( $3.9 \times 10^2$  cfu/g) than in open sun-dried ( $5.2 \times 10^2$  cfu/g). Significant differences ( $p < 0.05$ ), in total viable bacterial counts between open sun dried ( $1.6 \times 10^6$  cfu/g) and solar tent dried ( $1.4 \times 10^6$  cfu/g) were observed in *B. paludinosus*. (Likongwe, et al 2018)

Nutritive quality of fish may be affected by several factors among which are methods of processing and preservation. Protein content in solar dried and open dried Usipa were within the same range 63.3% to 61.0% and 63.3 to 58.19% but there was a significant difference in moisture contents 8.3% and 17.0% , respectively after 9 weeks in a shelf life study (Banda, et al., 2017). In contrast (Patterson et al., (2018) found higher protein content (17.93%) in solar dried fish than sun-dried fish (14.72%) while moisture content was low in solar dried fish. The high protein content is attributed to the less moisture. Ash content is higher in open dried fish than in solar dried (Banda, et al., 2017; Ojutiku & Kolo, 2009). Similarly, solar dried fish were found to be of high nutritional quality compared to traditional/open dried fish on day 5, with concentrating of protein increasing with decrease in moisture content while lipid content reduced to 28.50 and 26.50% in open sun drying and solar drying, respectively (Ojutiku & Kolo, 2009). Lipid oxidation affects storage time and studies have shown that lipid oxidation is high in dried fish (Majumdar, 2017). According to (Nkiruka et al., 2010) TBARs and peroxide values were found to be low in both STD and OSD which indicated low lipid oxidation in both techniques.

Dried fish are a popular food item because it is easily stored and transported to the market and consumer prefer the taste of dried fish. In addition, drying enhances the nutritive content of the fish. The mostly commonly dried fish, *Engraulicypris sardella*, locally known as Usipa, is a pelagic cyprinid endemic to lake Malawi and supports the bulk of artisanal fishery in Malawi (Banda, et al., 2017). However, it is not clear if the nutritional value of solar tent dried usipa and open dried usipa are maintained throughout the value chain, thus from the processing point, during transportation, storage at the market and during cooking. Therefore, the present study, aimed at investigating the changes in nutritional value and lipid oxidation in STD versus OSD *Engraulicypris sardella* at different nodes along the value chain.

## **Materials and methods**

### **Study area**

The study was conducted at Cape Maclear, Southern part of Lake Malawi and Limbe Market. Nutrient analysis was done at Chancellor Collage and Lilongwe University of Agriculture Natural Resources Chemistry Laboratories.

### **Sample collection and transportation**

Following the same batch, 1kg of solar tent and open sun dried Usipa were collected in triplicates at different nodes along the value chain (fresh samples, after drying, after transportation, three days at the market and after cooking). The samples were packed in zip-lock bags, labelled, put in cooler box containing ice and transported to responsible laboratories through cold chain. Each sample was then separately grounded and blended to ensure homogeneity, and then kept in freezer at  $-20^{\circ}\text{C}$  prior to analysis.

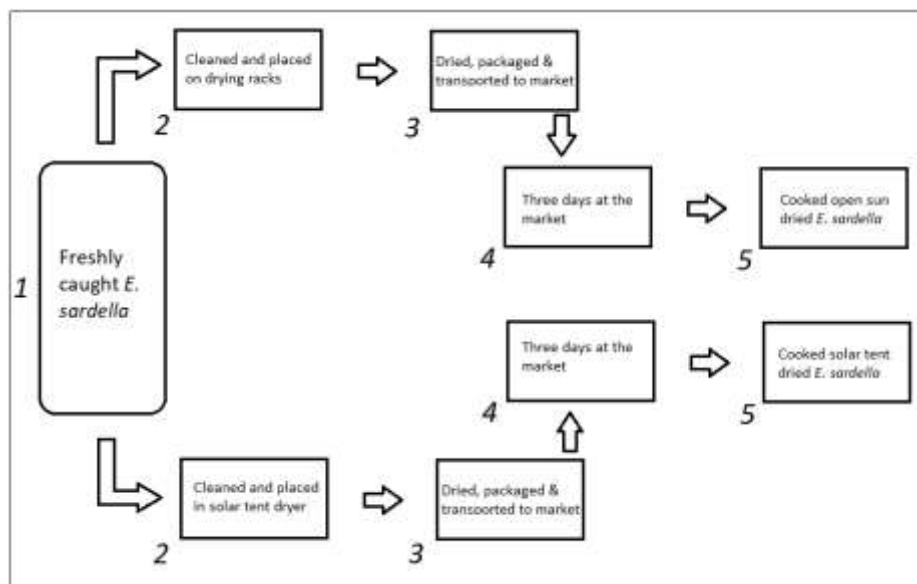


Figure 3 Nodes at which samples were collected.

### Determination of moisture content

Moisture content was determined following the method outlined by AOAC (2013) with some modifications. Sample of ground fish (3g) was placed in a crucible and dried at 105°C in an oven to a constant weight after the initial weighing. Moisture content of the fish was then calculated by subtracting the initial from the final weight of the fish sample.

### Determination of crude protein and crude fat

A procedure outlined by AOAC (2013) with some modifications was used for protein analysis. In this regard, 2 g of the grinded fish samples was weighed and separately digested using 98% sulphuric acid (H<sub>2</sub>SO<sub>4</sub>) in Kjeldahl flask with catalyst from Cupric Sulphate and Potassium Sulphate. The crude protein content was then calculated. Fat content was analyzed using the Soxhlet ether extraction method (AOAC, 2013). 10g of homogenized sample was weighed on an analytical balance and recorded. Petroleum ether at a boiling point of 40–60°C was added to 10 g sample of fish and placed in an extraction apparatus called a thimble. Extraction was carried out for 16 hours, after which the ether had evaporated to dryness and only fat remained in the flask. The amount of fat was obtained as the difference in the weight of the flask before and after drying.

### Determination of ash and mineral content

A 2g sample of ground fish was placed in a crucible, and then ashed at 550 °C for 5 hours in carbolite muffle furnace. This was followed by cooling to room temperature (AOAC, 2013). The amount of ash was estimated as the difference in weight of the crucible before and after cooling using an equation. The mineral contents were determined by AOAC (2013) method with modification by Bernárdez et al. (2005). A calibration curve of absorbance versus concentration in ppm was plotted for standard solutions Zinc, 196 nm for Selenium and 510 nm for Iron in Atomic Absorption spectrophotometer (AAS). Zinc, Selenium, and Iron contents in mg/100g was then obtained by using a formula.

### Determination of Peroxide value and Thiobarbituric acid (TBARS)

Sample weighing 5 g was placed into 50 mL tubes with a red screw cap. 10 mL of ice-cold solvent was added into the tubes and homogenized at 6000 rpm for 10 seconds. 5 mL of the sodium chloride solution was added to the homogenized content. This was followed by centrifuging the content at 5100 rpm (2350 g) for 5 min at 4 °C. 3 mL of the bottom layer was collected and transferred using a pipette into a 15 mL tube (with red screw cap). 500 µL of the bottom layer was added to Eppendorf tubes followed by 5 µL of ammonium thiocyanate and ferrous chloride solution with a ratio of 1:1. The content was vortexed and allowed to stand for 10 min at room temperature. 100 µL was placed in the PP microplate and read at 500nm. The results were calculated using a set equation. To measure Thiobarbituric acid-reactive substances (TBARS) Lemon (1975) with modifications by Wen, (2013) was used. This parameter was measured on both two groups of samples along the nodes.

### Data analysis

The data obtained in this study was analyzed using IBM SPSS Statistics 25 subjected to T-test and ANOVA at 5% significance level and means were compared using turkey test.

### Results and discussions

#### Proximate composition, mineral content, and lipid degradation along the value chain of OSD and STD *E. sardella*.

##### Proximate composition

Proximate composition is an indicator of basic nutritional quality it comprises ash, moisture, fat, protein, and carbohydrate contents of the food under study. Determination of proximate composition of processed fish is important to check the effect of processing, in this case to assess if there are changes that occur along the value chain. This study focused on four parameters: ash, moisture, fat and protein. One way ANOVA at  $P < 0.05$  was used to compare the changes in proximate composition along the value chain by following the nodes; fresh fish (FF), after drying (AD), after transportation (AT) and three days at the market (TDM), in each drying method (OSD and STD) as shown in Table 1 and 2.

Table 1 Proximate composition along the value chain of OSD *E. sardella*

Value chain node	Ash (%)	Moisture (%)	Fat (%)	Protein (%)
FF	10.7±1.45 <sup>a</sup>	69.74±0.17 <sup>d</sup>	33.73±3.82 <sup>b</sup>	43.22±1.85 <sup>a</sup>
AD	9.51±0.13 <sup>a</sup>	12.81±0.51 <sup>b</sup>	25.26±0.59 <sup>a</sup>	43.95±1.00 <sup>a</sup>
AT	9.58±0.1 <sup>a</sup>	12.48±0.8 <sup>b</sup>	24.98±0.86 <sup>a</sup>	44.16±1.21 <sup>a</sup>
TDM	10.54±0.11 <sup>a</sup>	11.18±0.20 <sup>a</sup>	23.78±1.3 <sup>a</sup>	43.62±1.13 <sup>a</sup>

FF=Fresh fish, AD=After drying, AT=After transportation, TDM=Three days at the market, OSD=Open sun drier, STD=Solar tent drier. Note: Reported values represents the Mean and SD of 3 replicates. Different superscripts show significant differences at  $p < 0.05$  within the column.

Ash (a collection of minerals) is the inorganic residue obtained from the incineration of organic matter. As shown in Table 1 there was no significant difference in ash content among all samples that were collected from each nodes of value chain for OSD *E. Sardella*. The values ranged from

9.51±0.13 to 10.54±0.11. These results for ash are similar to the results which were found by Mumba & Jose, (2005) in a study which assessed the nutritional composition of selected fresh and processed fish species from Lake Malawi. The values for ash, insignificantly changed from fresh *E. sardella* to sun dried *E. sardella*. The obtained values were 10.82 ± 1.0 for fresh *E. sardella* and 10.25 ± 0.25 for dried *E. sardella*.

The results of moisture content show that moisture content significantly decreased from fresh fish to dried fish as expected. There was further decrease of about 12.72% in moisture after three days storage at the market compared to when it was just dried. Substantial reduction of moisture from fresh to dried samples was due to heating process while and the loss after three days at the market samples would be attributed continued exposure to sunlight and humidity of the surrounding air which may have also absorbed moisture from the surface of the samples. During transportation there was insignificant loss of moisture. Insignificant loss of moisture during transportation was a result of less exposure to light because the samples were packed in cartons. The results for moisture are similar to the results which were found by Mumba & Jose, (2005) who reported a significant reduction in moisture content from 72.65% ± 0.3 in fresh *E. sardella* to 20.25% ± 1.1 in sun dried *E. sardella*.

Percentage fat content significantly decreased from 33.73 ±3.82 in fresh Usipa to 28.02±0.66 in dried Usipa samples. The decrease in fat content from fresh to dried sample may be attributed to oxidation of poly-unsaturated fatty acids contained in the fish samples to products like peroxides, aldehydes and ketones (Kiokias et al., 2009 and John, 1999) during the drying process. The results for fat are similar to the results which were found by Mumba & Jose, (2005). The values of fat significantly reduced from fresh *E. sardella* to sun dried *E. sardella* and the values were 29.9 ± 0.80a for fresh *E. sardella* and 23.95 ± 1.0 for dried *E. sardella*. Although the decrease in fat content was insignificant, within the nodes among the dried samples, fat content reduced by 5.35% after three days storage at the market.

Protein contents were not significantly different at p<0.05 among all samples that were collected at each node of the value chain of OSD *E. sardella*. The ranges were 43.22±1.85 to 45.2±0.25 and this would be an indication that protein content of *E. sardella* from OSD, do not change throughout the value chain. The results for protein are similar to the results which were found by Mumba & Jose, (2005). The values for protein insignificantly changed from fresh *E. sardella* to sun dried *E. sardella* and the values were 55.32 ± 1.34for fresh *E. sardella* and 57.3 ± 0.09 for dried.

Table 2 Proximate composition along the value chain of STD *E. sardella*

Value chain node	Ash %	Moisture %	Fat %	Protein %
FF	10.7±1.45 <sup>a</sup>	69.74±0.35 <sup>d</sup>	33.73±3.82 <sup>b</sup>	43.22±1.85 <sup>a</sup>
AD	9.40±0.49 <sup>a</sup>	14.29±0.48 <sup>b</sup>	28.02±0.66 <sup>a</sup>	44.58±0.95 <sup>a</sup>
AT	9.57±0.43 <sup>a</sup>	13.21±0.45 <sup>b</sup>	27.94±0.06 <sup>a</sup>	44.92±0.34 <sup>a</sup>
TDM	10.08±0.44 <sup>a</sup>	11.53±0.41 <sup>a</sup>	26.35±0.9 <sup>a</sup>	44.05±0.65 <sup>a</sup>

FF=Fresh fish, AD=After drying, AT=After transportation, TDM=Three days at the market, OSD=Open sun drying, STD=Solar tent drier. **Note:** Reported values represents the Mean and SD of 3 replicates. Different superscripts show significant differences at p<0.05 within the column.

Table 2 shows the changes in proximate composition along the value chain of STD *E. sardella*. Similar trends as those observed in the value chain of OSD *E. sardella* were found in ash, protein, moisture, and fat contents in STD Usipa. The changes in loss of fats and moisture were 5.96% and 19.31%, respectively. The fat reduction results prompted researcher to do further fat analysis to understand the cause for the difference which would be attributed to fat degradation.

### Mineral composition

Dried fish are a good source of minerals. Minerals commonly found in fish are sodium, potassium, calcium, magnesium, phosphorus, sulphur, iron, manganese, zinc, copper, and iodine. This study analyzed the mineral composition of Usipa focusing on calcium, zinc, and iron, because the latter two are micronutrients of public health concern in Malawi. One way ANOVA at  $P < 0.05$  was used to compare the changes in calcium, zinc and iron along the value chain and results are shown in Table 3.

Table 3 Mineral composition along the value chain of OSD and STD *E. sardella*

Value chain node	Zinc (mg/100g)		Calcium (mg/100g)		Iron (mg/100g)	
	OSD	STD	OSD	STD	OSD	STD
FF	13.1±0.31 <sup>a</sup>	13.1±0.31 <sup>a</sup>	422.17±1.46 <sup>a</sup>	422.17±1.46 <sup>a</sup>	15.24±0.43 <sup>a</sup>	15.24±0.43 <sup>a</sup>
AD	13.11±0.34 <sup>a</sup>	13.17±0.74 <sup>a</sup>	418.83±0.52 <sup>a</sup>	420.08±2.01 <sup>a</sup>	15.28±0.21 <sup>a</sup>	15.30±0.22 <sup>a</sup>
AT	13.45±0.28 <sup>a</sup>	13.49±0.01 <sup>a</sup>	422.67±2.98 <sup>a</sup>	422.75±0.87 <sup>a</sup>	15.32±0.24 <sup>a</sup>	15.32±0.21 <sup>a</sup>
TDM	13.37±0.33 <sup>a</sup>	13.85±0.13 <sup>a</sup>	421.67±0.63 <sup>a</sup>	421±2.63 <sup>a</sup>	15.11±0.29 <sup>a</sup>	15.4±0.13 <sup>a</sup>

FF=Fresh fish, AD=After drying, AT=After transportation, TDM=Three days at the market, OSD=Open sun drying, STD=Solar tent dryer. Note: Reported values represents the Mean and SD of 3 replicates. Different superscripts show significant differences at  $p < 0.05$  within the column.

There was no significant difference at  $p < 0.05$  in Zinc, Calcium, and Iron contents among all the samples that were collected on each value chain node of both OSD and STD *E. sardella* (Table 3). The values ranged from 13.1±0.31 to 13.45±0.28 for OSD and 13.1±0.31 to 13.85±0.13 for STD, 418.83±0.52 to 422.67±2.98 for OSD and 420.08±2.01 to 422.75±0.87 for STD, 15.11±0.29 to 15.32±0.24 for OSD and 15.24±0.43 to 15.4±0.13 for STD, respectively. Mineral composition did not change during drying, after transportation and after three days at the market due to the nature of minerals which makes them survive even in adverse conditions like high temperatures (Park, 2016). The results for iron from this study are similar to the results which were found by Mumba & Jose, (2005) in a study which assessed the nutritional composition of selected fresh and processed fish species from Lake Malawi. The values for iron insignificantly changed from fresh *E. sardella* to sun dried *E. sardella*. The values were  $10.82 \pm 1.0$  for fresh *E. sardella* and  $10.25 \pm 0.25$  for dried *E. sardella*. Contrary to the results of this study, Mumba & Jose, (2005) found a significant decrease in calcium levels from fresh to sun dried *E. sardella*. It is important to note that dried Usipa is a good source of zinc and iron, both of which are micronutrients of public health concern. The 2015-16 micronutrient survey revealed a high prevalence (60%) of zinc deficiency across all the population groups in Malawi. The amounts of zinc found in these OSD and STD usipa of around 13mg per 100 mg of edible portion, would meet the recommended zinc requirement per day for all ages groups which range from 3mg to 12 mg. Consumption of dried Usipa should be encouraged because it has potential to contribute towards reduction of zinc deficiency.

### Lipid degradation

Lipid oxidation is the oxidative degradation of lipids which is responsible for rancid odours in fish. High polyunsaturated fatty acids in fish makes it more susceptible to lipid oxidation, since they contain multiple double bonds that possess reactive hydrogen bonds. The greater the degree of unsaturation of the fatty acid, the more susceptible the fish is to oxidation. Peroxides are primary products of lipid oxidation when quantified are reported as peroxide values (PV) and thiobarbituric acid (TBA) values shows presence of aldehydes and malondialdehyde which are secondary products of lipid oxidation. One way ANOVA at  $P < 0.05$  was used to compare the changes in peroxide values and TBA values along the value chain.

Table 4 and Figure 1, show that in each drying technique, there was significant increase in the peroxide values (PV) of *E. sardella* after drying and after three days at the market. Thus PV values increased by 23.95% and 30.65% in OSD and STD Usipa, respectively, between soon after drying and after three days at the market, which can be associated with decrease in moisture content in the samples.

Table 4 Lipid degradation along the value chain of OSD and STD *E. sardella*

Value chain node	Peroxide value (Meq O <sub>2</sub> / Kg fat)		TBA value (Mg MAD/Kg)	
	OSD	STD	OSD	STD
<b>FF</b>	1.83±0.33 <sup>a</sup>	1.83±0.33 <sup>a</sup>	0.25±0.13 <sup>a</sup>	0.25±0.13 <sup>a</sup>
<b>AD</b>	6.68±0.55 <sup>b</sup>	5.22±0.23 <sup>b</sup>	0.76±0.22 <sup>ab</sup>	0.63±0.95 <sup>ab</sup>
<b>AT</b>	6.8±0.48 <sup>b</sup>	5.31±0.35 <sup>b</sup>	0.77±0.18 <sup>ab</sup>	0.75±0.90 <sup>ab</sup>
<b>TDM</b>	8.28±0.65 <sup>c</sup>	6.82±0.60 <sup>c</sup>	1.11±0.83 <sup>ab</sup>	1.06±0.46 <sup>ab</sup>

FF=Fresh fish, AD=After drying, AT=After transportation, TDM=Three days at the market, OSD=Open sun drier, STD=Solar tent drier.

Note: Reported values represents the Mean and SD of 3 replicates. Different superscripts show significant differences at  $p < 0.05$  within the column.

According to Ako et al., (2006) and Ahmed et al., (2016), heat, light, moisture and oxygen are some of the factors that induce lipid oxidation. Increase in peroxide values which is an indication of lipid oxidation or degradation would be attributed to exposure of heat, light, and oxygen during drying time in both methods. The insignificant difference between after drying and after transportation samples would be due to the packaging of fish hence less exposure to light and limited oxygen that could lead to lipid oxidation. The significant increase in peroxide values of samples collected on three days at the market is attributed to exposure of dried Usipa to light and oxygen on the benches which are favorable conditions for lipid oxidation, since at the market the samples were laid on benches.

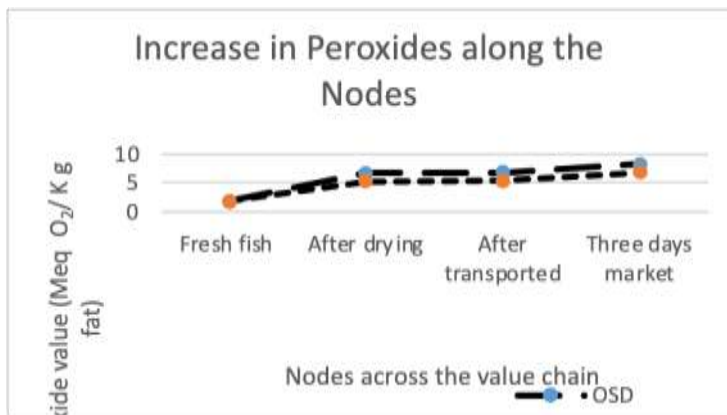


Figure 1 Showing increase in peroxides due to lipid oxidation

TBA values are indicators of secondary products/ of lipid oxidation which are formed during decomposition of hydro peroxides (Kiokias et al., 2009). In each technique, TBA values were not significantly different along the value chain within the three nodes. However, a similar increasing trend was observed (Figure 2), TBA values increased by 46.05% in OSD Usipa and 68.25% in STD Usipa (Table 4). These results would be attributed to the initial stages of lipid oxidation in both techniques, evidenced by low values of TBA. According to Kiokias et al., (2009), during the initial stages of lipid oxidation, peroxide values increases and then reach at a topmost. Later, the peroxide values start to decline and this time, the rate of production of secondary peroxidation products such as malondialdehyde, whose concentration is quantified by TBA values, start to increase. Results on peroxide and TBA values are similar to what Kumar et al (2017) found in a study which evaluated the effects of different drying methods on the quality of fish samples (*Pangasius hypophthalmus*). Peroxide values and TBA values for fresh fish were found to be low as compared to sun dried samples. Increase in PV of sun-dried fish samples were said to be due to prolonged exposure of fish to oxygen, light, and air during drying. According to Nkiruka et al., (2010), a rancid taste become noticeable when peroxide values is in the ranges of 10-20 Meq O<sub>2</sub>/Kg of fat. Therefore, the peroxide values obtained in this study were within the acceptable limit which indicates that all the open sun-dried samples were within the acceptable limit. Similarly, Kumar et al (2017) reported that TBARs value greater than 3-4 Mg MDA/Kg indicates a loss of product quality. Hence, the TBARs values obtained from sun-dried samples of this study are considered of good quality.

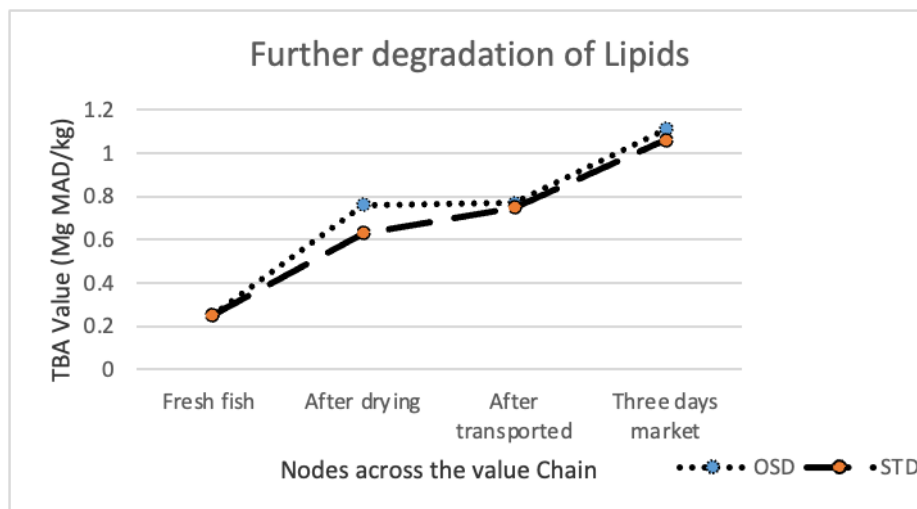


Figure 2 Showing increase TBA values during lipid oxidation

### Conclusion

According to the results of this study, only moisture and fat contents changed along the value chain while protein, ash, calcium, zinc and iron content did not change in both solar tent dried (STD) and open sun-dried (OSD) Usipa (*E. sardella*). Dried Usipa, is a good source of zinc, iron and calcium which are important minerals in the diet. Lipid oxidation occurred along the value chain, evidenced by increase in peroxide values and TBA values of *E. sardella* from both techniques' affecting not only the fat content but also the quality of the dried Usipa. Comparison the effect of method of processing solar tent dried and open sun-dried methods across the value chain showed no changes in content of most parameters, except for moisture content after drying, and fat content and peroxide value in all the three nodes. However, solar tent dried fish is superior to open sun-dried fish in maintenance of fat content and fat quality throughout the value chain. Therefore, use of solar tent drier has the potential to minimize fat degradation /lipid oxidation hence produce high quality and nutritious fish and in generally Usipa was a potential source of zinc, its consumption should be promoted at household level.

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## **HEALTH, POPULATION AND NUTRITION**

## **Assessment of the status of food safety and hygiene in City food outlets, a case of Zomba City, Malawi.**

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### **Abstract**

Food is a basic human need that plays a vital role in the sustenance of life. Consumption of contaminated food and water contributes to a myriad of health problems the world over. Food is contaminated from poor sourcing and handling practices. Food-borne diseases like cholera, diarrhea, dysentery and typhoid remain a contentious problem to both developed and developing nations. Food Safety has become a major concern to the food industry. This study then assessed the status of food safety and hygiene in food outlets in Zomba town. A community based cross-sectional study using interviews and observation was used to collect data. Respondents were food handlers. The study reviewed that the food handlers had knowledge but their food handling practices like hand washing, use of personal protective clothing, food covering, food storage were poor and the inspection of food premises by inspectors was also is poor. To ensure provision of safe food to consumers, training of food handlers in food safety, hygiene and sanitation, provision and use of protective clothing and frequent food premises inspection is required in the food outlets.

**Keywords:** Food Contamination, Food borne diseases. Food safety and Hygiene, Food handler, Personal protective clothing.

### **Introduction**

Food is a basic human need that plays a vital role in the sustenance of life. Its safety, however, has become a major concern to the food industry given that the consumption of contaminated food and water contributes to a myriad of health problems the world over. Food hygiene are the conditions and measures necessary to ensure the safety of food from production to consumption. Although food prepared and served at restaurants may look clean and taste delicious, it may have been contaminated during the preparation procedures from the source through to service. Food is contaminated from poor sourcing and handling practices which include poor personal hygiene, and use of unclean equipment and unclean environment.(WHO 2017) The World Health Organization (WHO) indicated that each year 600 million people in the world fall ill of which 420,000 die after consuming contaminated food. In the United States, foodborne illnesses affect an estimated 48 million people every year resulting in 128,000 hospitalizations and 3,000 deaths. Africa and Southeast Asia are believed to have the highest prevalence and death rates related to foodborne disease. Diego, (2008) The repeated occurrence of foodborne disease has led to an increase in global concern about food hygiene and safety among food handlers (WHO, 2015).Therefore, preventing restaurant-associated foodborne disease is an essential assignment of the public health departments.

Food outlet business is a source of income to some urban and rural dwellers. Although most of the people in Malawi eat fast foods and are involved in this business, a few get worried on the safety of the food. In most of the food outlets there are practices which contaminate the food such as washing of hands before touching or preparing food and dirty food contact surfaces.

Most of these practices are taken lightly but the effect is likely great like occurrence of foodborne disease outbreaks like cholera, diarrhea, dysentery and typhoid (Morse 2014 & Mphande, 2010)

A high standard of hygiene in the food preparing environment, in particular on food contact surfaces, availability of portable running water, places free from bad smells, proper equipment and building structures, is an important view for the prevention of microbial contamination of food and the occupation safety for the consumers. (Morse, 2014). Most food outlets are close to busted manholes, non-hygienic food handlers, dirty food contact surfaces, no portable running water nearby, poorly constructed crowded buildings and poor waste disposal that can cause a threat to the human health.

These food outlets pose a great threat to the health of the public because of poor food handling, poor hygiene and sanitation of food handlers and unclean environment. This necessitated the need to assess the status of food safety and hygiene in the small-scaled food outlets of Zomba City. This will help to know if the food outlets are eligible to sell food. All this, is to protect the health of the public which consumes the food. Improving food safety and hygiene is very important to the successful accomplishment of the Sustainable Development Goals (SDGs) (WHO, 2015).

An effective food safety management system, requires clear inspection policy and procedures that are applied by food monitors who are well trained not only to apply these procedures but also to act as quality assurance advisors and extension officers to the food industry to protect the health of the public. According to Masuku (2018), in Malawi the lack of clear marking out between ministries and departments currently leads to over assessment of some premises, (e.g., commercial premises who already practice self-regulation to achieve international certification for export), and lack of assessment in premises which are potentially high risk due to their practices, or their target consumers e.g., restaurants.

Food safety systems in Malawi have been described as ‘weak’, ‘fragmented’, ‘not well coordinated’, and ‘lacking in capacity’. There is no complete database of all food premises within Malawi. A comprehensive list of businesses holding Malawi Bureau of Standards (MBS) certification is available for large-scale businesses. On the other hand, at District level the information the number of premises differs in quality and data on the premises is not maintained in a single networked system pointing to the need for investigation of food hygiene and safety in small scale food outlets. (Morse, 2014).

Improving food safety and hygiene is very important to the successful accomplishment of Sustainable Development Goals (SDGs). A study by Masuku et al (2018), showed that that there is a significant threat to public health and market access due to uncoordinated, outdated or incomplete monitoring framework, poorly defined obligations, limited infrastructure, lack of equipment and skilled personnel, insufficient resources, and narrow awareness and ability to meet market sanitation and hygiene standards. This indicate that food premises are not healthy to provide safe foods to consumers.

Epidemiological data on foodborne diseases remain scarce because cases time and again go unrecognized, unreported or uninvestigated. According to Adane et al., (2018) done in Ethiopia,

there is a lack of documented information on the extent of foodborne diseases and the level of food hygiene and safety measures among street food vendors and food handlers of food establishments. A study by Chapabika, (2014) on assessment of food hygiene practices among food handlers in restaurants indicated that a number of food handlers were trained in food hygiene and the rest indicated that they came to know about food hygiene practices through inspectors who go round to inspect the food premises. This is also the problem in Malawi as stated by Masuku et al (2018) that foodborne disease outbreaks are often associated with poor personal hygiene practices of people handling foodstuffs. Therefore, preventing restaurant-associated foodborne disease is an essential assignment of the public health departments. The study then aimed to identify practices of food handlers in relation to food safety and hygiene, determine the level of knowledge of food handlers on food safety and hygiene and to determine the level of food premises inspection in Zomba town.

### **Materials and methods**

The study used a quantitative cross-sectional design. The study participants were food handlers, employed in the food outlets. Convenient sampling was done in the food outlets of Zomba city and a total of 47 food handlers, both males and females were found and participated in the study. Data was collected through face-to-face interviews using a semi-administered questionnaire and observation using an observation checklist. Data was captured in the Microsoft excel 2013 and will be imported into Statistical Package for Social Science (SPSS) version 20 application for analysis.

### **Results and Discussion**

#### **Demographic information of study participants**

The majority of the food handlers were females 26 (55.%) Most of the females were in the age range of 20 – 25 (62%) while most males were in the age range of 25 -30 (45%). This study also revealed that the majority (80%) of food handlers were above 21 years. This is similar to a study by Isara (2009) in Benin food outlets where the majority were females (69.5%). A study by Getachew (2010) on the assessment of hygienic practices in selected hospitals in Ethiopia also found that all food handlers (100%) were females. But a study by Kasturwar (2011) found that the majority of food handlers were males 52 (62.7%). From these studies it is clear that the majority of food handlers in food establishments are females

#### **Knowledge of food handlers on food safety and hygiene**

Results of the study indicate that most of the food handlers have knowledge that food borne diseases are preventable (81%). A greater number also know that putting on clean clothes (25%, personal hygiene (72%) and a clean environment (72%) prevents food contamination. On the other hand, majority of food handlers had inadequate knowledge that clean clothes prevents food contamination (75%), protective gear protects food contamination (68%) and that Fresh/raw food need to be cleaned with safe water (75%). (Table 1).

**Table 1 Knowledge of food handlers on food safety and hygiene**

Knowledge	Yes		No	
	Frequency	Percent	Frequency	Percent
Aware of prevention of foodborne diseases	38	81	9	19
Clean clothes prevents food contamination	12	26	35	75
Raw food spoil cooked food	20	43	27	57
Protective gear protects food contamination	15	32	32	68
Personal hygiene prevents food contamination	34	72	13	28
Fresh/raw food need to be cleaned with safe water	12	25	35	75
Clean surrounding prevents food contamination	34	72	13	28

The study found that of all the 47 food handlers that were involved in the study only very few (22%) were trained in food safety and hygiene while the majority (88%) were not trained. This is similar to a study done by Chapabika (2014) where an assessment of food hygiene practices among food handlers in restaurants was also done and only 26% of the food handlers were trained in food hygiene and the rest indicated that they came to know about food hygiene practices through inspectors who go round to inspect the food premises.

The study also looked at the practices of food handlers in restaurants on the safety of food. A greater number of food handlers do not wear clean clothes (55%), aprons (62%) and 93% do not cover their heads. On the positive side, the majority of food handlers use forceps or ladles to pick up ready-to-eat food (91%) other than handling food with bare hands and have short clean nails not coated (61%), just above half (53%) do not eat while preparing food and 76% regularly wash their hands (Table 2)

**Table 2 Practices of food handlers**

Practice	Yes		No	
	Frequency	Percent	Frequency	Percent
Wear clean clothes with sleeves	21	45	26	55
Wear aprons	18	38	29	62
Head covered	3	6	44	93
Short clean nails not coated	28	60	19	40
Use forceps or ladles to pick up ready-to-eat food	43	91	4	9
Regularly hand washing	36	76	11	24
Handle money and then handle food	33	70	14	30
Covering cooked food all the time	24	51	23	49
Don't eat while preparing food	22	46	25	53

Among those food handlers who wash hands, the majority (68%) indicated that they wash hands after every activity in the food outlet. (Figure 1). Hand washing with soap is also very important after visiting a toilet. Only 63% of food handles indicated washing hands with soap after using a toilet. This almost similar with a study done by Onyeneho (2013) on assessment of food safety needs of restaurants in Owerri, Imo State, Nigeria in which 70% of the food handlers reported that they wash hands with soap before preparing foods.

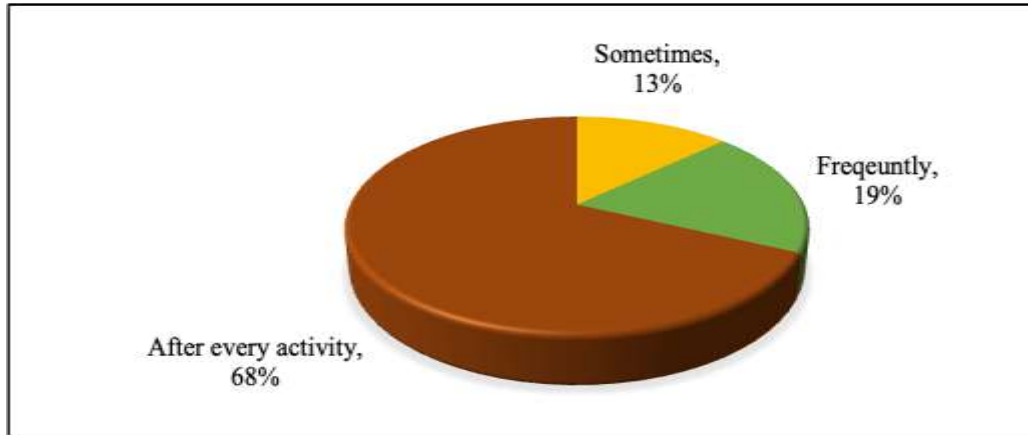


Figure 1 Hand washing frequency of food handlers

In a study done by Ali (2017) on an assessment the food safety practices of food handlers at an institution, the majority of the food handlers (96%) did not use apron or hair restraints during food handling and all (100%) food handlers do not use gloves when distributing ready-to-eat food.

### Food and Food Premises Inspection

The study found that the food outlets are not inspected as required. The majority (83%) indicated that food outlets are not visited by the city council inspectors while 4% and 12% indicated that inspection is done frequently and occasionally respectively (Figure 2)

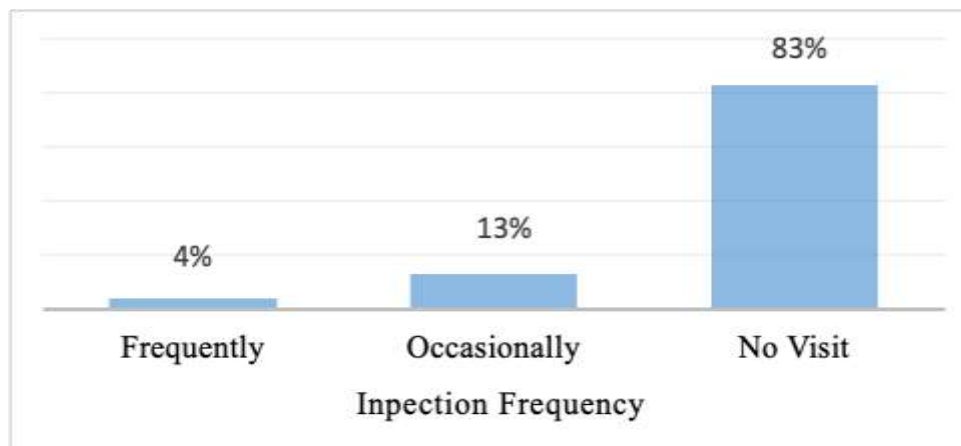


Figure 2 Food and food premises inspection frequency

Results of this study are different from that of Jones (2008) where the majority (97%) of respondents indicated that they were being inspected regularly by the Health Officers every month. This differs from the results of this study where inspection is rarely and not even done.

### Conclusion and recommendations

It is seen that the level of knowledge of the food handlers is inadequate on food safety and hygiene. majority of food handlers in food outlets in Zomba city town market are female. The food handlers demonstrated good knowledge in the areas of hand washing, general cleaning,

awareness on prevention of foodborne diseases with inadequate knowledge on the importance of using clean clothes, protective clothing and safe water for cleaning fresh and raw food.

Despite having the knowledge, their food handling practices are poor. The food handlers only had better practices in regular hand washing efficiently with soap. They also showed good hygiene practices in picking food with forceps or ladles other than bare hands. Most of the shortfalls are due to lack of training of the food handlers on food safety and hygiene as well as the failure of the City Council to do Food and Food premises inspection as revealed by the study.

The knowledge on food safety and hygiene has an impact on food safety which is not the case in this study. Training is a very important as food handlers are equipped with knowledge and be able to practice what the standard precepts of food safety. Food and food premises inspection influences following of standard practices for the provision of safe food in food outlets. To improve this these gaps, there is need to ensure that all food handlers are trained in food safety and hygiene, and carry regular food and food premises inspection to ensure proper and standard practices in all food outlets by food handlers.

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## Dietary Patterns and Gestational Weight Gain in the Third Trimester of Women Attending Antenatal Clinic at Bwaila Hospital in Lilongwe City, Malawi

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### Abstract

Healthy pregnancy weight gain has a number of benefits, whereas too little or too much gestational weight gain (GWG) are risk factors of various poor pregnancy outcomes. To determine the association between maternal dietary patterns and gestational weight gain in 3<sup>rd</sup> trimester among pregnant women attending antenatal clinic at Bwaila Hospital in Lilongwe city. This was a combined retrospective and cross-sectional study in which 285 consenting healthy pregnant women of all ages who were in their 9<sup>th</sup> month of pregnancy were recruited. As primary data, weight and dietary patterns at 9 months gestation were collected using structured questionnaires. Weight at the 7<sup>th</sup> and 8<sup>th</sup> month, and pre-pregnancy height and weight (for pregravid body mass index – BMI computation) were retrospectively obtained from health passports. Dietary patterns were established using Principal Components Analysis with Varimax rotation. Pearson correlation was used to determine the relationship between dietary patterns and GWG. **Results:** Thirty-nine percent of the subjects were overweight and obese. Two main dietary patterns, namely “Vegetarian” and “Mixed” were identified. Only the mixed dietary pattern had a significant but small and weak correlation with GWG ( $r=0.261$ ,  $p<0.01$ ). Regardless of pregravid BMI category, 41.8% of the women had insufficient GWG particularly among those who were underweight or had normal weight. Excessive weight gain was observed in 20.4% of the women, especially those who were overweight and obese. Women who were consuming a mixed dietary pattern were likely to gain weight than those whose diet was vegetarian. Insufficient GWG was widespread, particularly among those who had normal to low pregravid BMI. Counselling on dietary choices during pregnancy should be intensified.

**Keywords:** Dietary patterns, gestational weight gain, Malawi, pregnant women, third trimester

### Background

Pregnancy is a period when a woman is expected to gain weight to meet increased metabolic demand throughout the gestation period (Asefa *et al.*, 2020). There are substantial metabolic changes that occur during the gestation period. In the 1<sup>st</sup> trimester, the body undergoes anabolic metabolism, where there is an upsurge in maternal fat deposits in preparation to fulfil the fetal, maternal, and placental nutritional needs of the 3<sup>rd</sup> trimester and lactation via catabolism (Lain & Catalano, 2007). However, the extra weight that a woman gains during gestation can be a risk factor which is potentially modifiable for the reduction of negative pregnancy outcomes which culminate into neonatal and maternal mortality (Voerman *et al.*, 2019). On the other hand, if there is suboptimal GWG in women categorized as having a normal or low BMI, the consequences like miscarriage, anaemia and low birthweight may be detrimental for both the mother and the baby and can lead to both maternal and neonatal mortality Hirko *et al.* (2020).

In order to achieve positive pregnancy outcomes, the IOM (2009) recommend that the upper limit for GWG particularly those with singleton pregnancies, based on pre-pregnancy BMI is 18 kg for underweight (BMI <18.5), 16 kg for normal weight (BMI 18.5-24.9), 11 kg for overweight (BMI 25.0-29.9) and 9 kg for women with obesity (BMI  $\geq$ 30.0). Another proposition by the IOM was also that women of the reproductive age ought to have a weekly gestational weight gain during the 2<sup>nd</sup> and 3<sup>rd</sup> trimester at the rate of 0.44–0.58, 0.35–0.50, 0.23–0.33, and 0.17–0.27 kg/week, respectively, for the similar BMI levels (IOM, 2009).

Gaining weight during pregnancy has a direct link to a woman's dietary intake and her nutritional status (Cano-Ibáñez *et al.*, 2020), but other factors like pregravid BMI, dietary pattern, parity, intensity of exercises and maternal age have also been attributed to influencing weight gain (Hasan *et al.*, 2021). In order to understand the synergistic effect of different nutrients eaten together, in nutritional epidemiology the holistic approach of studying dietary patterns has gained ground as an exposure in order to overcome the methodological and conceptual limitations of single nutrient approaches (Itani *et al.*, 2020). Globally studies examining the association between GWG and dietary patterns have been done, some studies showed a negative correlation between GWG and dietary patterns rich in vegetables and fruits (Cano-Ibáñez *et al.*, 2020; Wrottesley *et al.*, 2017; Maugeri *et al.*, 2019). On the other hand, studies have established a positive correlation between GWG and dietary patterns rich in processed foods (Itani *et al.*, 2020; Tielemans *et al.*, 2015; Wrottesley *et al.*, 2017).

Although Malawi is regarded as one of the poorest countries in the whole world, there has been an epidemiological transition which has seen an increase in maternal obesity at national level, since 1992 overweight or obesity moved upwards from 10% to 21% in 2015-16, particularly in the urban areas (36%), as compared to the rural areas (17%) (NSO, 2018). Determinants of maternal obesity include sociodemographic and obstetric characteristics, antenatal and postpartum physical activities and dietary intake during gestation and postpartum among several factors (Nurul-Farehah & Rohana, 2020). Locally up to date, no studies have examined the dietary patterns and gestational weight gain particularly in the 3<sup>rd</sup> trimester of women attending antenatal clinic particularly at Bwaila Hospital in Lilongwe city in Malawi. The specific objectives of the study were to assess dietary patterns of pregnant women in 3<sup>rd</sup> trimester who attend antenatal clinic at Bwaila Hospital, to determine 3<sup>rd</sup> trimester GWG or GWGR of the women, to determine the association between GWG or GWGR and dietary patterns of women in third trimester, and to determine socio-demographic factors that may be associated with GWG or GWGR in 3<sup>rd</sup> trimester.

## **Materials and methods**

This study recruited 285 consenting pregnant women in their 9<sup>th</sup> month of gestation, with a singleton pregnancy, residing in urban areas, healthy, and were of different ages, and excluded all pregnant women who had overdue pregnancies, were sick (diabetes, hypertension, malaria, which require subjects to be placed on a special diet), or had a gestation of < 9 months, had a multiple pregnancy, had their pregravid weight and height data missing from health passport, or had been referred from a rural health facility. Data for this study were obtained both cross-sectionally and retrospectively from the health passports of women. Data were collected both cross-sectionally and retrospectively using interviewer-administered questionnaires addressing maternal sociodemographic and lifestyle characteristics such as age, education level, occupation, parity and

frequency and type of physical activity, maternal body weight at 9 months gestation and dietary patterns using a food frequency questionnaire (FFQ). Retrospectively, data collected include pregravid weight and height (for BMI computation), maternal body weight and height at 7 and 8-months gestation. Ethical approval and clearance for this study was sought from the National Health Sciences Research Committee (NHSRC), under the Ministry of Health in Malawi. The study was approved on 25<sup>th</sup> January, 2022 with approval reference number **2854**. Approval to conduct the study at Bwaila Hospital was sought from the research committee at Lilongwe District Health Office. Participants gave both verbal and written consent to participate in the study, and they were identified by code numbers during data entry. All data in printed and soft copies were only handled by the Principal Investigators.

### **Maternal Dietary Intake**

Maternal dietary intake was measured by a semi-quantitative food frequency questionnaire (FFQ). The FFQ comprised 59 food items commonly found in the urban residential areas, and consumption frequency was measured on the scale of once/week, 2-3 times/week, 4-5 times/week, 6-7 times/week,  $\geq 8$  times/week, never.

### **Maternal pregravid BMI**

In order to overcome the effects of lordosis and weight gain on maternal BMI during pregnancy, pregravid BMI was computed using pregravid height and weight recorded in the health passports of the women. BMI was computed as weight (in kg) divided by squared height (in meter). The pre-gravid BMI categories were according to the World Health Organisation (WHO) classification into 4 categories: underweight (BMI  $< 18.5$  kg/m<sup>2</sup>), normal weight (BMI 18.5–24.9 kg/m<sup>2</sup>), overweight (BMI 25.0–29.9 kg/m<sup>2</sup>) and obese (BMI  $\geq 30.0$  kg/m<sup>2</sup>) (WHO, 2010).

### **GWG and GWGR Computation**

GWG was computed by subtracting the maternal pregravid weight (obtained from the health passports) from the maternal gestational weight measured at 9 months. According to IOM (2009) GWG guidelines, GWG was classified as insufficient, adequate, or excessive weight, with reference to the pregravid BMI. The IOM recommended guidelines stipulate that GWG for underweight women ought to be between 12.5 to 18 kg, for women of normal weight between 11.5 to 16 kg, for overweight women between 7 to 11.5 kg, and for obese women between 5 to 9 kg (IOM, 2009). On the other hand, according to the IOM (2009) criteria, GWGR is defined as is the weight gain rate per week after the 12<sup>th</sup> week of gestation. In order to calculate GWGR in this study, all the women were postulated to have gained a mean of 1 kg throughout the first 12 weeks of gestation (first trimester). This postulation is grounded on the IOM weight gain reference of 0.5–2 kg over the 1<sup>st</sup> trimester. Hence the equation below adapted from Itani *et al.* (2020) was used:

$$\frac{\text{GWGR}}{\text{Week}} = (\text{Weight at 9 months-Pregravid Weight})-1/\text{Calculated Gestational Age-12}$$

In reference to the IOM weekly GWG based on pregravid BMI, it is recommended that during the 2<sup>nd</sup> and 3<sup>rd</sup> trimester pregnant women should gain weight at the rate of 0.44–0.58 kg/week for underweight, 0.35–0.50 kg/week for normal weight, 0.23–0.33 kg/week for overweight, and 0.17–

0.27 kg/week for obese women (IOM, 2009). In this study the IOM standards for GWGR were used to categorise the women to have either gained insufficiently, adequately, or excessively if their GWGR fell lower, within or over the recommended weekly weight gain, respectively.

### **Dietary Patterns Extraction**

To derive the dietary patterns, principal components analysis (PCA) with varimax/orthogonal rotation was done on the consumption of the 47 food items to extract factors and to derive non-correlated factors. The Kaiser–Meyer–Olkin (KMO) test (0.710) indicated the appropriateness of the factor analysis, and the  $\chi^2$  Bartlett test of sphericity (homogeneity of variance) at  $p < 0.05$  was acceptable. Eigen values  $> 1$  and the inflection point of the scree plot determined the number of factors to be retained and the interpretability of factors. The dietary patterns became clear after excluding all food items which had low consumption frequencies. To determine the food items which were significantly making up a diet, a factor loading of  $\geq 0.35$  was chosen due to  $n = 285$  (Hair *et al.*, 1998).

### **Statistical Analyses**

Data were entered and coded in Microsoft Excel, and IBM SPSS Statistics for Windows, v 23.0 was used for all analyses. Socio-demographic characteristics were analysed using descriptive statistics (means, percentages and frequencies) to generate summaries of the dependent variables. Non-parametric one-Sample Chi-square test ( $\chi^2$ ) was done to check whether the different categories per categorical variable were significantly associated ( $p < 0.05$ ). Principal Components Analysis (PCA) with Varimax rotation with Kaiser normalisation was used to generate and define the main dietary patterns. Varimax rotation was chosen because as an orthogonal rotation, it produces results which are easier to interpret because it highlights a small number of important variables (Cook, 2010). A scree plot and Eigen values  $> 1$  of the principal components were used to decide which components to retain. To determine which food items to retain in each dietary pattern, factor loadings of  $\geq 0.35$  were considered significant due to  $n = 285$ , and also for practical significance of the results (Hair *et al.*, 1998). To determine GWG/GWGR in the 3<sup>rd</sup> trimester, crosstabulation of GWGR categories against pregravid BMI using Fisher's Exact Chi-square test was done to generate percentages of women who gained insufficiently, adequately and excessively depending on their pregravid BMI. Results were regarded as significant at  $p < 0.05$ . Bivariate correlation using Pearson correlation was done to find which dietary pattern was significantly associated with GWGR/GWG. Correlation was regarded as significant at the  $p < 0.05$ . Independent multinomial regression (Bivariate logistic regression) was used to determine the socio-demographic factors which were associated with GWG/GWGR during the 3<sup>rd</sup> trimester. The covariates were selected after checking for multicollinearity using Pearson correlation, the independent variables which were highly correlated ( $r \geq 0.8$ ,  $p < 0.05$ ) were not considered for independent multinomial regression.

### **Results**

Over 36% ( $n = 104$ ) of the subjects had their ages falling within the age range of 21-25. Around 91.2% ( $n = 260$ ) of the pregnant women were married, and study participants who had attained upper primary education (Std 5-8) 37.2% ( $n = 106$ ), were significantly lower compared to the cumulative 48.1% had attained secondary level education (form 1-4), and almost 5% ( $n = 14$ ) of the

population had attained university education. Pregnant women who did not have any economic activity (61%) were significantly higher than those who had at least one income generating activity ( $p < 0.01$ ). Over 83% ( $n = 238$ ) of the study participants belonged to Christianity as a religion. Nearly 59% ( $n = 167$ ) responded that they engaged in physical activity whilst over 41% ( $n = 118$ ) were not into any form of exercises. Nearly 99% of the study participants were not taking any alcohol and none of the women were smokers. Using the pregravid BMI to check the nutrition status of the pregnant women before pregnancy, the results revealed that 4.9% were underweight and 55.8% had normal weight, almost 25% ( $n = 70$ ) of the subjects were overweight and 14.7% ( $n = 42$ ) were obese. Around 68.4% ( $n = 195$ ) of the women were multiparous, whilst 31.6% ( $n = 90$ ) were primiparous. Similarly, all these categories were also significantly different ( $p < 0.01$ ).

PCA unveiled two discrete patterns as shown by the scree plot (**Fig. 1**), named as “Mixed” and “Vegetarian” dietary patterns, which cumulatively explained 18.1% of the variance in dietary patterns of the study subjects.

**Table 1** below shows the factor loadings of the various food items making up these two dietary patterns. The “Mixed” dietary pattern was made up of foods which would be regarded as healthy and unhealthy such as meat and meat products, fruits and vegetables, processed cereals, saturated and unsaturated fats, sugar sweetened beverages (SSBs), nuts and irish potato, and junk foods, whilst the “Vegetarian” dietary pattern was largely comprised of food items of plant origin such as pulses/legumes, a lot of fruits and vegetables, unprocessed maize flour, roots and tubers.

**Table 2** below shows the percentages of how many women gained below, within and above the 2009 IOM guidelines on GWGR in reference to their pregravid BMI ( $p < 0.05$ ).

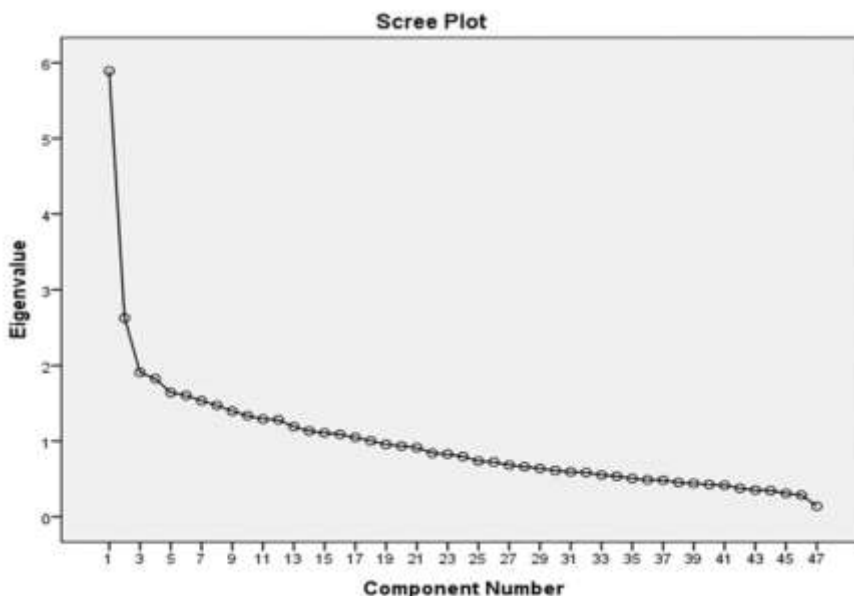


Figure 1 Scree Plot showing the inflection point

**Table 1** Factor loading matrix of the derived dietary patterns ( $n=285$ ), \*Factor Loadings  $\geq 0.35$  were considered significant.

<b>Mixed Dietary Pattern</b>		<b>Vegetarian Dietary Pattern</b>	
<b>Food Items</b>	<b>Loading Factor</b>	<b>Food Items</b>	<b>Loading Factor</b>
Beef	0.391	Green Beans	0.358
Milk & Milk Products	0.437	Aubergines	0.349
Eggs	0.355	Okra/Jute Marrow	0.482
Cucumber	0.409	Apples	0.362
Apples	0.398	Oranges	0.409
Bananas	0.506	Mangoes	0.655
G/nuts	0.398	Pawpaw	0.372
Gramil/ <i>Nsima Yoyera</i>	0.514	Cowpeas	0.415
Irish Potatoes	0.533	Pegion Peas	0.479
Bread	0.63	Cassava	0.463
Rice	0.51	<i>Mgaiwa Nsima</i>	0.436
Cooking Oil	0.443	Sweet Potatoes	0.419
Avocado Pears	0.48		
Butter/Margarine	0.46		
SSBs	0.458		
Junk Foods	0.414		

**Table 2** Gestational Weight Gain Rate (GWGR) Categories per BMI Category

	<b>Pre gravid BMI Categories<sup>b</sup></b>				<b>Total</b>	$\chi^2$	<b>P-value</b>
	<b>Under Weight</b>	<b>Normal weight</b>	<b>Overweight</b>	<b>Obese</b>			
<b><sup>a</sup>GWGR Categories</b>						97.135	<0.01*
Insufficient	13 (93%)	88 (55%)	12 (17%)	6 (14%)	119 (42%)		
Adequate	1 (7%)	63 (40%)	32 (46%)	12 (29%)	108 (38%)		
Excessive	0 (0%)	8 (5%)	26 (37%)	24 (57%)	58 (20%)		

\*Statistically significant at 5%

<sup>a</sup> Gestational Weight Gain Categories

<sup>b</sup> Pre gravid Body Max Index Categories

More than one third of women (37.9%) in this study had adequate GWGR with the largest proportion from women who were overweight (45.7%) and almost one fifth of women (20.4%) had excessive GWGR with largest proportion from women with obesity (57%). The proportions were significant at 5%. The results also showed that in the BMI category of underweight ( $<18.5\text{kg/m}^2$ ), 92.9% and 7.1% of the pregnant women had insufficient and adequate GWGR respectively, and this was significantly different ( $p < 0.01$ ). On the other hand, 55% of women with normal weight (BMI,  $18.5\text{-}24.9\text{ kg/m}^2$ ) had insufficient GWGR, whilst 40% and 5% of the same BMI category had adequate and excessive GWGR respectively ( $p < 0.01$ ). For the women categorised as overweight (BMI,  $25.0\text{-}29.9\text{ kg/m}^2$ ), over 45 % had adequate GWGR, whilst 37% and 17% had excessive and insufficient GWGR respectively ( $p < 0.01$ ). Almost half of women, regardless of the pregravid BMI, had insufficient GWGR (41.8%) with largest proportion from women who were categorised as underweight (93%).

The results in **Table 3** below show that the “Mixed dietary pattern” had a weak positive correlation with GWGR of ( $r=0.261$ ) but significant at 5%. On the other hand, the “Vegetarian dietary pattern” had a very weak non-significant negative correlation with GWGR ( $r = -0.003$ ,  $p=0.961$ ), which means that the women on this diet were losing weight.

**Table 3** Correlation between GWGR and Dietary patterns

Dietary Pattern	GWGR	
	R	P value
Mixed Pattern	0.261	<0.01*
Vegetarian Pattern	-0.003	0.961

\*Correlation is significant at 5%

**Table 4** show results from a Multinomial logistic regression done between each independent variable and GWGR categories to determine which socio-demographic characteristics are associated with GWG/GWGR in 3<sup>rd</sup> trimester.

Table 4 Association of third trimester GWG/GWGR and Socio-demographic characteristics

Determinants	Gestational Weight Gain				
	Insufficient (REF) <sup>a</sup>	Adequate (OR) <sup>b</sup>	P-value	Excessive (OR) <sup>b</sup>	P-value
<b>Occupation</b>					
No economic activity	1.000	1.000		1.000	
Formally employed	1.000	1.750 (0.530, 5.774)	0.36	1.000 (0.184, 5.421)	1.00
Self-employed	1.000	1.360 (0.769, 2.405)	0.29	1.765 (0.908, 3.429)	0.94
Parity Status	1.000	1.166 (0.906, 1.501)	0.234	1.454 (1.077, 1.963)	0.015*
Age	1.000	1.037 (0.991, 1.085)	0.118	1.068 (1.012, 1.127)	0.016*
Frequency of physical activity	1.000	1.272 (0.750, 2.157)	0.371	0.936 (0.491, 1.785)	0.841

\*Statistically significant at 5%. <sup>a</sup>The reference category is Insufficient. <sup>b</sup>Odds Ratio (OR)

The results of this study indicate that in terms of age, it showed that for every increase in years of age, the subjects were 7% more likely [OR: 1.068 (95% CI: 1.012, 1.127)] to have excessive weight gain than insufficient weight gain. On the other hand, in this study the odds of having excessive gestational weight gain in 3<sup>rd</sup> trimester was 1.454 times higher than the odds of having insufficient weight gain with every increase in number of children for a pregnant woman had ( $p=0.02$ )

## Discussion

This study examined the dietary patterns of 3<sup>rd</sup> trimester pregnant women attending ANC at Bwaila Hospital. The findings uncovered two dietary patterns which were labelled “Mixed Dietary Pattern” and “Vegetarian Dietary Pattern”. The former was characterised by high intake of meat and meat products,

processed cereals, both saturated and unsaturated fats, nuts, high glycaemic index foods and low intake of fruits. On the other hand, the latter pattern was characterised by foods like legumes, non-processed cereal products, a lot of fruits and vegetables, and tubers like cassava and sweet potatoes. Dietary patterns are precise to diverse populations, although they may differ with socioeconomic status, age, culture, ethnicity, and the accessibility of diverse foods (Fernández-Gómez *et al.*, 2020). Vasantha *et al.*, (2015) and Aboul-Einen *et al.*, (2017) stipulated that lifestyle changes and food accessibility, has brought about shifts in dietary intakes amongst people in many countries, whereby the consumption of more westernized types of diets that are rich in processed foods is becoming prominent. Most analyses defining dietary patterns show that fruits, whole grains, legumes, fish and vegetables, align to health-advancing dietary patterns, while polished grains, pastries, cakes and processed meats are typical of lesser healthy diets (Newby & Tucker, 2004). Dietary patterns rich in energy-dense, fast or junk foods which usually contain a huge quantity of saturated and trans-fatty acids and are ultra-processed, in many studies including this study, have been linked to excessive GWG (Tielemans *et al.*, 2016; Samano *et al.*, 2022; Maugeri *et al.*, 2019). Empirical evidence of the direct consequence of the consumption energy dense dietary patterns rich in trans-fats, processed cereals, both saturated and unsaturated fats on excessive GWG calls for public health interventions to minimise its adherence and promote consumption of different patterns related to healthier outcomes amongst pregnant women (Itani *et al.*, 2020). To that end this study revealed a negative correlation between GWG and vegetarian dietary pattern. Vegetarian diets are not bad per se, but whether a pregnant woman becomes a vegan by choice or due to circumstances, deliberate efforts should be set in place at ANCs to advise pregnant women on how to plan balanced meals in order to gain adequate weight even using a vegetarian diet. Insufficient and excessive GWG which have been found in this study are linked to obesity developing in the infant both in early childhood and later on in life (Yoshizawa, 2012; Fall & Kumaran, 2019; Edwards, 2014; Almond *et al.*, 2011). GWG is an important intervention window that can be utilised to curb future obesity rates by ensuring that pregnant women are gaining weight within the IOM GWG guidelines depending on their pregravid BMI.

### **Recommendations**

GWG across all trimesters is a modifiable factor to consider when developing both maternal and neonatal health policy and programs. Therefore, health practitioners should time and again advise the women patronizing ANC services how much weight they are supposed to gain in line with the 2009 IOM GWG recommendations. Deliberate efforts have to be put in place by all relevant stakeholders to engage in nutrition interventions using locally sourced foods to help eradicate risk for insufficient and excessive GWG, thereby improving pregnancy outcomes and also improving multigenerational risk reduction of overweight and obesity in both mothers and their offspring. This study was conducted in an urban area, but in order to generalize the findings on dietary patterns and GWG in the 3<sup>rd</sup> trimester of women attending ANCs across the country a larger comparative study comprising both urban and rural areas is needed.

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## **Experiences Of Mothers With Critically Ill Preterm Neonates At Mzuzu Central Hospital, Malawi**

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### **Abstract**

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Preterm births account for about 15 million worldwide each year and 60% of these births occur in South Asia and Africa. In Malawi, 18.1% of all babies are born preterm and about 75% of preterm neonates end up being hospitalized in the neonatal care unit (NCU). Mothers of preterm neonates play a critical role in the care of the preterm baby. However, information on the mothers' experiences of having critically ill preterm neonates is limited. Therefore, this study seeks to explore the experiences of mothers with critically ill preterm neonates at Mzuzu Central Hospital. The purpose of the study was to explore the experiences of mothers with critically ill preterm neonates during the time of admission in the neonatal care unit at Mzuzu Central Hospital. A qualitative descriptive study was conducted at Mzuzu Central Hospital. A total of thirteen mothers were purposively recruited for the study and the principle of data saturation guided the sample size. Data was collected through face-to-face in-depth interviews with individual participants after obtaining informed consent. Interviews were audio-recorded and transcribed verbatim. Thematic analysis as outlined by Braun and Clarke (2006) was used to identify key themes. The findings revealed that mothers assist with activities of daily living and maintaining mother-child interaction. Major Sources of support were husbands, family, friends, hospital, and peers. Mothers have also reported facing challenges physical, psychosocially, and financial challenges. With inadequate information from health care workers, the mothers depended on peers for information. Strengthening support services for mothers would improve their experience during their stay in the neonatal care unit. Future areas of research should focus on the experiences of the fathers of preterm neonates.

**Keywords:** Experiences, preterm, neonates, neonatal care unit, mothers

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### **Abstract**

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#### **Introduction**

Preterm birth is the single major cause of infant mortality and morbidity in both developed and developing countries (World Health Organization, 2018) (Muhe et al., 2018). Approximately, 15 million preterm neonates are born worldwide each year and 60% of these births take place in South Asia and Africa (Chawanpaiboon et al., 2019). Malawi has a high preterm rate estimated at 18.1 % per 100 live births (Blencowe et al., 2012). It is further reported that in Malawi, the neonatal mortality rate is at 27/1000 live births, and complications of preterm birth contribute to 33% of all neonatal deaths (National Statistical Office (NSO) & ICF., 2017). Morbidity among critically ill newborns and preterm infants varies widely from no late effects to severe complications such as visual or hearing impairment, chronic lung disease, growth failure in infancy and specific learning impairments, dyslexia, and reduced academic achievement (Rinehimer, 2017; Leung et al., 2018; Doyle et al., 2014).

About 75% of preterm neonates need to be hospitalized in a neonatal care unit with special equipment and skilled staff required for the care of sick preterm neonates (Obeidat et al., 2009). The hospitalization of a preterm baby is a challenging experience for mothers and their families since the highly modern and technological environment of the neonatal care unit separates the babies from their parents. In addition, mothers are usually away from their homes and require support from all facets to cope with an unexpected event. In Africa, literature has focused on the experiences of mothers with preterm babies after discharge from the hospital setting (van Veenendaal et al., 2022; A. Gondwe et al., 2014; Steyn et al., 2017). In Malawi, there is still inadequate information on the experiences of mothers with critically ill preterm neonates in the hospital setting. Therefore, the study aimed to explore the experiences of mothers with critically ill preterm neonates admitted at Mzuzu Central.

Understanding the experiences of mothers with preterm neonates in this particular setting is critical to recognizing and successfully addressing their needs and assisting policymakers involved in child health in improving the quality of care for preterm neonates to improve their survival and reduce mortality at Mzuzu Central Hospital and other similar settings in Malawi.

### **Materials and methods**

This study was conducted at Mzuzu Central Hospital (MZCH). MZCH is located in the northern region of Malawi. The hospital provides free tertiary childcare services to preterm babies born within the institution and those referred from all district government and Christian Health Association of Malawi hospitals in the region. MZCH registers high numbers of preterm neonates needing specialized neonatal care due to complications of prematurity.

Thirteen mothers with critically ill preterm neonates in the neonatal care unit were purposively recruited in this study. Inclusion criteria included mothers who gave birth before 37 completed weeks of gestation, aged 18 years old and above, stayed at least five days in the unit and consented to participate in the study. Mothers practicing Kangaroo, physically and mentally ill and those whose babies had malformation were excluded from this study. Data was collected through face-to-face in-depth interviews with the mothers in a private room provided within the neonatal care unit at their convenient time. A pretested semi-structured interview guide with probes was used to collect detailed information. Each interview session was audio-recorded and lasted between 30-40 minutes. Data collection continued until there was no new information generated (data saturation) (Brink et al., 2012).

Data were deductively analyzed using manual thematic analysis (Braun & Clarke, 2006). Data collection and analysis occurred concurrently until data saturation. Trustworthiness was ensured through Lincoln and Guba's (1985) principles of credibility, confirmability, dependability and transferability. Credibility and confirmability were achieved by member checking of transcripts and peer checking of themes. Dependability and transferability were achieved by field notes and thick description of study processes.

### **Ethical consideration**

The study was approved by College of Medicine Research and Ethics Committee (COMREC) University of Malawi with certificate NO. REF P.09/20.3119. Permission was obtained from Mzuzu Central Hospital. Confidentiality and anonymity were achieved by using codes and not the names of participants and conducting interviews in a private room. Informed consent was obtained from each participant prior to interviews.

### **Results**

#### **Demographic characteristics of mothers**

Thirteen mothers participated in this study (N=13). Most of them were aged between 19 to 25 years. Eleven mothers were married. 12 out of 13 were referred from other hospitals. Details of other demographic characteristics of mothers are shown in **table 1**. Regarding the babies, the mean gestation age was 30 weeks. Ten of them were delivered between 28 to 32 weeks. Ten of them were born singletons. Apgar score ranged from 3/10 to 7/10. All of the babies had low birth weight (< 2500g) 9 of 13 babies had weight of <1500g. Minimum length of stay was 8 days.

From the qualitative analysis, three broad themes were deductively generated; roles of the mothers, sources of support, and challenges faced by mothers when providing care to critically ill preterm neonates as shown in **table 2**.

Table1 Demographic characteristics of mothers with critically ill preterm neonates

Factor	Variable	Output
Age	≤ 18	1
	19-25	9
	26-35	3
Marital status	Married	11
	Single	1
	Widow	1
Occupation	Housewife	1
	farming	5
	Small scale business	6
	student	1
Gestation age	≤28 weeks	1
	28-32	10
	33-36	2
Referral status	Referred	12
	None referred	1

### Qualitative findings

Table 2 Major themes and subthemes

Number	Theme	Subthemes
1	Roles of mothers	<ul style="list-style-type: none"> <li>• Assist in activities of daily living</li> <li>• mothers -child interaction</li> </ul>
2	Sources of support	<ul style="list-style-type: none"> <li>• family and friends</li> <li>• hospital</li> <li>• peers</li> </ul>
3	Challenges	<ul style="list-style-type: none"> <li>• Physical</li> <li>• Psychological</li> <li>• financial</li> </ul>

### **Roles of the mothers in NCU**

Under the theme of roles of the mothers in the NCU, mothers reported, feeding, skincare, ensuring infection prevention, promoting sleep, and maintaining the mother-baby relationship as common roles they perform during their stay in NCU. Mothers said:

*"I express breast milk and feed him using a syringe as my baby is too small to suckle from the breasts." (P1).*

Another one commented

*"In the morning I take a bath before I come in contact with my baby. I also wash the soiled nappies and beddings to make them clean and prevent infections" (P8).*

*"Apart from feeding my baby, I carry him and play with him until he sleeps..." (P5).*

### **Sources of support for mothers with critically ill preterm neonates.**

All mothers who participated in this study said they one way or the other got some form of support from the hospital, their husbands, mothers and in-laws, friends, and peers. The support was in forms of materials, finances, emotional and clinical care. They further said nurses were passionate about their work. They gave treatment to their babies and health education to the mothers to ensure that mothers' needs are also met. One prim-para mother stated:

*"Nurses do not sleep. They are always available for our babies despite the workload they have (P10).*

Some mothers said their mothers and in-laws supported them by taking care of other siblings left at home. One mother said,

*"It's now a month in the hospital, throughout this period, my mother in-law is the one who takes care of the elder children at home" (P8).*

### **Challenges experienced by mothers with critically ill preterm neonates**

The challenges that were generated from interviews were further divided into three subthemes include; physical, financial, and emotional challenges. Caring for the ill preterm is

demanding as mothers are to provide services day and night. Frequent waking up to attend to the baby deprived mothers of sleep and leaves them exhausted. Majority of mothers presented with headache and dizziness. One mother said:

*“..., I do not sleep because I have to feed my baby day and night. Most of the times I experience headache and exhaustion” (P11)*

Apart from failing to sleep, majority of mothers reported failure to produce adequate breast milk. This was reported by mothers with multiple neonates. A mother of twins said:

*“The milk I produce is not adequate for two babies but I keep on expressing to meet the required amount” (P6).*

This study has also revealed that mothers experienced psychological challenges such as stigma, separation, negative attitudes from healthcare workers and inadequate information. Separation was created by 2- hour schedule of NCU which altered attainment of maternal roles and deprived the mothers from sleep. Few mothers reported that people laugh at them for delivering a preterm baby and accused them of either being HIV infected or being a weak woman. This caused anxiety and self- blame. One of the mothers said:

*“People from my husband side laugh at me for giving birth to a preterm baby. They call me a weak woman for giving birth to a preterm baby. This is bad as if I asked God to bear a preterm baby” (P2).*

## **Discussion**

Current study aimed at exploring the experiences of mothers with critically ill preterm neonates admitted in the neonatal care unit at Mzuzu Central Hospital.

### **Roles of the mothers in neonatal care**

Our findings illustrate how mothers experience in participating in the care of their preterm neonates in the neonatal care unit. Mothers ensure feeding, infection prevention and promoting

This study has revealed that most of the mothers were feeding their babies with breast milk, unlike formula or donor's milk. This was encouraging as breastmilk is safe, always at a good temperature, rich in antibodies and cheap and promote child growth (Akum, 2018). Mothers indicated that mother-baby interaction started differently. Some mothers experienced delayed initiation of mother-baby interaction due poor condition of the baby at birth which needed admission and caesarean section delivery. Similar findings were also found in a study done at Mother and Baby unit tertiary hospital, Ghana (Lomotey et al., 2020), involving mothers with preterm babies as study participants also experienced a late interaction process with their babies for those who had caesarean section but it was on the same day of delivery. Interaction with the preterm baby is delayed by admission and physiological instability of the mother (Nicolaou & Glazebrook, 2008). However, mother-child interaction improves with time (Fróes et al., 2019). Mothers described gentle touch, talking to, smiling at playing with and holding their babies as ways of interacting with their babies inconsistent with the findings from previous studies (Lomotey et al., 2020; K. W. Gondwe et al., 2020). On the other hand, preterm neonates interact mostly by gazing at the face and environment (Lavelli et al., 2022; Stefana et al., 2020). Mothers are more socially stimulating and familiar which increases engagement when interacting with their preterm neonates (Lavelli et al., 2022).

### **Support of mothers in the neonatal care unit**

The study found that all 13 mothers received support in one way or the other from the hospital, their husbands, other family members or peers. Support was in form of materials, money, emotional support and care for other siblings. Care of critically ill preterm neonates requires support from all facets as demands increase. These findings are in line with previous study which found that mothers received support from family and friends (Abeasi & Emelife, 2020). Adequate support builds confidence in the mothers, lessens the emotional burden and increases the morale of the mother to continue caring for their newborns (Akum, 2018; Arzani et al., 2015).

Current study has reported inadequate spousal support as a challenge experienced by mothers with critically ill preterm neonates. Husbands are much closer to the mothers and are expected to be the main source of support for the mothers, especially during their stay in the neonatal care unit (Barclay et al., 1997). Lack of support from husbands causes mothers to feel blamed and rejected by their husbands which reduces their morale to care for preterm neonates. Previous studies have indicated that mothers did not receive adequate emotional support from their husbands during their stay in the hospital. (Lomotey et al., 2020; Abeasi & Emelife, 2020). Despite the studies conducted in different continents, it is evident that lack of spousal support affects the emotional well-being of the mother and provision of care to the critically ill preterm neonates.

Physical exhaustion was another challenge reported by mothers in this study as a result of inadequate sleep due to 2-hour feeding and frequent expression of breast milk. This is due to the constant care requirement of preterm babies. Preterm babies have underdeveloped suckling reflexes that prevent them from suckling successfully leading the mother to express the breast milk to feed the baby (Mulaudzi, 2018). This finding is consistent with findings from a study done by Labushnaga (2015) who reported that often mothers feel physically drained during the NICU experience. There could be a possibility that those mothers had no one to help them doing other roles such as washing and cooking which make them do almost everything leaving them exhausted. Support from family members lessens the workload as other duties can be done by the guardian hence allowing the mother to rest.

### **Strengths and limitations**

First, it is the first study to explore the experiences of mothers with critically ill preterm neonates in Malawi and also adds to the few studies that have looked at the experiences of preterm mothers in other countries. Second, it has focused on the experiences of the mothers, while their preterm neonates are still on admission not after discharge. It is important to investigate their experiences early while still in the hospital so that the necessary interventions done before being discharged home. This can in the long term improve their experience of having a preterm baby after discharge (Malakouti et al., 2013). However, the study was conducted only at one place which may affect the generalization of findings. Nevertheless, the findings provided by this study are consistent with what was found in other studies reviewed.

### **Conclusion**

Mothers with preterm neonates in NCU experience physical, psychological and financial challenges. Providing support services, health education, and good attitude of health care workers would improve mothers' participation and experience in NCU. Future studies should focus on the experiences of healthcare workers working in the neonatal care unit.

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## **Men's Knowledge, Attitude And Practices Towards Injectable Contraceptive In Mzimba, Malawi**

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### **Abstract**

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#### **Introduction**

Men's knowledge and understanding of family planning contraceptives can have an impact on their access and use in the families. Hence, assessing the reasons people do not use family planning is important to address the unmet needs and increase contraceptive use (Tilahun et al., 2013). According to the 2015-16 Malawi Demographic and Health Survey, knowledge of contraceptive methods is almost universal in Malawi, with 98% of women and nearly 100% of men aged 15-49 knowing at least one method. These include hormonal contraceptives, non-hormonal contraceptives and permanent sterilization. Despite having the universal knowledge of contraceptive methods, 58% of married women use these methods in Malawi (MDHS, 2017), with only 52% of them aged 15-49 using the contraceptives in Mzimba district, which is lower than the national target. So, to increase contraceptive use, the Ministry of Health (MoH), in May 2018, introduced a self-injection method named subcutaneous depot medroxyprogesterone acetate (DMPA-SC), also known as Sayana press, in which women can inject themselves at home after being trained how to do so (PATH, 2018). Data shows that between April and May 2019, 32% of women in Mzimba North were on self-injection and the remaining 68%, for fear of their husbands, had a provider injection (DHIS2). This was also observed in a study conducted in 2010 in Mangochi district, where most women like injectable contraceptives because it is secretive and easy to hide from the husband (Chipeta et al., 2010). Hence, lack of information and understanding could result in negative attitude towards contraceptives (Population Malawi.org). This is backed by a study done in 2005 by Marston, which found that men with good knowledge are more likely to practice family planning or encourage their partners to do the same. Based on the above, the current study aimed at exploring men's knowledge, attitude and practices on DMPA-SC, which was recently introduced in Mzimba North.

#### **Materials and methods**

##### **Study site and population**

The Study was conducted within the catchment area of Mzimba North District Health Office between January and March, 2022. Mzimba is in the Northern part of Malawi, with a population of 56,595. The study was conducted in the community at health posts under Luzi, Kafukule and Mzuzu Health Centres catchment areas, which were randomly selected out of the 6 facilities that had high numbers of DMPA –SC usage. The study included men aged between 18-49, whose partners use DMPA-SC and signed the consent form. Convenience sampling was used to recruit 47 participants in which those younger than 18 years old and those whose partners were not using the DMPA-SC were not included in the study.

##### **Study design and data collection**

In this study, qualitative method was used, where 6 focus group discussion (FGDs) sessions with 47 married men were done and on average, each session had 7 participants. The discussions lasted between 45 and 60 minutes, where data was collected using an interview guide, which was first developed in English and then translated to local languages (Chichewa and Chitumbuka). Pre-testing of the tool was done on two groups at Mzuzu Health Centre. After the pre-test, necessary modifications and corrections were made to ensure validity. The interview guide contained four

sections: demographic details, men's knowledge on general contraceptives, attitudes and practices toward the use of DMPA-SC. Three research assistants were involved in the data collection; one was facilitating the discussion, the other one was taking notes and the third one was audio recording the conversation. Data was collected until saturation was reached and thereafter, it was transcribed and analysed using Braun and Clarke thematic analysis technique.

## **Results**

Out of the 47 men who were recruited in the study, 27% were 18-30 years old, 43% were between 31-40 years and 30% were between 41-49 years. They encompassed qualified professional workers (teachers, police officers) and skilled and unskilled workers (drivers, businessmen and farmers). Major themes that emerged from the discussions were related to knowledge on contraceptive and self-injection method; attitude toward the use of self- injection method; and the practices and/or roles on use of self-injection method.

### **Men's knowledge about contraceptives**

Most men were knowledgeable about the contraceptive methods, as they named some like vasectomy, norplant, loop, pills, injection, BTL, condom, Jadelle, depo, sayana press, implants, natural methods like withdraw, and following menstrual cycle using cycle beads. Men communicated that they knew or heard about these contraceptives through the radio, reading books, television, and health education at clinics, sensitisation campaigns and some learned from school. One of the participants said, *"I got to know the self-injection method when my wife went to hospital, so she explained to me when she came back"*. Another participant also commented that, *"I heard about the method from the radio"*. In addition, another participant stated that he got the information from a health facility.

### **Attitude towards use of self-injectable contraceptive (DMPA-SC)**

Men showed positive attitude towards the use of self-injection method, citing that it is important for women to take contraceptives to prevent unintended pregnancy. It was also observed that men liked this method as they mentioned its benefits, compared to other family planning methods. The benefits included privacy to the family, as one of the participants stated: *"nobody knows that you're taking family planning methods in your house, as the woman just injects herself in the house...so it's just us who know"*. Other participants said self-injection is good, because it reduces visits to the clinic, which in turn improves financial income in homes, as women have time to earn some money, as one participant said: *"this method helps us to save money for transport as women travel once a year to get the method"*. Another participant also commented to say, *"women have time to do other things that can bring money at home"*.

It was also found that self- injection encourages male involvement in family planning and strengthens trust between couples as this participant expressed: *"when the woman takes sayana, we both participate by following the injection dates and it also promotes trust in the family"*. Ather participant also commented on the size of the family: *"it helps the family to have a smaller number of children"*. Men also said that there is sexual freedom between couples, because they are assured that the woman cannot intentionally get pregnant: *"I can sleep with my wife as many times as I want, because I know she can't get pregnant"*. Men also said that self-injection could promote active participation in family planning, because they will be reminding the wife to inject herself so that no dose is missed.

On the contrary, some participants indicated that this method has challenges, especially when a woman forgets the dates and also that some women might fear to inject themselves: *"it is difficult when the lady forgets the injection dates, she can get pregnant"*. Another participant also commented that, *"some women fear that they will make a mistake during the injection"*.

Misconception towards this method was also captured, as some participants claimed that when a woman uses DMPA-SC, she will not conceive again and eventually develop cancer: *“some women have increased vaginal fluid, reduced libido, and some have continuous menses and don't taste sweet”*.

### **Decision on the contraceptive method to use in the family**

The decision to use the self-injection method in the family was also assessed. Some men reported that the woman is responsible for choosing the family planning method. One participant said, *“women have greater power to decide, so we just support the decision”*. In support, another participant said, *“the woman is told all the methods and decides which one to take, but I just encourage her to get the FP method”*. Contrary to this, another participant said the man of the house is the one to make the decision, *“the woman needs to ask the husband before she gets the method”*. Another participant further commented that, *“men need to take the lead in the decision because when the woman gets pregnant, it is the man who has the bigger role to take care of the family”*.

Some men stated that both man and wife are to make the decision together as family. As one of the participants also commented that, *“the man and wife need to sit down and discuss, then choose the method”*, whilst another participant further commented that, *“we always discuss on which method my wife should take at that particular time”*.

### **Men's reaction if women get a contraceptive (DMPA-SC) without their permission**

When participants were asked how they would react if women got the self-injection method without their permission, there were mixed reactions. Some would accept that the woman has made a wise decision towards her health and also to prevent unintended pregnancy: *“I will just accept that my wife has started FP and looking at the age of the last child, it means she is preventing me from going out to sleep with other women”*. *“I would think that this woman thinks of her future as she's protecting herself from unplanned pregnancy”*.

Some indicated that they would have a discussion with the wife to find out why she got the method without their permission: *“I could ask her to explain what the method is all about, where she got it from, I could go to the health worker and ask him to explain all about the method to me”*.

On the other hand, some men had negative reactions, which included ending the marriage, beating the woman, not trusting her again: *“I would slap her and the marriage would end straight away!... this just shows that she is cheating on me, how could she have the courage to get the method without my knowledge?”* *“I would call and discuss with her... for her to explain, it may happen that we are not having sex in the house but she goes and get the FP method”*. *“This would not make me happy because a woman cannot get FP method without man's permission”*. *“I would think this woman is a prostitute”*.

### **Practices: roles and responsibilities on the use of DMPA-SC**

When men were asked to mention their roles and responsibilities in the self-injection method, they indicated that they were responsible for reminding the women on injection dates, encouraging and ensuring that the women inject themselves: *“I remind her on the date of next injection so that she doesn't miss the dose”*, one participant said. Some men also felt some women are afraid to inject themselves, so as partners they are supposed to encourage and support them. One of the participants said, *“it happens that some women are afraid to inject themselves, so we encourage them to do it”*. They also said as husbands, they monitor if the wife has any problem with the self-injection method. One commented that *“I also ask her if she is experiencing any side effect of the method”*. Participants also indicated that there are activities that could enhance active involvement in encouraging women or families to constantly or correctly use self-injection method (DMPA-SC) in their community. The activities include sharing family planning messages through health talks during community gatherings, and peer to peer education. Some men said after acquiring the

information from either friends or health workers, they share with their wives at home. Some also suggested that information about self-injection and its benefits could be shared through man-to-man talk at leisure meetings and similarly, couples that use DMPA-SC can counsel other families on the method.

### **Discussion of findings**

Men's participation in family planning is one of the cornerstones in women's reproductive health. This study aimed to assess men's knowledge, attitude and practices towards the use of self-injection contraceptive method in Mzimba District, Malawi.

#### **Knowledge and decision making about the general contraceptives and self-injection method**

According to Singh et al. (2016), having inadequate knowledge is associated with improper perceptions of the risks and side effects of contraceptive use, incorrect or inconsistent use, and method discontinuation. Thus, contraceptive knowledge can have a big impact in its use, where men can influence positively or negatively by consenting or obstructing, depending on the information they have. When men have adequate information about the contraceptives, it is easy for them to support and use it. This study found that men ever heard about self-injection method from their wives, radio, television and health education from health personnel during health promotion activities. This corresponds with results from the Malawi Demographic Health Survey (MDHS, 2015-2016), which show that 64% of men heard about family planning messages on the radio, the most common source of family planning messages. And 36% heard about the messages via health promotion activities like dramas and health talks. There seem to be insufficient information on the part of men in Mzimba on how the self-injection method works, its side effects and effectiveness, which might mean that men were not actively engaged or informed in the introduction of the DMPA-SC method in the district. Previous studies also found that spousal communication is useful to raise contraceptive practice among couples (Kabagenyi et al., 2016).

Basically, contraceptive knowledge affects choice of the right method to use in the family (Nuwasiiima et al., 2016), and the support from the spouse. So, informing and engaging men in dissemination of self-injection method can improve its usage and gender equality outcomes. For instance, when men were asked about choosing this method in their families, majority stated that both husband and wife agreed to use self-injection in their families, while minority said it was the wife's decision to use this method and the husband was just in support. This indicates that there is no hindrance for women to use this contraceptive method. This concurs with the Malawi Demographic Health Survey of 2015-2016, which says that eight in ten married women using family planning reported that using contraception is usually a joint decision between the wife and her husband.

In addition, men cited that if they were involved in family planning programmes, they would encourage and support the women to use the contraceptives including the self-injection method. A similar study done in Thyolo and Mangochi by Ruderman et al. (2022) showed that men can be supportive and change agents in using the DMPA-SC, and if men are involved and support the self-injection method, women will be encouraged to use it. However, if men are not involved or support this method, women will not be able to use it. Another study done in Malawi and Uganda found that partner support of self-injection can enhance continuation and willingness to use the method (Cover et al., 2017; Burke et al., 2018).

#### **Attitude towards self-injection method**

On attitude, there were both positive and negative attitudes towards the use of self-injection method. Most participants in this study stated that self-injection method is a good and reliable method, compared to other methods. They also revealed to have seen the benefits of using this method which includes; getting the contraceptive in time, saving money for transportation since the woman

only goes once a year to collect another supply of contraceptive, provides privacy to the family, promotes male involvement in the use, and gives time for women to do their household chores or income generating activities. In agreement, a study done in southern Malawi by Ruderman et al. (2022), shows that men reported that self-injection gives women more time for household chores, allows men to be more involved in decision-making, and enables men to know their partners' whereabouts.

Nonetheless, some men claimed that they discovered that women use family planning methods in the family without their permission. The reactions included beating the wife, divorce and confronting the health service provider. This shows that men have power and authority in their families, hence they need to be involved when it comes to reproductive health issues.

### **Practices on self-injection method**

Men also felt that they have roles and responsibilities on the use of injectable contraceptive, such as ensuring that their wives inject themselves in time, to avoid unplanned pregnancy. In another study done by Lome et al. (2018), men whose wives use self-injection method described their roles as; helping to administer the actual injection when their wife got scared, helping their wife remember injection dates (by setting an alarm or marking the calendar), and ensuring that DMPA-SC is stored out of children's reach. Participants also voiced out that there are some activities that could help enhance knowledge of family planning methods including the DMPA-SC self-injection method. The activities include peer education to fellow men and to the community at large, engaging influential community members to effectively grow responsiveness to family planning and reproductive health. However, misconceptions towards the use of contraceptives could be clarified amongst men, which would result in more men having the accurate knowledge that could change their mind set towards the use of self-injection contraceptives. Similarly, a study done in southern Malawi by Ruderman et al. (2022), found that men can support their partners in DMPA-SC self-injection use through actively participating in the injection process, providing emotional support and encouragement, and advocating for other men and communities to accept self-injection and family planning use.

### **Limitations of the study**

A number of limitations should be considered when interpreting the results. The sample size reduced due to convenience sampling on the days of data collection. In addition, to meet the study's objective of making recommendations that can help promote the use of DMPA-SC, we purposely sampled men who were familiar with the method, who could explain their views of self-injection based on experience. However, it is possible that most men in these communities do not like or did not accept this self-injection method. It is also possible that the participants gave favourable views on self-injection and positive roles men can play due to social interest preferences.

### **Conclusion and recommendations**

The study provides the insights on men's knowledge, attitude and practices towards the DMPA-SC self-injection method. The study also identified the need for provision of health education to men, so that they have enough knowledge on all family planning methods. When men have adequate knowledge and positive attitude towards self-injection, they will promote its use. Furthermore, men suggested that there should be routine sensitisation in the communities, targeting men, so that they know about self-injection method (DMPA-SC), that is, at community gatherings, and men should accompany their wives to the clinic so that they get the information about self-injection method together. They also recommended that men should be taught how to inject their wives, as some women do not have the courage to inject themselves. In addition, family planning should be included in the secondary school curriculum, so that youths know about it before they get married. However, strategies to engage men in the dissemination of family planning information should be

reinforced, so that men fully participate in issues of women reproductive health, and to address issues of misconception on contraceptives.

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## **Prevalence of early postpartum depression and associated risk factors among selected women in southern Malawi: a nested observational study**

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### **Abstract**

The birth of a child should be a time of celebration. However, for many women, childbirth represents a time of great vulnerability to becoming mentally unwell, a neglected maternal morbidity. This study aimed to determine the prevalence of early postpartum depression (PPD) and its associated risk factors among women giving birth at health facilities in southern Malawi. We conducted a nested cross-sectional study. Women were screened for early PPD using a locally validated Edinburgh Postpartum Depression Scale (EPDS) as they were discharged from the maternity ward. The prevalence of moderate or severe (EPDS $\geq$ 6) and severe (EPDS $\geq$ 9) PPD was determined, including 95% confidence intervals (CI). Data on maternal age, education and marital status, income source, religion, gravidity, and HIV status, among others, were collected during the second trimester of pregnancy, and obstetric and infant characteristics during childbirth were examined as potential risk factors for early PPD using univariable and multivariable logistic regression analyses. Data contributed by 636 women were analysed. Of these women, 9.6% (95% CI; 7.4 – 12.1%) had moderate to severe early PPD using an EPDS cut-off of  $\geq$ 6, and 3.3% (95% CI; 2.1 – 5.0%) had severe early PPD using an EPDS cut-off of  $\geq$ 9. Multivariable analyses indicated that maternal anaemia at birth (aOR; 2.65, CI; 1.49 - 4.71, p-value; 0.001) was associated with increased risk for moderate and/or severe early PPD, while live birth outcome (aOR; 0.15, 95% CI; 0.04 – 0.54, p-value; 0.004), being single compared to divorced/widowed (aOR; 0.09, 95% CI; 0.02 – 0.55, p-value; 0.009), and lower education level (aOR; 0.36, 95% CI; 0.20 – 0.65, p-value; 0.001) were associated with decreased risk. Being HIV positive (aOR; 2.88, 95% CI; 1.08 – 7.67, p-value; 0.035) was associated with severe PPD only. The prevalence of early PPD was slightly lower in our selected sample compared to previous reports in Malawi and was associated with maternal anaemia at birth, non-live birth, being divorced/widowed and HIV-positive status. Therefore, health workers should screen for depressive symptoms in women who are at increased risk as they are discharged from the maternity ward for early identification and treatment.

**Keywords:** Anaemia, delivery, risk factors, postpartum depression

## Introduction

The birth of a baby can be associated with mixed feelings and psychological adjustments. To some women, it is a life-changing moment, one that is bound by love, hope and excitement [1], and represents a period of vulnerability to physical and mental stressors [2-3]. Globally, the prevalence of postpartum depression (PPD) ranges from 0.5% to 60.8%, and the wide variability in reported PPD prevalence might be due to the use of non-validated screening instruments, lack of consideration of low familiarity with test taking or having low literacy, reporting styles, cross-cultural variables, differences in socio-economic environments (e.g. poverty, levels of social support or its perception, nutrition, stress), differences in perception of mental health and its stigma, and biological vulnerability factors [4]. The prevalence of depression is higher in low and middle-income countries (LMICs) than in high-income countries and it is estimated that depression will be the second-highest cause of disability by 2030 [5].

Depression is described as a psychological state characterised by persistent sadness and a loss of interest in activities that one usually enjoys and is accompanied by an inability to carry out activities of daily living for at least two weeks [1]. Postpartum depression (PPD) is the depression that occurs after childbirth and the current Diagnostic and Statistical Manual for classifying mental disorders (DSM-5) includes peripartum onset specifier [6]. This paper defines depression that occurs within the first week of childbirth as early PPD as previously reported [7]. Of note, some authors have referred to the depression and anxiety symptoms that women experience a few hours after childbirth as maternity blues, a concept characterised by an episodic psychological distress that mimics symptoms of depression and anxiety but is usually self-limiting [8-9]. However, a recent longitudinal study assessing the transition from maternity blues to full-blown perinatal depression reported that although maternity blues were self-limiting in most of the participants, depressive symptoms arose quite often immediately after childbirth [10].

Untreated PPD can affect the health and survival of both the mother and child. Howard and colleagues described that there is no time in the lifespan that the statement “*there is no health without mental health*” rings truer than in the perinatal period [11]. Additionally, literature has shown that maternal depression in the first weeks after childbirth negatively affects the mother-infant relationship, potentially impacting long-term infant development and health [8,10]. Additionally, early PPD has been reported as a risk factor for suicidal ideation [14].

The World Health Organization recommends screening for perinatal depression with referral and management services where needed [1]. This recommendation has recently been backed with a global call to action to prioritise perinatal mental health arguing that unless maternal mental health is taken as seriously as their physical wellbeing, maternal morbidity, mortality and the ability of the women to thrive will not be improved [15]. However, it remains unknown whether universal screening for maternal depression after childbirth improves clinical outcomes and whether it is feasible especially in LMICs where human work force is not adequate [3,13]. In low resource settings, targeted screening is more realistic but it requires the accurate identification of high-risk women. A recent systematic review and meta-analysis of observational studies found a strong association between experiences of violence, unintended pregnancy, caesarian birth, gestation diabetes, and preterm birth with PPD whilst weak association was reported between PPD and postpartum anaemia [17]. However, it is also important to note that the risk factors for PPD vary with women’s age, race, ethnicity and cultural context [18].

Several studies have investigated PPD among women in Malawi. Many of these studies have focused on validating [16-18] and contextualizing screening tools for PPD and understanding perception of women on perinatal depression [21]. More attention has also been paid to assessing the association between maternal HIV sero-status and postpartum depression than other risk factors [20-21]. Stewart et al. investigated associated factors for common mental disorder among mothers

of infants who were due for measles vaccine, that is at 9 months postpartum or over [24]. However, this study did not collect data on other known risk factors of PPD especially data on events during childbirth and physiological biomarkers for anaemia and iron deficiency. Therefore, our study aimed to determine the prevalence of early postpartum depression and its associated risk factors (socio-demographics, obstetric and clinical factors including maternal anaemia and iron deficiency status at childbirth) among women attending rural and urban health facilities in southern Malawi. Identifying women who are vulnerable to PPD after childbirth will help health practitioners provide appropriate targeted interventions before discharge. We believe that hospitalisation following childbirth provides opportunity for screening and treatment of early PPD as it is a time when women are in touch with health services.

## **Materials and methods**

### **Study design and sample size**

We conducted a cross-sectional study nested in two ongoing studies 1) the Randomised controlled trial of Effect of intraVenous iron on Anaemia in Malawian Pregnant women (REVAMP study) [25], and 2) an observational cohort (REVAMP Observe). Based on previous estimates of the prevalence of depression (13.9 % and 11.0%) among postpartum women attending child health services at health facilities in southern Malawi [20,22], we assumed the prevalence of PPD to be 13%. A minimum sample size of 179 was required to obtain a two-sided 95% confidence interval of +/- 5% (i.e. 95% CI; 8 – 18%) using a Wald confidence interval.

### **Participants and study sites**

The participants were a cohort of women who gave birth at urban and rural health centres within Zomba and Blantyre districts, southern Malawi and were part of the REVAMP and REVAMP Observe studies. Details of the inclusion and exclusion criteria for the REVAMP trial have been published elsewhere [25]. Briefly, the REVAMP trial recruited 862 anaemic (haemoglobin level  $\geq 5$  but  $< 10$ g/dl) pregnant women in their second trimester and randomised them to either standard of care treatment of oral ferrous sulphate (200mg twice a day for 90 days or until birth whichever comes first) for the remainder of pregnancy or intravenous ferric carboxymaltose (20mgs/kg or maximum of 1000mg for  $\geq 50$ kgs) once. The REVAMP observe study had similar inclusion and exclusion criteria to the REVAMP trial except that their baseline haemoglobin level was  $\geq 10$ g/dl (half between 10-11g/dl and the other half  $> 11$ g/dl) and women were not given any study intervention. However, participants from REVAMP Observe might have received oral ferrous sulphate with folic acid from government health facilities during their antenatal visits as this is part of routine care. As part of our nested study, women who gave birth between December 2019 and August 2021 were approached for postpartum depression assessment (Figure 1).

### **Study measurements and procedures**

#### *Socio-demographic and obstetric variables*

Data for maternal socio-demographic variables and obstetric history such as age, education status, marital status, religion, source of income, maternal HIV status, history of miscarriage, gravidity and smoking history were derived from the REVAMP and REVAMP Observe databases. The data were collected when these women were enrolled into the REVAMP and REVAMP Observe studies during the second trimester of their pregnancy.

#### *Pregnancy and neonatal outcome data*

Trained research nurses collected data on pregnancy outcomes which included data on whether a woman gave birth spontaneously, assisted or by cesarean, place of childbirth, estimated blood loss with postpartum hemorrhage defined as blood loss of  $\geq 500$ mls estimated visually by midwives, childbirth complications (i.e. cord prolapse, perineal tear, abnormal fetal heart rate, obstructed labour, premature rupture of membrane), whether the woman received blood transfusion after

childbirth and pregnancy outcome categorised as full term ( $\geq 37$  weeks' gestation age), preterm ( $< 37$  weeks' gestation age), still birth (baby born dead after 28 completed weeks of pregnancy) and spontaneous and induced abortion (baby born dead before 28 completed weeks of pregnancy). For the newborn, a trained research midwife collected data through a structured questionnaire on whether the baby suckled immediately after birth, birth weight, sex of the baby and whether the baby was admitted immediately after birth.

### ***Postpartum depression***

Maternal depression status was assessed using a Chichewa translated and validated Edinburgh Postpartum Depression Scale (EPDS) on discharge from the maternity ward, between 24 and 72 hours after childbirth. The EPDS is a 10-item self-report scale and each question is rated on a scale of 0 to 3. Total scores can range from 0 to 30, with a higher score representing more depressive symptoms. The Chichewa EPDS version has shown to be a valid tool for screening and detecting episodes of both major and minor depression among women who are pregnant (AUC=0.77, 95% CI; 0.69-0.84) in Malawi. When compared with the gold standard Structured Clinical Interview for DSM-IV (SCID) for major depression, the Chichewa EPDS version demonstrated a specificity of 74.1% and sensitivity of 76.3% at a cut-off 5/6 [26]. However, a previous multi-site study in similar settings used a higher EPDS score cut-off of  $\geq 9$  [27]. Therefore, we chose to use both cut-off points to make our findings comparable with findings from both local and international studies.

### ***Blood sampling***

Trained research nurses collected finger prick capillary blood and venous blood from the mothers at childbirth. After wiping off the first drop, the second drop of finger prick blood was immediately used for checking haemoglobin concentrations and malaria falciparum rapid test. We used the Hemocue 301+ (Angelholm, Sweden) which has an inbuilt system for internal quality control to measure haemoglobin concentrations and CareStart™ Malaria HRP2/Pldh, Pf/Pan (Access Bio, Somerset, NJ 08873, USA) for rapid diagnoses of malaria (mRDT). Maternal anaemia at childbirth was defined as a haemoglobin (Hb) concentration of  $< 11\text{g/dl}$  [28]. We used the Hemocue 301+ Hb and mRDT results for anaemia and malaria classification respectively as it is the current practice in most of the health facilities in Malawi.

Trained laboratory technologists separated serum from whole blood and stored samples in a  $-80^\circ\text{C}$  freezer before shipping them to the Netherlands for analysis of serum ferritin levels and the inflammatory marker, C-reactive protein (CRP). The analysis was done at Abbott Architect IA analyser at Meander Medical Centre, Amersfoort, The Netherlands, with reagents from and as per instructions of the manufacturer (Architect IA Ferritin Reagent). Iron deficiency was defined as ferritin  $< 15\mu\text{g/l}$  or ferritin  $< 30\mu\text{g/l}$  if CRP  $> 5\text{mg/l}$  and iron deficiency anaemia referred to Hb levels  $< 11\text{g/dl}$  (Sysmex haematology analyser) and iron deficiency as above. Presence of inflammation was defined as CRP values  $> 5\text{mg/L}$  [28].

### ***Statistical analysis***

Maternal socio-demographic variables (age, education level, marital status, religion and source of income), obstetric characteristics at birth (gravidity, miscarriage history, pregnancy outcome, mode of childbirth, birth complication, anaemia, malaria status, HIV status, iron deficiency, iron deficiency anaemia, inflammation), newborn characteristics were summarised and presented as counts and percentages. The prevalence of moderate or severe (EPDS $\geq 6$ ) and severe (EPDS $\geq 9$ ) PPD, based on maternal depression status at discharge from maternity ward (between 24 hours and 72 hours after childbirth depending on maternal condition), and corresponding Clopper-Pearson two-sided 95% confidence intervals (CI) were obtained.

We used univariable logistic regression to assess the association between early PPD, defined as an EPDS score  $\geq 6$  (moderate or severe) and  $\geq 9$  (severe), and all the study variables. We ran a

multivariable analysis to examine risk factors of moderate or severe depression including only variables with a p-value  $\leq 0.20$  in the univariate models. Due to the small number of women with severe depression (EPDS  $\geq 9$ , n=21), we only included variables with a p-values  $< 0.05$  (univariable analyses) in the multivariable logistic regression model to examine risk factors of severe depression. Not all measurements were complete for some demographic and clinical data and in such case statistical analyses were done on the actual available data. We chose the binary version of the variables such as hemoglobin (anaemic and non-anaemic) and not the continuous version (haemoglobin levels) for fitting in the model as it has an easier clinical interpretation. In order to test for multicollinearity, we checked whether the variables of the multivariable model (moderate or severe depression) were strongly correlated with each other (e.g., “pregnancy outcome” and “birth weight”). For severe depression model, the check was performed for variables “anaemia” and “HIV status”. Data analyses were performed using Stata SE 15.1 (STATA Corp, College Station, TX, USA).

### **Ethical consideration**

The present study was a sub-study embedded in two studies. The REVAMP trial was approved by the College of Medicine Research and Ethics Committee (COMREC), Malawi (P.02/18/2357) and the Walter and Eliza Hall Institute of Medical Research Ethics Committee, Australia (WEHI REC 18/02). The REVAMP Observe study was approved by COMREC (P.02/20/2951). Information about the substudy was given to all study participants, as they were enrolled in the main studies, and all participants either signed a consent form or printed a thumb print (observed by an impartial witness) for those who could not write. Participants who were identified as severely depressed were referred to the local Ministry of Health psychiatric services for further assessment and treatment.

### **Results**

#### ***Characteristics of the study participants***

Of the 746 women who gave birth during the study period, a total of 636 (85.3%) participants completed EPDS assessments for this substudy (Figure 1). The demographic variables between those who completed the EPDs questionnaire did not differ statistically from those who did not (data not shown). A total of 456 (71.8%) and 180 (28.2%) were enrolled from REVAMP trial and REVAMP observe study respectively. The respondents’ age ranged between 15 to 41 years with a mean ( $\pm$ SD) age of  $22.8 \pm 6.4$  years. Detailed socio-demographic characteristics of the study participants during pregnancy has been presented in Table 1.

Table 2 presents maternal and infant characteristics at birth. A total of 611 (96.7%) women had a live birth and 21 (3.3%) women had either a stillbirth or miscarriage. Four women had their record on pregnancy outcome missing. A total of 323 (50.9%) newborns were male and 89 (14.0%) had low birth weight ( $< 2500$ g). Only 28 (4.4%) women had malaria by rapid test and 161 (25.3%) were anaemic at delivery. Assessments for iron deficiency, iron deficiency anaemia and inflammation were performed on the REVAMP trial participants only and results for 440 (69.2%) women were available for analysis. Iron deficiency adjusted for inflammation was found in 124 (28.2%) women whilst iron deficiency anaemia in 54 (12.3%) women. Elevated CRP (a sign of acute inflammation) was noted in 319 (72.5%) women and anaemia and inflammation in 93 (21.2%).

Approximately 9.6% (95% CI; 7.4 – 12.1%) and 3.3% (95% CI; 2.1 – 5.0%) had early PPD at EPDS cut-off  $\geq 6$  and  $\geq 9$  respectively at discharge from the maternity ward (between 24 and 72 hours after childbirth). The total individual EPDS score ranged from 0 to 14 and the median (interquartile range) was 1 (0 - 3). A total of 227 (36.1%) women had a zero EPDS score of which 159/227 (70.0%) had primary school or less education.

### ***Risk factors for early PPD***

In univariable analyses, maternal anaemia at birth (OR; 2.24, 95% CI; 1.30 – 3.87, p value = 0.004) increased the odds of early PPD whilst live birth (OR; 0.25, 95% CI; 0.09 - 0.66, p value = 0.006), being single/never married compared to being divorced/widowed (OR; 0.13, 95% CI; 0.02 - 0.66, p-value = 0.014) and lower education status (OR; 0.46, 95% CI; 0.27 - 0.78, p-value = 0.004) decreased the odds of early PPD using an EPDS cut off of  $\geq 6$  (Table 3). No evidence of an association was found for iron deficiency (OR; 0.85, 95% CI; 0.23 – 3.18, p-value = 0.80), iron deficiency anaemia (OR; 1.44, 95% CI; 0.31 – 6.77, p-value = 0.64), and other variables as potential risk factors (Supplementary Table 1). In multivariate analysis, the observed association remained significant for anaemia (adjusted OR; 2.65, 95% CI; 1.49 – 4.71, p-value = 0.001), being single/never married compared to being divorced/widowed (adjusted OR; 0.09, 95% CI; 0.02 – 0.55, p-value = 0.009), live birth (adjusted OR; 0.15, 95% CI; 0.04 – 0.54, p-value = 0.004) and lower education status (adjusted OR; 0.36, 95% CI; 0.20 – 0.65, p-value = 0.001) (Table 3). Pregnancy outcome was not strongly correlated with low birth weight in our sample, therefore both were maintained in the model.

Using an EPDS cut-off of  $\geq 9$ , univariable analyses showed variables maternal HIV positive status (OR; 3.16, 95% CI; 1.24 - 8.06, p-value = 0.016), and maternal anaemia at delivery (OR; 2.79, CI; 1.16 - 6.71, p-value = 0.022) were significant risk factors whilst live birth (OR; 0.09, 95% CI; 0.03 - 0.26, p-value;  $<0.001$ ) conferred protection for early PPD. All these variables remained significantly associated with early PPD in a multivariable analysis (Table 4). Anaemia was not strongly correlated with HIV sero-positivity of the mother in our sample, therefore both were maintained in the model.

## **Discussion**

### ***The prevalence of early PPD***

The prevalence estimates of early PPD in this study, which likely included maternity blues and depression persisting from pregnancy, was 9.6% (95% CI; 7.4 – 12.1%) and 3.3% (95% CI; 2.1 – 5.0%) using an EPDS cut-off score of  $\geq 6$  and  $\geq 9$  respectively. Previous studies in Malawi reported mixed findings with the prevalence of postpartum depression ranging from 2.6% to 33.0% [6,16,18,20,21,24,26]. The observed mixed findings might be attributed to variations in study design, population studied (enrolling only HIV-positive women), different study points at which PPD was measured and studies using different screening tools and cut-off scores for classifying postpartum depression, among other reasons. These variations make direct comparison almost impossible. However, a recent multi-country cross-sectional study determining physical and psychological comorbidities in Malawi, India, Pakistan and Kenya reported higher early PPD prevalence (defined using an EPDS cut-off of  $\geq 10$  within 1 – 7 days after childbirth) in Malawi than what we found. Authors in this study reported the prevalence of early PPD as 15.0% [7]. The most likely reason for the observed difference could be the strict inclusion and exclusion criteria of the two studies from where our study participants were drawn, thereby limiting generalizability of our findings.

### ***Risk factors for early PPD***

Postpartum depression is a complex phenomenon that includes interaction between biochemical, genetic, economic, psychosocial and situational life stress factors [27-28]. The risk factors for postpartum depression have predominantly included psychosocial factors with weak evidence for other physiological factors such as anaemia and mode of birth [17]. Our study assessed associated risk factors for early PPD.

Regarding maternal socio-demographic variables, our study findings indicated a significant association between education level, marital status and early PPD. Women who only attended

primary school or less were less likely to experience symptoms of early PPD than those who went beyond primary education. Our findings are in conflict with several studies that have reported maternal lower education status as a risk factor for PPD [31-32]. It is important to note that 227 (36.1%) participants in our study had a total individual EPDS score of zero, of which 159/227 (70.0%) were women with lower education. The findings suggested that women with lower education in our study had a tendency of rating items on the scale as zero possibly because they did not understand or were not familiar with the rating scale. This was despite that trained nurse administered the EPDS questionnaire. Additionally, it has been speculated that women with lower education status and mostly poor do not regard psychological problems as health problems and mostly because of fear of being stigmatized they do not disclose their mental illness to others [15]. However, we do not think that our study participants had these fears as the interviews were done in private rooms and the interviewers had already met and interacted with the participants at several study points as part of the main studies.

Our findings on marital status are consistent with several studies that have reported being divorced/widowed as a risk factor maternal PPD [30,32]. However, it is important to note that some factors that are connected to marital status and known risk factors for PPD such as family violence, poverty or wealth, dowry or bride price were not assessed in our study thereby limiting comparison with previous research. Our study did not find significant associations between other socio-demographic factors such as age, source of income and religious beliefs.

Our study found HIV-positive status as a significant risk factor for the severe form of early PPD. This finding was expected considering that women living with HIV are reported to have high prevalence of physical and sexual abuse, caregiving stress and elevated internalized stigma [35]. Previous studies in Malawi have reported mixed findings on whether maternal HIV-positive status is a risk factor for PPD. For example, Stewart et al. [24], Zafar et al. [27], and Harrington et al. [23] reported a significant association between maternal HIV-positive status and PPD while Dow et al. [22] reported no association between maternal HIV status and PPD. Possible explanations for these mixed findings may be the use of different screening tools and, although Zafar et al. and Dow et al. used EPDS, they used different cut-off points for depression classification. However, future research should further explore on the reasons for these inconsistent findings, as our study also found no association with PPD using an EPDS score cut-off of  $\geq 6$ .

Inconsistent findings have been reported on some obstetric variables such as gravidity/parity, history of miscarriage, pregnancy outcome, mode of childbirth, birth complications and postpartum haemorrhage (PPH) as risk factors for PPD [36]. Several studies have reported that primiparous women are at increased risk for PPD [35-38] whilst other authors have reported no significant association between being primigravid and the increased risk for PPD [39]. Our study finding is consistent with those studies that reported primigravid as a non-significant risk factor for PPD. Although authors who found a significant association between the two argued that first time mothers have increased fear during pregnancy and at childbirth predisposing them to the development of depressive symptoms [40], we believe that with adequate support from family members or others [33], these fears might be relieved. This study did not find history of miscarriage, mode of birth, childbirth complication, and PPH as significant risk factors for early PPD as reported in previous studies. Poor pregnancy outcome (still birth and experiencing miscarriage in the current pregnancy) was a risk factor for both moderate and severe PPD in our study. This finding is consistent with several other studies [32,40-41]. However, considering the time at which EPDS was administered, it could be argued that the symptoms observed were a result of a normal grieving process and not necessarily depressive symptoms.

None of the newborn characteristics that were measured in this study were found to be significant risk factors for early PPD. We found no evidence of associations between sex of the newborn, low birth weight, immediate admission of the newborn and early PPD. In some cultures where sex of the newborn is a preference, female sex has been reported as a risk factor for early PPD [43]. Some authors have also reported very low birthweight or preterm birth as risk factor for PPD [43]. Our study did not further classify the low birthweight which might obscure the possible association. However, it is important to note that previous studies have also reported no association between newborn sex [44], birth weight [33] and PPD, which is consistent with our findings.

Maternal anaemia at childbirth increased the risk for both moderate and severe early PPD. Although our findings are consistent with several individual studies and results from meta-analysis and systematic reviews [44-45], several observation studies found no association between the two. For example, Armony-Sivan et al. found no relationship between either maternal Hb levels or iron status and PPD [47]. The authors in this study reported no significant difference in EPDS scores between anaemic and non-anaemic mothers regardless of timing of maternal Hb and iron assessments. In addition, the authors reported that women with or without PPD had similar iron status [47]. Another study also reported no significant difference in hemoglobin or iron status in women who had PPD compared to those without (OR: 0.69, 95% CI: 0.15-2.49) [48]. However, this study had high loss to follow-up as only 103/248 were assessed at 6 weeks and none of the women were anaemic at the time of EPDS assessment thereby limiting the variability in the exposure. A recent umbrella review of the current evidence from systematic reviews and meta-analyses of observational studies on risk factors of postpartum depression has reported a weak association between maternal anaemia and postpartum depression [17].

Neither iron deficiency nor iron deficiency anaemia were found to be associated with early PPD in this study. Our findings are consistent with a previous longitudinal study conducted in China [47], but in conflict with several other studies [49]. Iron is a crucial cofactor in the synthesis of serotonin, dopamine and norepinephrine in the brain, neurotransmitters implicated in clinical depression [51]. Furthermore, iron is an essential element in the production of hemoglobin, and iron supplementation increases haemoglobin [52]. Low haemoglobin levels in the body cause fatigue that might lead to depression [54]. In this study, we classified iron deficiency based on serum ferritin levels adjusting for inflammatory markers (CRP). Elevated CRPs is an indication of acute inflammatory process and not a chronic inflammatory process which might be associated with pregnancy [25,54], limiting its accuracy during this period.

### ***Strengths and limitations***

Our study has several limitations. First, maternal depression status was not measured using a gold standard diagnostic approach and the measurement time may have led to maternity blues being misinterpreted as PPD. We also acknowledge the emotional disruption (focus shift to wellbeing of the baby and not on women themselves) that occurs in the early postpartum days. However, we used a locally validated EPDS tool that demonstrated good internal and construct validity against a structured clinical interview for DSM-IV [26] and the recent DSM-V includes peripartum onset as a qualifier for postpartum depression [6], which is within our assessment time. Second, our participants are not a true representation of the population of pregnant women in Malawi as they were drawn from other studies that had strict inclusion and exclusion criteria. Third, we did not collect data on other important risk factors for PPD such as hormonal levels, social support, household wealth and gender-based violence [56] thereby limiting generalisability of the study findings.

Nevertheless, this is the first study to our knowledge in Malawi that has examined anaemia, iron deficiency, iron deficiency anaemia and inflammation at childbirth as potential risk factors for early

PPD. Additionally, our findings have several clinical implications. First, depressive symptoms (moderate or severe PPD) is prevalent in women immediately after childbirth and identifying women with depression at an earlier stage might reduce the severity and chronicity of the condition. This is important considering that early maternal PPD has been associated with increased risk for maternal suicidal ideation [11,56], and poor child growth and development [30]. Second, our study has identified potential risk factors for early PPD which clinicians can pay more attention to if routine screening for PPD is not feasible, a common case in LMICs. Previous studies have shown that routine screening for PPD is not feasible in Malawi due to human resource constraints. Therefore, our study findings can help health practitioners to target at-risk populations and provide appropriate therapy or referral.

### **Conclusion**

Our findings indicate a slightly lower prevalence of early PPD among women who gave birth at health facilities in southern Malawi than previously reported and was associated with anaemia at childbirth, non-live birth, being divorced/widowed and HIV positive status. Given that most of the women in Malawi give birth at health facilities, health practitioners should screen for depressive symptoms in women who are at increased risk (if routine screening is not feasible) as they are discharged from the maternity ward for early identification and treatment.

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## Prevalence of multidrug-resistant foodborne bacterial isolates from chickens, goats, cattle and pigs in Bvumbwe, Malawi

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### Abstract

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Antibiotic resistance is a serious problem worldwide affecting human and animal health. There is a potential that antibiotic resistant bacterial strains are passed on from animals to humans leading to more serious bacterial infections and burden. The aim of this study was to determine antibiotic resistant bacterial profile in chickens, cattle, goats and pigs. Prospective cross-sectional laboratory-based study was conducted on droppings, mouth, nose and hooves samples obtained from chickens, cattle, goats and pigs from Bvumbwe, Malawi. Gram stain and biochemical reactions were used to identify bacterial pathogens. Susceptibility of bacterial isolates to commonly used antibiotics in Malawi was done using disk diffusion method under both aerobic and anaerobic conditions. In total, 110 animal samples were examined and all (100%) were found positive with at least one type of bacteria. *Citrobacter*, *S. aureus*, *Bacillus*, *E. coli*, *Clostridium*, *Klebsiella*, *Streptococcus*, other coliforms and *Staphylococcus* spp. were isolated. *Bacillus* spp. recorded the highest prevalence (77.3%), followed by *Citrobacter* spp. (41.6%) and *S. aureus* (39.1%). *S. aureus* and *Citrobacter* spp. demonstrated multidrug resistance to at least four antibiotics including Gentamycin, Tetracycline, Ampicillin, Ciprofloxacin, Chloramphenicol and Erythromycin. Highest resistance of 41.7 % was observed in *S. aureus* followed by *Citrobacter* species of 33.3%. Among the antibiotics tested, highest resistance was portrayed by Ampicillin (77.8%) and Tetracycline (66.7%). This study highlighted that healthy farm animals such as chickens, cattle, goats and pigs harbour multidrug-resistant bacteria with high levels of Ampicillin and Tetracycline resistance. This will likely limit options for antibiotic therapy in animals and humans. Efforts are therefore needed to control the use, distribution, storage and sale of antibiotics in veterinaries.

**Keywords:** Antibiotic resistant bacterial profile, Human and animal health, Susceptibility testing, bacterial infections

### Introduction

Antibiotic resistance is a serious problem worldwide affecting human and animal health. Some bacteria are resistant to more than one antibiotic class and this multidrug-resistance is one of the top 10 threats to global health (World Health Organization, 2019). Development of multidrug-resistant bacteria could be due to improper use of antibiotics in both humans and animals (Pokharel, Shrestha and Adhikari, 2020). Antibiotic resistance has been reported in Malawi and across Sub-Saharan Africa (Haigh, Dube, Kasambara, Feasey and Lester, 2020; Essack, Desta, Abotsi and Agoba, 2017). In this region, there is a potential that antibiotic-resistant bacterial strains are passed on from animals to humans and vice versa through food chain and direct contact. This spread of antibiotic-resistant strains could lead to narrowed therapeutic options, more serious bacterial infections and burden and exerting pressure to already struggling health systems in these developing countries. It is estimated that by 2050, antibiotic-resistant infections

are likely to cause the death of 10 million people per annum if the current trends of antimicrobial resistance persist (O'Neill, 2016; O'Neill, 2014).

Currently, there is a growing demand for high quality animal protein in Low- and Middle-Income Countries (LMICs) such as Malawi due to high levels of malnutrition and communicable diseases. This demand has been associated with an increase in livestock farming. In most cases, livestock is free-roaming and gets into contact with contaminated water, food and infected human beings. To protect or treat such animals, farmers have resorted to the use of antibiotics intended for human use and this has been linked to the development of multidrug-resistant pathogens in animals and humans (Aarestrup, Kruse, Tast, Hammerum and Jensen, 2011; O'Neill, 2015). The rise of antibiotic resistance in zoonotic pathogens poses a serious challenge to humans and animals as it is associated with fatal untreatable infections (Aarestrup, 2015). The accumulation of harmful resistant bacteria in livestock and poultry is primarily attributed to the frequent use of inadequate doses of antibiotics in livestock farming such as chickens, goats, pigs and cattle (Aarestrup, 2015). It is reported that the use of antibiotics in food producing animals outweigh human consumption in many countries (CVM, 2013). In animals, antibiotics are used as growth promoters and are inappropriately used as low-cost substitutes for hygienic measures that are aimed at infection prevention.

This indiscriminate use of antibiotics in food producing animal farming facilitates development of antibiotic resistance in pathogenic and commensal bacteria. These bacteria use different mechanisms in development of resistance such as enzymatic inhibition, penicillin-binding protein (PBP) modifications, porin mutations, efflux pumps, and target changes (Munita and Arius, 2016). Apart from the reported concerns linked to emergence of antibiotic resistance in bacteria isolated from livestock and poultry, there are also human health concerns associated with the presence of antibiotic residues in meat and eggs (Agyare, Boamah, Zumbi and Osei, 2018). This could be one of the contributing factors to high levels of bacterial bloodstream infections (BSIs) and mortality in Sub-Saharan Africa (Economou and Gousia, 2015). These bacterial blood stream infections are usually difficult to treat as the pathogens are exposed to antibiotic residues or compounds prior to prescribed treatment. Enterobacteriaceae are some of the major pathogens that have developed resistance to third generation Cephalosporins leading to widespread reliance on Ceftriaxone for management of sepsis in Africa, including Malawi. In addition to Cephalosporins, others are resistant to Methicillin, Tetracycline, Enrofloxacin, Streptomycin, Neomycin, Gentamicin and Amoxicillin among others (Haulisah, Hassan, Bejo, Jajere and Ahmad, 2021; Kimera, Mshana, Rweyemamu, Mboera and Matee, 2020).

In Malawi, chickens, cattle, goats and pigs are predominately used as a source of income and food although they are key reservoirs of bacteria. Malawi and other governments established regulations through different institutions such as Malawi Bureau of Standards (MBS) to protect consumers from harmful effects of pathogenic bacteria (Malawi Bureau of Standards, 2017; Malawi Government, 2014). Unlike with other countries, the enforcement of these regulations in LMICs including Malawi are challenged by numerous factors such as poor examination, inspection, analysis and testing before human consumption. Currently, there are no published antibiotic resistance profiles and cross contamination studies that have been reported on chickens, cattle, goats and pigs in Malawi.

In this regard, the current study was therefore carried out to assess the presence of bacteria in the aforementioned farm animals and determine resistance patterns of isolated bacteria to commonly used antibiotics in Malawi's hospitals.

## **Materials and methods**

### **Study design**

The study employed laboratory based experimental design. This involved isolation, identification and antibiotic susceptibility testing of bacteria from chickens and animals belonging to bovidea family namely; goats, cattle and pigs against commonly used antibiotics in Malawi.

### **Study site**

The study was conducted in Bvumbwe, an agriculture-based rural settlement located approximately 21 Km from east of Blantyre city and laboratory analyses were performed at Malamulo College of Health Sciences in Thyolo District located in the Southern Region of Malawi. Bvumbwe was chosen based on its rural setting and highly populated with large number of food producing animal farmers. Anecdotal evidence shows that majority of families are either subsistence or commercial animal farmers and are the major producers of meat and milk in the district and surrounding districts.

### **Sampling of study animals**

In March 2021, the samples were obtained from four different farmers who were selected using simple random sampling. Sampling of herds and flock of chickens were based on the willingness of farmers and number of animals being kept. For instance, only farmers with herd and flocks not less than 15 were selected. In total, 110 samples were collected from mouth, nose and hooves of cattle, pigs and goats without any sign and symptom of bacterial infection while droppings and rectal swabs were collected from healthy chickens. Animals from kraals containing both healthy and diseased animals were excluded from this study. . The samples were not collected repeatedly from these farm animals.

### **Sample collection and transportation**

ESwab™ (Medline industries, China) sterile swabs were used to swab the mouth, nose, hooves, rectum and droppings of study animals using sterile disposable gloves. The swabs containing the samples were carefully labelled and placed in a 2 ml nutrient broth agar transport media which were packed in Ziploc bags. Then after, the swabs were packed in a cooler box at a temperature range of 4 to 8°C and transported to Malamulo College of Health Science Microbiology Laboratory for analyses. The samples were immediately prepared and analysed at the laboratory.

### **Bacterial culture, isolation, and identification**

All the laboratory media preparations were done according to standard procedures (Quinn, Markey, Carter , Donnelly , Leonard and Maguire, 2011). The swabs were removed from the transport media and streaked over the petri dishes (plates) containing well prepared nutrient, blood, MacConkey and *Salmonella* or *Shigella* agar. The plates were labelled and incubated aerobically and anaerobically at 37°C for 24 hours. Colony characteristics were noted and the smears were prepared from different colonies on glass slides. The smears were labelled and subjected to Gram's reaction for cell morphology identification using 100x light microscope. Conventional biochemical tests were performed to identify the bacterial isolates further (Collee, Miles and Watt, 1996). Biochemical tests which were done include catalase, coagulase, indole, oxidase, simon citrate, urease and triple sugar iron tests (Scharlau, Germany).

### **Antibiotic susceptibility tests**

Disk diffusion (modified Kirby-Bauer) method was employed to determine antibiotic resistance and was done according to Clinical and Laboratory Standards Institute (Clinical and Laboratory Standards Institute, 2020). The tests were done on Mueller-Hinton agar (Oxoid, Hampshire,

England). About 12 commercially available antibiotic susceptibility disks (Oxoid, England) were used. The disks were Amikacin (30 µg), Amoxicillin (25 µg), Bacitracin (10 µg), Ceftriaxone (30 µg), Penicillin (10 µg), Doxycycline (30µg), Ampicillin (10µg), Tetracycline (30µg), Erythromycin (15µg), Gentamycin (10µg), Chloramphenicol (30µg) and Ciprofloxacin (5µg). Aforementioned antibiotics were selected following consultations with different local hospitals and they are currently used in hospitals in Malawi. The pure isolates and the controls (reference strains) were inoculated on a sterile Muller-Hinton agar and incubated aerobically and anaerobically for 24 hours at 37 °C. The reference strains were obtained from Malamulo Mission Hospital and were characterised by the hospital with known susceptibility profiles to various antibiotics. The zones of inhibition were measured using a ruler in millimetres and interpreted as either susceptible or resistant following Clinical and Laboratory Standards Institute guidelines (Clinical and Laboratory Standards Institute, 2020).

### Statistical analysis

Data was analysed using Statistical Package for Social Science (SPSS, version 20, Chicago: IBM Corp.) and Microsoft Excel (version 16, Microsoft Corporation, New York, USA). Laboratory analyses were performed in triplicates and the means were computed. The data were summarised and presented in tables and figures. The prevalence of bacterial isolates in different samples was computed by dividing positive samples by total number of examined samples and multiplied by one hundred.

### Ethical approval

Permission to conduct the study was sought from National Health Science Research Committee (NHSRC), Department of Biomedical Sciences at Malamulo College of Health Science and Bvumbwe Veterinary Officer. An informed oral consent was obtained from the owners of the study animals during sample collection. All the methods were performed in accordance with International Council for Laboratory Animal Science (ICLAS) guidelines.

## Results

### Prevalence of bacterial isolates

A total of 110 samples were collected from chickens (n=10), cattle (n= 30), goats (n=40) and pigs (n=30). Bacteria were detected in all the 110 (100%) samples (Table 1). Nine types of bacteria isolated from these food producing farm animals as shown in Table 1. Among the samples, the most predominant bacterial isolates were *Bacillus* spp. (77.3%), followed by *Citrobacter* spp. (41.6%) and *Staphylococcus aureus* (39.1%). On the other hand, the least predominant bacterial isolates were *Streptococcus* spp. (1%). Of all the farm animals, chickens harboured six types of bacteria while the rest of the animals harboured at most five types.

### Antibiotic susceptibility

Susceptibility profiles of bacterial isolates to antibiotics commonly used to treat human infections in Malawi are summarised in Table 2. The levels of antibiotic resistance ranged from 0 in *Streptococcus* spp. to 41.7% in *S. aureus*. The highest levels of resistance were observed in *S. aureus* (41.7%) followed by *Citrobacter* spp. (33.3%) while *Bacillus* spp and *E. coli* demonstrated similar moderate levels of antibiotic resistance of 25%. These bacterial isolates were resistant to at least three classes of antibiotics. Among the antibiotics, the isolates were highly resistant to Ampicillin (77.8%) followed by Tetracycline (66.7%). The resistance pattern to Ampicillin and Tetracycline was more common in cattle and pigs.

## Discussion

This study applied microbiological and epidemiological approaches to characterise the epidemiology and antimicrobial susceptibility of different species of bacteria isolated from chickens, cattle, goats and pigs. The prevalence of bacteria reported herein agrees with the theory that postulates that food producing farm animals are constantly infected by different bacteria (Haulisah, Hassan, Bejo, Jajere and Ahmad, 2021). In this study, *Citrobacter*, *Staphylococcus*, *Bacillus*, *Escherichia*, *Clostridium*, *Klebsiella* and *Streptococcus* species, and other coliforms were isolated from chicken, cattle, goat and pig samples. Although aforementioned organisms were isolated, their prevalence and distribution among the samples were inconsistent, both high and low prevalence were recorded in *Bacillus* spp and *Streptococcus* spp respectively. This variation may have resulted from several factors such as (1) collection of samples from different kraals and animals. Different kraals are subjected to different hygienic conditions and those poorly managed kraals are likely to harbour a lot of microorganisms. (2) Genetic variation of animals. The widely accepted idea is that there is genetic variation in different animals, making the host resistant to bacterial attack and survival. (3) Differences in feeds and their preparations. The fact that these samples were collected from various animals and different kraals their feeds are more likely to be different as noted during sample collected. These feeds may be contaminated by different bacteria from different locations in the community and would favour growth of distinctive bacteria. (4) Use of antibiotics. Some populations of bacteria may have been eliminated by antibiotics used by the owner of the farms. And (5) survival mechanisms of bacteria in host bodies; whereas it is possible that some bacteria would fail to survive in bovine animals. For instance, the presence of *Bacillus species* in all the samples is attributed to its ability to produce spores in times of stress conditions and vegetate when the conditions are favourable. As such, the present study suggests that distribution of bacteria in different samples and animals from the same community is heterogeneous. Although the study did not endeavour to systematically identify the actual species of some bacteria using Polymerase Chain Reaction (PCR), it is our recommendation that future studies take that path. Several studies have documented similar isolated bacteria in different farm animals globally, but none has matrixed a combination of chickens, cattle, goats and pigs ( Haulisah, Hassan, Bejo, Jajere and Ahmad, 2021; Arbab, Ullah, Wang, Li, Akbar and Zhang, 2021; Langata , Mainigi , Musonye , Kiiru and Nyamache, 2019). Variation in the types and number of bacteria isolated in different studies is attributed to differences in location, feed and type of samples tested.

Over six types of bacteria were isolated from different farm animals. The occurrence of types of bacteria was high in Chickens where 66.7% of these types of bacteria were isolated. Types of bacteria reported herein are an indication of the risk of exposure of these chickens and other farm animals to bacteria. Infact, the results indicates that the reasons could be multifactorial as it became evident during visual assessment of the kraals and feeds that hygiene was not satisfactory. For instance, there was high animal density and not well cleaned surfaces. Similar factors were reported in which bacteria contamination was associated with animal density and scrapings, manure storage, water and pest control among others (Ghougal, Dib, Lakhdara, Lamri , Baghezza , Azizi, *et al.*, 2021).

An unusual antibiotic resistant bacterial profile in chickens, cattle, goats and pigs were recorded in this study. High multidrug resistant profiles to commonly used antibiotics tested were demonstrated by *S. aureus* and *Citrobacter* spp. in cattle, goats and pigs. For instance, Ampicillin resistance was common in these bacteria followed by Tetracycline, Gentamycin and chloramphenicol. This emergency of multidrug resistance could be due to the improper use of antibiotics in the farms as indicated orally by the farmers that they use antibiotics to treat their animals. Others had mentioned that they do so without consulting veterinary officers. This implies that farmers are not following WHO guidelines on the use of antibiotics in animal

production (World Health Organization, 2017). It could also be due to the fact that the owners employ free range system of animal keeping especially after harvesting of crops and also animals were exposed to other chemicals with compounds similar to antibiotics that could confer cross resistance.

Occurrence of similar resistance profile in pigs for *S. aureus*, *Bacillus* spp, *E. coli* and other coliforms against Ampicillin and Tetracycline re-affirms that the owners of the pigs were improperly administering these antibiotics to the pigs. Similarly, in this area the owner of the cattle had been using Ampicillin and Tetracycline and the observed resistance was not surprising. It is not surprising that Tetracycline resistance was displayed by these organisms as similar results were observed previously in Malawi's neighbouring countries namely, Tanzania and Zambia (World Health Organization, 2017). In these countries, organisms isolated from cattle, poultry and pig samples were resistant to Tetracycline. This similarity could be due to free flow of animals among these countries in trade and pasturing hence easy transfer of resistance genes and organisms. It is now clear that in these three countries Tetracycline has been abused in animal farms.

The resistant strains are not only common in Africa as mentioned earlier but also in other continents where farming has been exploding. In Malaysia, similar patterns of resistance for *S. aureus* but not for *E. coli* have been reported in samples collected from diseased farm Haulisah, Hassan, Bejo, Jajere and Ahmad, 2021). However, the findings from the current study have been novel as the study was done among physically healthy animals. Just like in humans, the data from this study clearly indicate that farm animals may look physically healthy but carrying bacteria with resistance genes. This has a strong impact in both food security and safety as these resistant organisms can be passed on to humans through food consumption or contact with infected environment. As such, this pattern of resistance to commonly used antibiotics in local hospitals is a great threat to Low- and Middle-Income Countries with limited variety of antibiotics. This serves as a wakeup call to all farmers and Ministry of Agriculture to step up measures that should protect consumers such as strong surveillance of antimicrobial resistance in agriculture and proper use of antibiotics. Further, it is strongly recommended that distribution, handling, storage and sale of antibiotics in Malawi and other Sub-Saharan countries should be effectively monitored and controlled. These measures can help in limiting emergence and distribution of resistant strains yet protecting the citizens who are not aware of health risks associated with such bacterial strains.

### **Conclusion**

This study provides the first published data on the profile of antibiotic resistant strains isolated from chickens, cattle, goats and pigs in Malawi. The study has revealed that the most common bacterial isolates are *Citrobacter*, *S. aureus*, *Bacillus*, *E. coli*, *Clostridium*, *Klebsiella*, *Streptococcus*, other coliforms and *Staphylococcus* species. *S. aureus* and *citrobacter* species demonstrated highest multidrug resistance while Ampicillin and Tetracycline resistance was the most distributed resistance among the samples. The data presented herein suggests that mitigation efforts are needed to limit emergency and distribution of resistant bacterial strains in the farm animals as a way of addressing the challenge of antibiotic resistance in Malawi and globally.

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Table 1 Prevalence and distribution of bacteria isolated from chickens, cattle, goats and pigs

Isolated bacteria	Prevalence in different samples [n (%)]									
	Chickens (n=10)	Cattle (n=30)			Goats (n=40)		Pigs (n=30)			Total (%)
		Mouth	Nose	Hooves	Mouth	Nose	Mouth	Nose	Hooves	
<i>Citrobacter spp</i>	3(30)	10(100)	10(100)	5(50)	2(10)	0	6(60)	6(60)	4(40)	46(41.8)
<i>Staphylococcus spp</i>	-	4(40)	1(10)	10(100)	2(10)	-	0	6(60)	0	23(20.9)
<i>S. aureus</i>	3(30)	-	-	-	20(100)	20(100)	-	-	-	43(39.1)
<i>Bacillus spp</i>	3(30)	10(100)	8(80)	8(80)	20(100)	20(100)	2(20)	10(100)	4(40)	85(77.3)
<i>E. coli</i>	2(20)	-	-	-	-	-	0	0	6(60)	8(7.3)
Other coliforms	1(10)	-	-	-	-	-	8(80)	0	4(40)	13(11.8)
<i>Clostridium spp</i>	-	-	-	-	1(5)	16(80)	-	-	-	17(15.5)
<i>Klebsiella spp</i>	-	0	5(50)	0	-	-	-	-	-	5(4.5)
<i>Streptococcus spp</i>	1(10)	2(20)	0	0	-	-	-	-	-	3(2.7)

Table 2 Susceptibility profiles of bacteria isolated from healthy chickens, goats, cattle and pigs

Bacterial isolates	Antibiotic Resistance Profile								n (%)
	Chickens		Goats	Intermediate	Cattle		Pigs		
	Resistance	Intermediate	Resistance		Resistance	Intermediate	Resistance	Intermediate	
<i>Citrobacter spp</i>	-	CIP	PEN	TET	AMP-CHLO-TET	ERY	CHLO-TET	AMP-ERY	4 (33.3)
<i>Staphylococcus spp</i>	-	-	-	-	-	-	-	-	0

<i>S. aureus</i>	-	GEN-TET- AMP	STRE-PEN	-	AMP-GEN	TET-CIP	AMP-TET	GEN	5 (41.7)
<i>Bacillus spp</i>	-	GEN-ERY	ERY-TET	-	AMP-TET	CIP-ERY	AMP-TET	ERY	3 (25)
<i>E. coli</i>	GEN	ERY-TET	-	-	-	-	AMP-TET	-	3 (25)
<b>Other coliforms</b>	-	-	-	-	-	-	AMP-TET	-	2 (16.7)
<i>Clostridium spp</i>	-	-	AMP	TET	-	-	-	-	1 (8.3)
<i>Klebsiella spp</i>	-	-	-	-	AMP-TET	-	-	-	2 (16.7)
<i>Streptococcus spp</i>	-	AMP	-	-	-	AMP- CHLO- GEN-ERY	-	-	0

CIP, Ciprofloxacin; PEN, Penicillin; TET, Tetracycline; AMP, Ampicillin; CHLO, Chloramphenicol; ERY, Erythromycin; GEN, Gentamycin; STRE, Streptomycin; PEN, Penicillin; - , blank; n, number of positive resistance (each drug counted once within a row).

## **Prevalence of the comorbidity of NCD and HIV/AIDS among young adults in Blantyre, Malawi.**

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### **Abstract**

The comorbidity of Non-Communicable Diseases (NCD) and HIV/AIDS has been on an upward trend in LMIC especially Sub-Saharan Africa due to an increase in risk factors for both diseases. The purpose of this paper was to describe the prevalence of the comorbidity of NCDs and HIV/AIDS in young adults in Blantyre, Malawi. The study followed a retrospective study design where quantitative data was collected from 2019 to 2022. This study was conducted in Blantyre which a part of a large study where the sample included four cities and seven districts. Data was collected from all health facilities using mastercards in Blantyre. Monthly data aggregates for patients with a comorbidity of NCD and HIV/AIDS was collected from the sampled health facilities. Time series models was employed to show trends and make predictions/ forecast on the prevalence using the NCD and HIV/AIDS comorbidity monthly aggregate data. An increasing trend in the comorbidity of NCDs and HIV/AIDS was observed in Blantyre using a time series plot with a sharp increase between 2021 and 2022. Forecasts for Blantyre for the next 8 years showed a slight decline in the prevalence's between 2023 and 2025. The forecast for further shows very minimal consistent increases through 2030. The comorbidity showed an increasing trend which was attributed to large numbers of pre 2019 cases. This led to high prevalence's but the forecasts show consistent minimal increases in the prevalence. The results for Blantyre may highlight attainment of SDG3 and WHO targets on reduction of NCD and HIV/AIDS with proper management but a tangible conclusion should be drawn with the inclusion of all the selected cities and districts.

**Keywords:** Non-Communicable Diseases, HIV/AIDS, Prevalence, Trends, Time series.

### **Introduction**

#### ***NCD and HIV/AIDS Comorbidity***

Both NCDs and HIV/AIDS are fatal in their own existence hence their co-existence is even more lethal (Crabtree-Ramirez et al., 2014). The risk of both ailments coexisting in an individual grows with an increase in urbanisation rate and rapid life style changes (Levitt et al, 2011, McCombe et al., 2021). Growth in economic activities provides the major risk factors in the co-existence of NCDs and HIV/AIDS since this leads to unhealthy diets, lack of exercise and increase promiscuous behaviors as well as drug abuse (Rokhmah & Khoiron, 2015). The chances of NCD and HIV/AIDS comorbidity are even higher for people living with HIV (PLHIV) (Crabtree-Ramirez, et al., 2014). The use of anti-retroviral treatment (ART) prolongs the life expectancy of PLHIV which in turn is now threatened by NCDs (Geneau et al, 2012, Haregu et al., 2015). Conversely, NCDs aggravate the severity of HIV/AIDS among those with the comorbidity (Petersen et al., 2014).

The comorbidity of NCD and HIV/AIDS is becoming common in an individual (Haregu et al., 2015). Developing countries have the highest burden of NCD and HIV/AIDS because of large population size, increase in life expectancy and rapid changing life style. (Haregu, et al., 2015). The

extent of the comorbidity of NCD and HIV/AIDS cannot be described or estimated due to lack of data and evidence (Petersen et al., 2014). The co-existence of NCDs with HIV/AIDS implies a new dimension to two ailments that were dreadful individually for which little to no information is available (Crabtree-Ramirez et al., 2014). Thus, quality data and analyses are required and needs to improve to inform a response to NCD and HIV/AIDS comorbidity (Petersen et al., 2014). As such, there is no coordinated management and planning of interventions of the comorbid or multi-morbid cases of NCD and HIV/AIDS (Haregu et al., 2015, Kavishe et al., 2015).

### ***Trends in the Comorbidity of NCDs and HIV/AIDS***

NCDs and HIV/AIDS are a major public health problem especially in developing countries (Haregu et al., 2015). Data on trends of the comorbidity barely exists however, data on individual diseases is available although not comprehensive for non-communicable diseases (Haregu et al 2014). There are an estimated 35 million PLHIV in the world and an estimated 36 million lives lost per year due to NCDs. The majority (69%) of PLHIV and 90% of NCD death were from LMICs which includes SSA (Haregu et al., 2015). The data available shows that the two diseases have high prevalences in LMICs especially Sub-Saharan Africa (SSA) (Kandala et al., 2012, Kavishe et al., 2015).

There is limited data on the interaction and prevalences of the NCD and HIV/AIDS comorbidity (Crabtree-Ramirez et al., 2014, Haregu et al., 2015). Therefore, data quality and analyses needed to inform the response to NCDs and HIV/AIDS comorbidity needs to improve in LMICs (Petersen et al., 2014, Kavishe et al., 2015).

The Sustainable Development Goal (SDG) target 3.3 calls for the end of the HIV/AIDS epidemic, referring to new infections and deaths by 2030 (Dwyer-Lindgren et al., 2019, WHO, 2022). SDG - target 3.4 also calls for a reduction in premature deaths from NCDs by one-third by 2030 (NCD Countdown Collaborators, 2018, WHO, 2022). The framing of the SDGs was not developed without consideration of the comorbidity of NCD and HIV/AIDS hence no target. However, the increase in cases of the comorbidity prompts action to be taken in response.

The purpose of this paper was to describe the prevalence of the comorbidity of NCDs and HIV/AIDS in young adults in Blantyre, by identifying the nature of the comorbidity and making projections of the occurrences of the comorbidity.

### **Materials and methods**

The study followed a retrospective study design where quantitative data was collected from July 2019 to June 2022.

The study was conducted in Blantyre, Malawi. This study was conducted within a larger study, where the cities and districts in Malawi represent the study population. A sample for the study included purposively chosen cities; Blantyre, Lilongwe, and Mzuzu, and districts; Zomba, Mwanza, Mangochi, Salima, Mchinji, Nkhata-bay and Karonga. Health facilities were selected from these cities and districts. The inclusion criteria of health facilities required those that were using NCD mastercards. As such, all health centers from the selected cities and districts were included in the study and specifically for this study all health centers using mastercards in Blantyre. All participants from the selected health centers were included in the study, where a participant refers to an individual registered at a facility as having an NCD or a comorbidity of NCD and HIV/AIDS.

Data was collected from all the participants at a given health center. Monthly data aggregates for patients with a comorbidity of NCD and HIV/AIDS was collected from each health center. The data collected ranged from 2019 to 2022. The data collection exercise for the study was still in progress for the other cities and districts and complete data was only available for Blantyre. As such the analysis pertains to Blantyre only.

The first step was to aggregate the data from all the facilities in Blantyre to obtain the total number of cases for each month. The point prevalence for each month was calculated for each month. Thus, the number of cases for each month divided by the estimated monthly population. The estimated monthly population was obtained using the 2018 census data accounting for the annual intercensal increase for the years 2019 to 2022.

Data analysis involved summary measures and time series analysis that were carried out in R (version 4.2.1) and RStudio (version 2022.07.2). Average, minimum and maximum number of cases were produced for the city of Blantyre on the point prevalences for each year. A time series plot was used to summarise the point prevalences for each year 2019 to 2022. To carry out the Time series modeling the monthly prevalences were accumulated to account for the fact that both non-communicable diseases and HIV/AIDS are lifelong illnesses hence the cases can only increase with time with a few dropouts' due death or lost to follow-up. The time plot for the data showed and increasing prevalence which was not stationary. Therefore, the first difference of the prevalence was conducted to remove the trend. The accumulated prevalence data also lacked seasonality due to the nature of individual diseases and comorbidity as they depend on lifestyle changes and human behaviour. There were no monthly patterns for the recorded 4-year time frame implying that there is no seasonality.

The data was fit to three methods in time series to examine a which method would produce better forecast results. The three methods were the Seasonal Naive method, Error, Trend and Seasonality (ETS) method and the Auto Regressive Integrated Moving Average (ARIMA) method. The ARIMA methods provided a better fit to the data using the AIC. The residuals and autocorrelation (ACF) also showed ARIMA method to be a better fit. Therefore, the ARIMA methods was the better fit for the accumulated data on comorbidity prevalences. Then ARIMA method was be used for NCD and HIV/AIDS comorbidity monthly aggregate data to make predictions/ forecast on prevalence. The Auto ARIMA function which accounted differencing,  $|d| = 1$ , step incrementation of the model set to false, approximation set to false and tracing of models tested set to true was employed. The model was validated by the Ljung-Box test which showed the residuals of the forecasts were deemed independent.

## **Results**

The data was collected from 21 health facilities in Blantyre which were using mastercards to record data on NCDs. Figure 1 shows the mean, minimum and maximum number of NCD and HIV/AIDS comorbidity. The high maximum number were attributed to cases diagnosed earlier than July, 2019 but were now recorded using the new NCD mastercard system. The year which the highest prevalence average was 2022 with approximately 0.024%. This mean prevalence has been increasing year by year as well as the minimum and maximum.

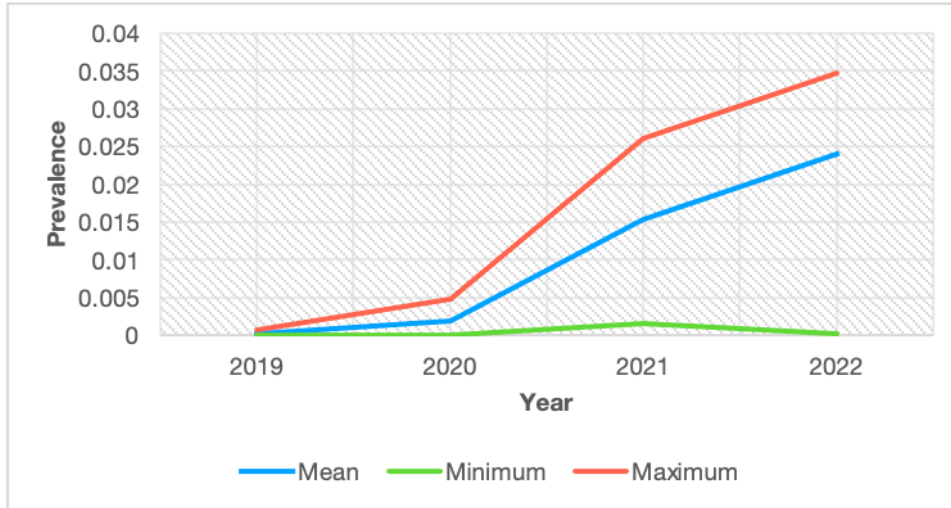


Figure 1 Summary of prevalences per year among young adults in Blantyre, Malawi.

The time plot for each year showed point prevalences close zero with some deviations for the year 2019. Major growth in the prevalences was observed in 2021 and 2022 which could be attributed to more facilities adopting the mastercard system and old cases being recorded in the system as well.

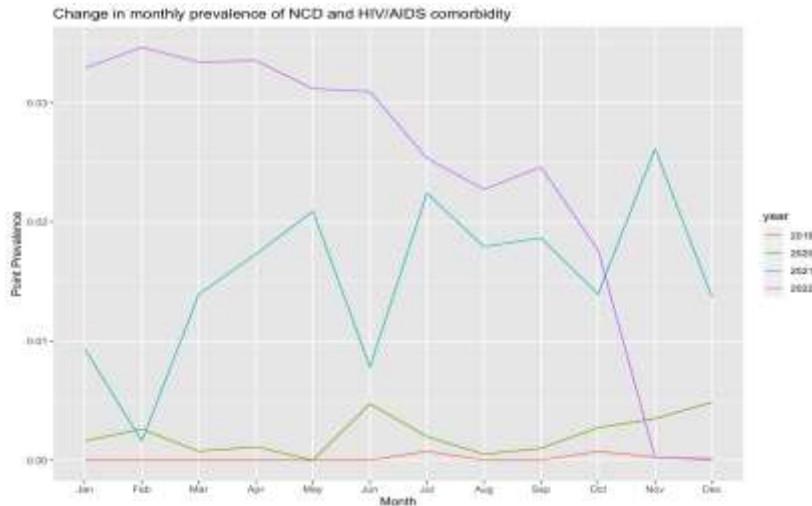


Figure 2 Annual point prevalences of young adults from 2019 – 2022 in Blantyre, Malawi.

The time series plot showed the increase in the point prevalence for each month from the time mastercards were introduced in 2019 to 2022. Accumulated point prevalences provided a realistic view of the comorbidity since both NCDs and HIV/AIDS are lifelong illness. Therefore, the graph showed sharp rise in point prevalences between 2021 and 2022.

The data showed an increasing trend in the point prevalence implying that the data was not stationary. After taking the first difference that data achieved stationarity allowing for further analysis in forecasting. The data does not have significant seasonality which cannot be observed from Figure 3.

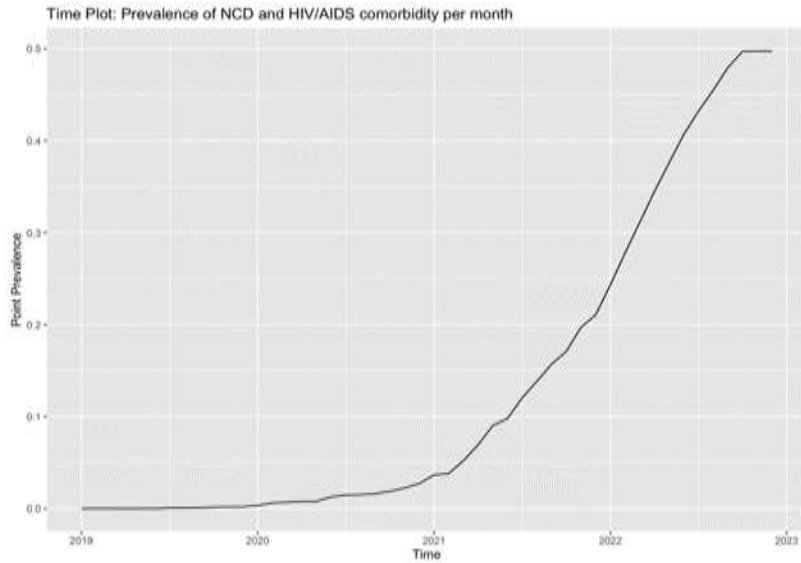


Figure 3 Time series graph for point prevalences among young adults in Blantyre, Malawi.

The data was fit using three methods; Season naïve methods which did not show a significant fit. The lack of fit may be expected as the data did not have a significant seasonality component which this method excels at estimating. The ETS method was also not a significant fit for the data. By comparison to these two methods, the Auto Regressive Integrated Moving Average (ARIMA) method was the best fit with the least residual variance, achieved independence of the residuals and the lowest AIC which would enable forecasting.

Forecasting was based on ARIMA (5, 1, 0) without the seasonal component to predict the point prevalences for the next eight years. The forecasts for Blantyre for the next eight years at 95% C.I., were visualized in Figure 4 where the point prevalences drop from about 0.5% in 2023 to about 0.25% from 2024 to 2025. The prevalences then remain constant at about 0.3% up to 2030.

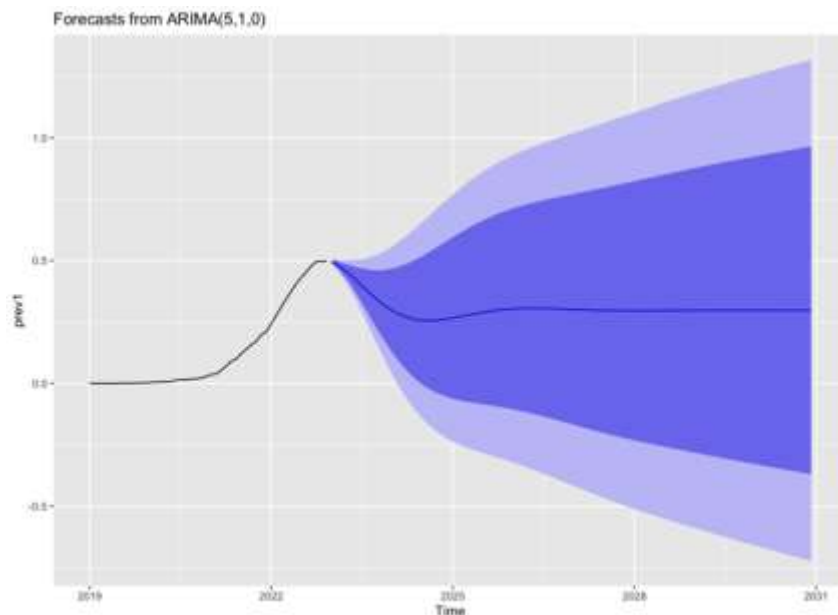


Figure 4 Forecasting NCD and HIV/AIDS comorbidity up to 2031 for Blantyre, Malawi.

### **Discussion**

The NCD and HIV/AIDS comorbidity prevalences data for Blantyre from 2019 to 2022, presented gradual growth in the first two years and a sharp increase in the prevalences from 2021. The increase was as a result of the NCD mastercard system being commenced in more facilities in Blantyre. The magnitude of the comorbidity could not be accounted for since there was no data and the available data was not readily available for use especially LMIC including Malawi (Dalal et al., 2011, Haregu et al., 2014, Petersen et al., 2014). The growth in the prevalence also pertains to the registration of old cases diagnosed before 2019 in addition to new recorded cases. This entails data completeness as the old cases need to be recorded for good quality data for estimation and forecasting (Petersen et al., 2014).

The forecasts for Blantyre for the next eight years show that there would be slight consistent increases in the prevalence through to 2030 which may imply a comorbidity that can be controlled and thereby achieving SDG3 (Dwyer-Lindgren et al., 2019, WHO, 2022). Strategies on interventions and management of the comorbidity should be designed with reference from data since the comorbidity should still be considered a growing burden (Haregu et al., 2015, Kavishe et al., 2015). Thus, even though the status of the comorbidity does not seem alarming there is still need to manage individual ailments since those with either a NCD or HIV/AIDS are still at risk of the comorbidity (Geneau et al., 2012, Kandala et al., 2012).

### **Conclusions**

A gradual increase in the prevalence of the comorbidity of NCD and HIV/AIDS in Blantyre, has been observed from the data. Although there was a sharp increase attributed to the pre 2019 cases that were recorded in the system, the gradual increase was still observed in the forecasts. This calls for action to be taken in order to manage the comorbidity of NCD and HIV/AIDS to meet the SDG3 and WHO targets of reduction in morbidity and mortality by 2030.

The results from this study are preliminary since data collection from other cities and districts is yet to be completed. According to our expectation the additional data should bring insight on current trends and forecasts about each city or district, region and the whole country.

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**Reliability and Validity of Depression Anxiety Stress Scale (DASS)-21 in Screening for Common Mental Disorders among Postpartum Women in Malawi**

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**Abstract**

Approximately one in five women who have recently given birth suffer from common mental disorder (CMD), particularly depression and/or anxiety. Having a screening tool that is free to use, short in assessment time, and used to screen for more than one CMD is appealing in a resource-constrained setting. We conducted a criterion validation study of the Chichewa translated and adapted DASS-21 instrument against gold standard diagnoses of depression and anxiety disorders. Internal reliability was reported using both Cronbach's alpha and ordinal alpha. The DASS-21 and EPDS ability to discriminate cases from non-cases was assessed by receiver operating characteristics (ROC) analysis. We selected cut-off points for DASS-21 and EPDS that maximise both sensitivity and specificity. 115 participants were enrolled. Approximately 11.3% and 14.8% had depression and anxiety diagnoses respectively using SCID. The overall Cronbach's alpha for the DASS-21 scale was 0.74. The DASS-21 subscales had Cronbach's alpha values of 0.66, 0.29 and 0.52 for depression (DASS-D), anxiety (DASS-A) and stress (DASS-S), respectively. The ordinal alpha for DASS-D, DASS-A and DASS-S subscales were 0.83, 0.74 and 0.87, respectively. The area under the ROC curve was 0.76 (95% CI: 0.61; 0.91) for DASS-D and 0.65 for DASS-A. At a cut-off point of  $\geq 1$ , the sensitivity and specificity for DASS-D were 69.2% and 75.5%, whilst DASS-A was 52.9% and 75.5%, respectively. Pearson correlation coefficient for association between DASS-D and EPDS was  $r = 0.61$ ,  $p < 0.001$ . The DASS-21 had good internal reliability (Cronbach's alpha), and its ordinal alpha demonstrated good internal reliability for all its subscales. Only the DASS-D and EPDS demonstrated a satisfactory ability to discriminate cases from non-cases. Our findings suggest that health practitioners can use DASS-D as an alternative tool in screening depression as it has fewer questions than EPDS.

**Keywords:** Anxiety, depression, internal reliability, validation, postpartum

**Introduction**

Maternal mental health problems remain a global public health challenge. Approximately 13% of women who have given birth in high-income countries suffer from common mental disorder

(CMD), primarily depression and/or anxiety [1]. The situation is worse in low and lower-middle-income countries (LMICs), where one in five (19.8%) women who have recently given birth experience a CMD [1]. Untreated CMDs reduce maternal level of functioning [2] and may consequently impair mother-infant interaction [3] and infant cognitive development [4].

Currently, there is a low detection and treatment rate of CMDs in LMICs. There are several reasons for this. First, perinatal mental health for women living in LMICs is only an emerging area of interest for researchers and policymakers. The international agenda has moved beyond survival to understand what is needed to enable women (and infants) to thrive [1]. Second, it has been thought that women living in LMICs are protected from experiencing postpartum mental disorders by social and traditional cultural practices during the postpartum period, which has not been substantiated [1]. Third, the low detection and treatment rate of CMDs in LMICs might be attributed to a lack of culturally sensitive screening tools that are simple to use. Lastly but importantly, in most LMICs, perinatal mental health screening and treatment are yet to be integrated into a routine healthcare package of mother–child dyadic interventions offered when a mother attends well-baby clinics [5].

Several perinatal CMD screening tools such as Edinburgh Postnatal Depression Scale (EPDS) [6], WHO Self-Reporting Questionnaire [7], Patient Health Questionnaire-9 [8], and Post-Traumatic Stress Scale [9] have been validated for screening perinatal mental disorders in Malawi. However, these individual tools are not designed to screen for multiple separate common mental disorders (e.g., depression, anxiety, PTSD). Having a screening tool that is free to use, short in assessment time, and used to screen for more than one CMD is more appealing in a resource-constrained setting. This study aimed to assess the reliability and validity of the Depression, Anxiety, and Stress Scale-21 items (DASS-21) for screening common mental disorders among postpartum women in Malawi. Specifically, we aimed to 1) translate the DASS-21 into Chichewa language and adapt it for use in Malawi, 2) in postnatal Malawian women, establish the reliability of DASS-21 and its subscales and the criterion validity of the adapted DASS-21 against the gold standard of the Diagnostic and Statistical Manual of Mental Disorders, 4th edition (DSM-IV) diagnosis of major or minor depression and generalized anxiety disorder, and 3) compare the test characteristics of the DASS-21 depression scale and EPDS.

## **Materials and methods**

We conducted a criterion validation study, comparing the responses to the Chichewa language translated and adapted DASS-21 instrument (and the EPDS) against a blinded independent administration of the Structured Clinical Interview for DSM-IV (SCID).

## **Participants**

Participants were women who had recently given birth in Zomba district, southern Malawi, who participated in the Randomised controlled trial of the Effect of intravenous iron on Anaemia in Malawian Pregnant women (REVAMP – ACTRN12618001268235) trial.

The REVAMP study randomized 862 anaemic (haemoglobin level between 5 g/dl and 10 g/dl) pregnant women in their second trimester to either standard treatment of oral ferrous sulphate (200

mg twice a day for 90 days or until birth, whichever came first) or intra-venous ferric carboxymaltose (20mgs/kg or maximum of 1000 mg for  $\geq 50$ kgs) once for the whole duration of pregnancy. We included a sub-set of participants who came for follow-up visits with babies aged between 1 and 12 months.

## **Measures**

### **Depression anxiety stress scale (DASS-21)**

The DASS-21 is a widely used screening tool, which can separately measure depression, anxiety, and stress symptoms. The DASS-21 has been derived from the original 42-items DASS developed by Lovibond et al. (1995), which has three sub-scales, namely the depression subscale (DASS-D), Anxiety subscale (DASS-A) and stress subscale (DASS-S) [10]. The DASS-D measures an individual's hopelessness, positive affect and self-esteem. The DASS-A measures autonomic arousal, situational anxiety, musculoskeletal symptoms, the perceived experience of anxiety arousal and situation anxiety. Finally, DASS-S measures agitation, tension and negative affect [11]. Each subscale comprises seven items that are scored from 0 (did not apply to me at all) to 3 (applied to me very much, or most of the time) for the week preceding the interview to reflect severity. The total score for each DASS-21 subscale ranges from 0 to 21. The items' scores are added and multiplied by two to obtain the total score that can be compared with the original DASS-42. The DASS-21 has been translated into more than 54 languages (<http://www2.psy.unsw.edu.au/groups/dass/translations.htm>) but not into Chichewa language, and has demonstrated good internal consistency and validity. However, very few studies have established cut-off points for severity classification, limiting its use in clinical settings [12].

### **Edinburgh postnatal depression scale (EPDS)**

The EPDS is a ten-item self-report scale that has been widely used to detect clinically significant depressive symptoms experienced by women during the postnatal period. Each question is rated on a scale of 0 to 3, and total scores can range from 0 to 30, with a higher score representing more depressive symptoms. If criteria for culturally sensitive translation are met, EPDS has shown to be a reliable screening tool for depression in LMICs [13]. Some authors suggest that EPDS items number 3, 4 and 5 (EPDS-3A) that assess guilt, anxiety and fear can detect anxiety disorders. However, studies have reported mixed findings on the reliability of EPDS-3A in screening anxiety symptoms in other settings [14–17]. In Malawi, the EPDS has been validated for use among pregnant women, and the interviewer-administered Chichewa-translated EPDS has shown to be a valid tool for screening and detecting episodes of both major and minor depression among antenatal women (AUC = 0.767: 95% CI 0.695–0.839) [6]. Diagnostic and statistical manual of mental disorders: fourth edition (DSM-IV)

The DSM-IV remains the gold standard tool for diagnosing mental disorders. The Structured Clinical Interview for DSM-IV (SCID) uses categorical classifications to divide mental disorders based on criteria with defining features. It requires an individual with clinical training and experience to administer the SCID. The specific diagnostic criteria included in the SCID are only meant to guide, but a diagnosis is informed by clinical judgment [16]. This study used SCID

modules for depression (minor and major) and anxiety (current generalised anxiety disorder) previously translated into Chichewa, adapted and used in Malawi [6].

## **Procedures**

### **Content validation**

The DASS-21 was translated from English into Chichewa (Appendix 1) by professional accredited translators at Malawi Liverpool Wellcome Trust Research Centre in Malawi. Chichewa is the widely used language in most parts of Malawi. After that, it was reviewed by a group of health workers and mental health clinicians for appropriateness of language and cultural idioms. This meeting agreed that DASS-Stress subscale item questions measure different constructs from those in the stress module in DSM-IV, and assessment for criterion validation has therefore not been done for this subscale. The DSM-IV was used instead of the current version of DSM-5 as it was actively in use for diagnosing mental health disorders by psychiatrists in this setting when data for this study was collected. A field trial of the reviewed DASS-21 was conducted with 20 women who were pregnant and contributed information on clarity, comprehensibility, and suggestions of culturally sensitive phrases. The tool was then back-translated by an independent professional translator for verification.

### **Construct and criterion validation**

#### **Sample Size**

Assuming that the prevalence of postpartum depression was at 10% [6, 18], a minimum sample of 120 participants (including 12 having clinical symptoms of depression) was adequate to achieve a minimum power of 90% to detect a change in the percentage value of sensitivity of DASS-21 items from 0.50 to 0.90 based on the target significance level of 0.05. This sample size was also adequate to detect a change in the value of specificity from 60 to 80%, which only required a minimum of 50 participants (including five participants with clinical signs of depression). The sample size was calculated based on the prevalence of depression as it is the most common and significant public health with serious clinical impact compared to anxiety [19].

### **Questionnaire administration**

#### **We used a convenience sampling technique to select**

120 participants from the REVAMP trial participants who came for their scheduled visits with babies aged between one and 12 months. A maximum of five consecutive participants were assessed in a day to ensure quality assessments. Data collection was performed between November 2020 and May 2021. Participants were first interviewed by 1) a mental health clinician (TK) who administered the SCID modules for major or minor depression, current and generalised anxiety disorder, and 2) a trained registered nurse (GK) who administered the DASS-21 and EPDS in individual interviews thereafter. This is usual and best practice in settings with low familiarity with test-taking and where many people have low literacy [13]. The mental health clinician had a degree in clinical medicine (mental health) and over four years' experience using SCID at a mental hospital. The registered nurse was trained on the use of DASS-21 and EPDS and was actively supervised by EM. The two assessors worked independently and were blinded to each other's scores.

### **Data management and quality assurance**

The paper-based SCID administered by the mental health clinician was checked for completeness by the EM before entry in Open Data Kit (ODK). The DASS-21 and EPDS were directly collected using a tablet (ODK), and data were checked for completeness before being uploaded to the server. Data were cleaned and checked for consistency before analysis by EM.

## **Statistical analysis**

### **Internal reliability**

The reliability of any given measurement is the extent to which it is a consistent measure of a concept. Internal reliability was measured by both Cronbach's alpha (most widely and frequently used reliability index) which reflects the extent to which different subsets of the test items produce similar measures [18], and ordinal alpha [20]. We have reported both overall alpha and instrument (DASS-21) subscale alphas for the Cronbach's alpha. The alpha coefficient of reliability ranges from 0 (all items are entirely independent of one another) to 1 (all items are highly related). Alpha coefficient between 0.70 and 0.80 was regarded as acceptable and less than 0.5 as not acceptable [21]. Further analysis of the internal consistency reliability was done by calculating item-test, item-rest and average inter-item correlations. All of this influence and describes the overall item score reliability. However, it is now known that Cronbach's alpha underestimates the correlation alpha when data from Likert-type scales are used [20]. The polychoric correlation matrix used in ordinal alpha calculation corrects attenuation caused by the scaling of items in Likert-type scales. It tends to estimate reliability more accurately than Cronbach's alpha [20, 22–24].

### **Correlation between DASS-21 subscale of depression and EPDS**

We examined the convergent validity of the DASS- Depression subscale by assessing its correlation with EPDS. This scale has been demonstrated to be a valid depression screening measure in Malawi. A Pearson's correlation coefficient ( $r$ ) for the DASS-21 subscale of depression and EPDS was also calculated as the scores in both tools were normally distributed. The  $r$  correlation measures the strength of the linear relationship between two continuous variables. The following cut-off  $0.1 < [r] < 0.3$ ,  $0.3 < [r] < 0.5$  and  $0.5 < [r] < 0.7$  and  $[r] > 0.7$  were used to measure the strength of association and interpreted as very weak correlation, weak correlation, moderate correlation and strong correlation respectively [25].

### **Criterion validation for DASS-D, DASS-A and EPDS against the SCID**

Compared to the DSM-IV structured interviews (SCID) scores, we calculated the sensitivity, specificity, and positive and negative likelihood ratio for DASS-21 and EPDS. A positive likelihood ratio (LR+) tells us how much to increase the probability of the disease if the test is positive, while a Negative likelihood ratio (LR-) tells us how much to decrease the probability of the disease if the test is negative. The larger the LR+ ( $\geq 5$ ), the greater the likelihood of the disease and the smaller the LR- ( $< 5$ ), the lesser the likelihood of disease. The ability of DASS-21 and EPDS to discriminate cases from non-cases was assessed by receiver operating characteristics (ROC) analysis, and its curve was used to select cut-off points for DASS-21 subscales and EPDS. The area under the ROC curve (AUC) is the best parameter for summarizing a screening tool's overall discriminative value. A value of  $\geq 0.70$ , 0.80 up to 0.90 and  $> 0.90$  is interpreted as reasonable, good and excellent, respectively [26]. Comparisons were made between the AUCs for the DASS-D and EPDS. The criteria for choosing an optimal cut-off value were to maximise both sensitivity and specificity and to set sensitivity values higher than specificity to detect all potential cases. Youden index (sensitivity + specificity - 1) was used to assess the ability of screening tools to balance sensitivity and specificity, and the results were presented as a percentage. It has been recommended that for a test to be useful, the Youden Index should be  $\geq 50\%$  [27]. Data analysis was conducted using Stata Version 15.1 (Stata Corp LP, College Station, Texas, United States of America, 2017).

## **Ethical considerations**

This study was nested within the REVAMP trial, approved by the College of Medicine Research and Ethics Committee, Malawi (P.02/18/2357) and the Walter and Eliza Hall Institute of Medical Research Ethics Committee, Australia (WEHI REC 18/02). All participants were given information about the study and either signed a consent form or printed their thumb print (as witnessed by an impartial observer) for those who could not write. Assessments were done in closed rooms to maintain privacy. Participants were given unique identifying numbers, and forms containing their names were kept separately from their files. Participants identified needing further assessment and management were referred to the local Ministry of Health psychiatric services.

## **Results**

### **Descriptive analysis**

Overall, 115/120 (95.8%) of the required sample provided complete responses to all the three questionnaires (SCID, DASS-21 and EPDS) administered. The mean age of the included participants was 24 (standard deviation: 6.8) years. 82% of the participants were either married or living together with their husbands, and 68.7% were Christians (Table 1). Most of the participants had either attended primary (60.9%) or secondary (34.8%) school and depended on either casual labour (35.7%) or farming (36.5%) to earn a living.

Using the SCID interviews, 13/115 (11.3%) participants were diagnosed with current depression (3 with major depression and 10 with minor depression) and were diagnosed with current generalised anxiety disorder. The 3 participants diagnosed with major depression were referred to local psychiatric services for further management.

### **Internal reliability of DASS-21 items and EPDS**

The overall DASS-21 item test scale reliability results are shown in Table 2. The overall Cronbach's alpha for DASS-21 was 0.74. The Cronbach's alpha for the DASS-D subscale, DASS-A subscale and DASS-S subscales were 0.66, 0.29 and 0.52, respectively. Detailed results on item-test correlation, item-rest correlation and average inter-item correlation, which influences the overall Cronbach's alpha, are shown in Table 2. The internal reliability (Cronbach's alpha) of EPDS was 0.74, with item-test correlation and item-specific alpha ranging from 0.30 to 0.81 and 0.67 to 0.76, respectively. The ordinal alphas for DASS-D, DASS-A and DASS-S subscales were 0.83, 0.74 and 0.87, respectively.

### **Correlation between DASS-D subscale and EPDS**

A Pearson correlation coefficient examined the relationship between scores on the DASS-D subscale and EPDS. The results showed a statistically significant positive and moderate association ( $r = 0.61$ ,  $p < 0.001$ ).

### **Criterion validity for DASS-21, DASS-D, DASS-A and EPDS against SCID**

The results of sensitivity, specificity, Youden index, cases correctly classified, positive likelihood ratio (LR+) and negative likelihood ratio (LR-) for both DASS-21 (Depression and Anxiety subscales) and EPDS compared to SCID are shown in Table 3. The receiver operating curve (ROC) analysis for the DASS-21 depression subscale against the criterion of DSM-IV current depressive episode (minor or major) gave an area under the curve (AUC) value of 0.76 (95% CI: 0.61; 0.91), and details are shown in Fig. 1A. The ROC analysis for the DASS-21 anxiety subscale against the DSM-IV current generalized anxiety disorder criterion gave an AUC value of 0.6505 (95% CI: 0.52; 0.79), as shown in Fig. 1B. The ROC analysis for EPDS against the DSM-IV current depressive episode (minor or major) gave an AUC value of 0.75 (95% CI: 0.60; 0.89). As shown in Fig. 1A, although the AUC for DASS-depression subscale is larger than that of EPDS, the chi-squared test yielded a probability of 0.88, suggesting no significant difference between the

two areas. The ROC area for the whole DASS-21 against SCID depression and anxiety diagnoses were 0.71 (95% CI: 0.54; 0.87) and 0.77 (95% CI: 0.62; 0.92) respectively.

**Table 2** DASS-21 Item test scale reliability

Item question	Obs	Sign	Item-test correlation	Item-rest correlation	Average inter-item correlation	Alpha
DASS-Depression subscale						
I found it difficult to work up the initiative to do things	115	+	0.5908	0.3907	0.2151	0.6219
I couldn't seem to experience any positive feeling at all	115	+	0.4552	0.2263	0.2515	0.6685
I felt that I had nothing to look forward to	115	+	0.6124	0.4183	0.2093	0.6137
I felt down-hearted and blue	115	+	0.5742	0.3697	0.2196	0.6280
I was unable to become enthusiastic about anything	115	+	0.4266	0.1934	0.2592	0.6774
I felt I wasn't worth much as a person	115	+	0.7136	0.5532	0.1822	0.5720
I felt that life was meaningless	115	+	0.6536	0.4720	0.1983	0.5974
Test Scale Reliability (Cronbach's alpha)					<b>0.2193</b>	<b>0.6629</b>
DASS-Anxiety subscale						
I was aware of dryness of my mouth	115	+	0.4242	0.1068	0.0587	0.2722
I experienced breathing difficulty	115	+	0.4748	0.1657	0.0484	0.2336
I experienced trembling (e.g. in the hands)	115	-	0.3392	0.0130	0.0760	0.3305
I was worried about situations in which I might panic and make a fool of myself	115	+	0.4485	0.1347	0.0537	0.2541
I felt I was close to panic	115	-	0.4349	0.1190	0.0565	0.2643
I was aware of the action of my heart in the absence of physical exertion	115	+	0.5410	0.2467	0.0349	0.1781
I felt scared without any good reason	115	-	0.3961	0.0751	0.0644	0.2923
Test Scale Reliability (Cronbach's alpha)					0.0561	0.2937
DASS-Stress subscale						
I found it hard to wind down	115	+	0.6744	0.4705	0.0963	0.3899
I tended to over-react to situations	115	+	0.2857	0.0052	0.1886	0.5824
I felt that I was using a lot of nervous energy	115	+	0.3669	0.0923	0.1693	0.5501
I found myself getting agitated	115	+	0.6929	0.4963	0.0919	0.3777
I found it difficult to relax	115	+	0.5571	0.3158	0.1241	0.4595
I was intolerant of anything that kept me from getting on with what I was doing	115	+	0.3083	0.0291	0.1832	0.5737
I felt that I was rather touchy	115	+	0.6929	0.4963	0.0919	0.3777
Test Scale Reliability (Cronbach's alpha)					0.1355	0.5233

### Choice of cut-off points

A cut-off point of 1 or higher on the DASS-D depression subscale provided the best combination of sensitivity and specificity (optimal point) in detecting a minor or major depression diagnosis. This cut-off point gave 69.2% and 75.5% for sensitivity and specificity, respectively (Youden Index: 44.7%). At this cut-off point (1 or higher), the correct classification was 74.8%, with a positive likelihood ratio of 2.8 and a negative likelihood ratio of 0.4 (Table 3). For the DASS-A (anxiety subscale), the optimal cut-off point was obtained at a cut-off point of 1 or higher, which gave a sensitivity of 52.9% and specificity of 75.5% (Youden Index: 28.4%). This cut-off point gave a correct classification value of 72.2% and 2.16 and 0.62 for positive and negative likelihood ratios, respectively (Table 3). For EPDS, the best combination for sensitivity and specificity was 76.9% and 66.7% (Youden Index: 43.6%), respectively, at a cut-off point of 1 or higher. This cut-off point gave a correct classification value of 72.2%, with a positive likelihood ratio value of 2.16 and a negative likelihood ratio of 0.62 (Table 3).

### Discussion

### Reliability and validity of DASS-21

This study aimed to determine the reliability and validity of DASS-21 in screening for common mental disorders (CMDs) among postpartum women in Malawi. We found that DASS-21 as an overall tool has a good internal reliability. Inconsistent findings were observed between Cronbach's alpha and Ordinal alpha values for the DASS-21 subscales with the later indicating good internal reliability for all DASS-21 subscales. The internal reliability of the scale is defined as the ability of the scale to measure the construct in question without the influence of measurement error from the use of different questions. A high internal reliability scale has items that are consistent

Table 3: Operating characteristics of DASS-D, DASS-A and EPDS at various cut-off scores for identifying depression and anxiety against the SCID

Cut-point	Sensitivity	Specificity	Youden Index	Correctly Classified	LR+	LR-
DASS-D (Depression subscale)						
> = 0	100.00%	0.00%	0%	11.30%	1.0000	
> = 1	69.23%	75.49%	44.72%	74.78%	2.8246	0.4076
> = 2	53.85%	89.22%	43.07%	85.22%	4.9930	0.5173
> = 3	38.46%	95.10%	33.56%	88.70%	7.8462	0.6471
> = 4	30.77%	96.08%	26.85%	88.70%	7.8462	0.7206
> = 6	7.69%	99.02%	6.71%	88.750%	7.8462	0.9322
> = 7	0.00%	99.02%	-0.98%	87.83%	0.0000	1.0099
> = 8	0.00%	100.00%	0%	88.70%		1.0000
DASS-A (Anxiety subscale)						
> = 0	100.00%	0.00%	0%	14.78%	1.0000	
> = 1	52.94%	75.51%	28.45%	72.17%	2.1618	0.6232
> = 2	23.53%	89.80%	13.33%	80.00%	2.3059	0.8516
> = 3	17.65%	96.94%	14.59%	85.22%	5.7647	0.8495
> = 5	5.88%	100.00%	5.88%	86.09%		0.9412
> = 6	0.00%	100.00%	0%	85.22%		1.0000
Edinburgh Postpartum Depression Scale (EPDS)						
> = 0	100.00%	0.00%	0%	11.30%	1.0000	
> = 1	76.92%	66.67%	43.59%	67.83%	2.3077	0.3462
> = 2	53.85%	81.37%	35.22%	78.26%	2.8907	0.5672
> = 3	30.77%	87.25%	18.02%	80.87%	2.4142	0.7934
> = 4	30.77%	94.12%	24.89%	86.96%	5.2308	0.7356
> = 5	30.77%	95.10%	25.87%	87.83%	6.2769	0.7280
> = 6	30.77%	97.06%	27.83%	89.57%	10.4615	0.7133
> = 7	30.77%	98.04%	28.81%	90.43%	15.6923	0.7062
> = 8	23.08%	99.02%	22.10%	90.43%	23.5385	0.7768
> = 9	15.38%	100.00%	15.38%	90.43%		0.8462
> = 12	7.69%	100.00%	7.69%	89.57%		0.9231
> = 13	0.00%	100.00%	0%	88.70%		1.0000

LR+ Likelihood Ratio Positive, SCID Structured Clinical Interviews for Diagnostic Statistical Manual, LR- Likelihood Ratio Negative

enough whilst a low internal reliability scale has items that are different from one another creating a larger error component [22]. Only the DASS-D and EPDS demonstrated a satisfactory ability to discriminate participants with depression from non-depressed. Using Cronbach's alpha values, our findings indicated that the internal consistency of the whole DASS-21 was good (Cronbach's alpha = 0.74). However, internal consistency was unsatisfactory for the DASS-21 depression and stress subscale and very poor for the DASS-21 anxiety subscales. These findings are not consistent with

those reported in high-income countries where the Cronbach's alpha coefficient for the DASS-21 subscales ranged from good to excellent, indicating good internal consistency [25–27]. A study in Nigeria also reported high Cronbach's alpha for all DASS-21 subscales [28].

Evidence suggests that increasing the response options in a Likert scale question provides more accurate composite score estimates with sampling variability, consequently increasing item test reliability [23]. However, comprehending and choosing the right response option depends on individual literacy levels. Differences might influence the above discrepancies in findings in participants' level of education among studies. For example, most of the participants in our study had received primary school education compared to a study in Nigeria which involved medical students. In high-income countries, most of the study participants had a minimum of a first degree. Vignola and Tucci (2014) suggested that participants with low literacy might have difficulties understanding and rating subjective emotional states presented on a Likert scale [29].

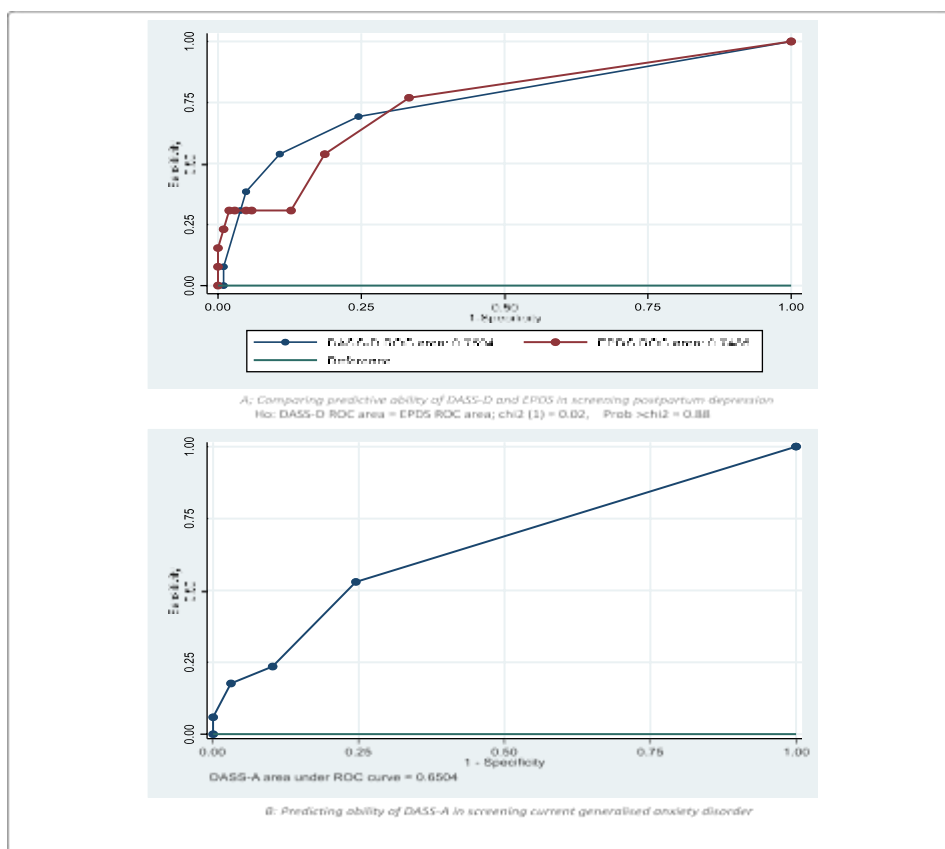


Figure 1 **A** Comparing predictive ability of DASS-D and EPDS in screening postpartum depression Ho: DASS-D ROC area = EPDS ROC area;  $\chi^2(1) = 0.02$ ,  $\text{Prob} > \chi^2 = 0.8844$ . **B** Predicting ability of DASS-A in screening current generalised anxiety disorder

Stewart et al. (2009) addressed the challenges of Likert scale rating among low literate participants by introducing pictorial faces that demonstrate variation in an emotional state [6]. However, these additions might add complexity to tool use, requiring adequate training before use and raising feasibility constraints, especially in LMICs where resources are limited. It is known that DASS-21

anxiety subscale items measure two different constructs, namely somatic symptoms and negative emotional symptoms. Additionally, it has been suggested that women with common mental disorders in LMICs tend to endorse more somatic symptoms than negative emotions [30]. This was evident in this study as three of the DASS-21 anxiety subscale items indicated negative inter-item correlation (Table 2). This consequently reduced the average inter-item correlation as items that are not related and going in different directions end up cancelling each other, thereby affecting the overall Cronbach alpha (Cronbach alpha coefficient for DASS-A subscale = 0.29).

Using ordinal alpha which of recent has been recommended as an alternative for Cronbach's alpha for Likert scales [20], high reliability values for all DASS-21 sub-scales were reported. A detailed explanation on the pros and cons of ordinal alpha vs Cronbach's alpha are beyond the scope of this paper and reported elsewhere [20, 23, 24]. However, it is important to note that two assumptions are associated with Cronbach's alpha, namely 1) the tau-equivalence (all items are of equal importance when measuring the unobserved construct, but that the respective error variances for each item are allowed to differ) and 2) uncorrelated errors [20]. When using a Likert scale, correlated errors might be introduced through 1) not creating enough categories to fully represent the construct in question, 2) when the underlying continuous distribution does not match the observed categorical distribution of scores in terms of skew and 3) misclassification errors. These affect Cronbach's alpha as the Pearson product-moment correlations are attenuated when using Likert scale data [20].

A large difference was observed in the Cronbach's alpha compared to the Ordinal alpha for the DASS-21 anxiety subscale (Cronbach's alpha = 0.29 versus Ordinal alpha = 0.74). This difference was expected as items that are not measuring the same construct as in the DASS-anxiety subscale tend to yield lower values of Cronbach's alpha as the Pearson covariance matrix is substantively distorted [20, 22]. The high ordinal alpha value, in this case, is a result of the polychoric correlation matrix, which corrects for the attenuation caused by the transformation of categorical Likert scale data into unobserved continuous data [20, 22].

Another important finding in this study is that none of the DASS-21 item subscales combined sufficiently to give high sensitivity and specificity for routine screening for common mental disorders even at a cut-off point of 1 or more. The Youden indexes for all DASS-21 subscales and EPDS are below 50%, demonstrating a lack of the diagnostic tools to detect either disease or health. However, it is important to note that even the current EPDS that was validated in this setting and reported to show good test characteristics as a screening measure for depressive disorders had Youden Index < 50% (calculated: 48.9%, not shown in the article) [6]. Perhaps this emphasizes that screening tools are not for diagnosing diseases but rather for identifying probable cases that can be referred for further assessments. Additionally, the prevalence of depression in this setting was very low (with only 3 participants diagnosed with major depression), which may affect the sensitivity and specificity of the screening tools [31, 32].

Similar findings were also reported by Tran et al. [11] in the validation of the DASS-21 as a screening instrument for depression and anxiety in a rural community-based cohort of northern Vietnamese women. Using exploratory factor analysis, Tran et al. [11] found DASS-21 not good at

distinguishing different conditions. Still, the single factor in which all subscales are added had some value in detecting any CMD [30]. Hanlon et al. (2015) argued that in low-literacy settings, it is possible that the potential accuracy of a screening tool can be offset by the complexity of the multiple response categories presented in Likert scales [33]. The area under the ROC curve for the DASS-21 depression subscale was 0.76, and EPDS was 0.75; this is a moderately high value suggesting the reasonable diagnostic ability of both the DASS depression subscale and EPDS. The AUC for EPDS in this study is almost similar to what was reported (0.77: 95% CI; 0.695–0.839) in a previous study that validated the use of EPDS in screening minor or major depression among antenatal women in our setting [6]. A comparison of AUCs between EPDS (an established tool in our setting for screening postpartum depression) and the DASS-D subscale indicated no significant difference between the two areas. Our results have also shown a statistically significant positive and moderate association between the DASS-21 depression subscale and EPDS score, suggesting a DASS-21 depression subscale is a reliable tool for screening minor or major depression.

### **Strength and limitation**

This study is the first study in Malawi to conduct criterion validation of the DASS-21 subscales against SCID diagnoses. Besides using Cronbach's alpha which is a standard analysis of internal reliability (item inter-relatedness) of psychometric tool, ordinal alpha was also reported. However, we acknowledged that we did not do test–retest reliability due to resource constraints. Our study findings may have reduced generalisability. We only included mothers who had babies aged between one and 12 months old who were previously enrolled in a randomisation study that recruited only anaemic pregnant women. Lastly, most of the participants in this study received primary education, and the findings should not be generalised to a population with a high literacy level.

### **Conclusion**

The study found DASS-21 as an overall item having good internal reliability. Still, none of its subscales (DASS-A and DASS-S) had satisfactory internal reliability except for the depression subscale, as indicated by Cronbach's alpha. However, ordinal alpha demonstrated good internal reliability for all DASS-21 subscales. Researchers have now agreed that ordinal alpha may be the most appropriate measure of internal reliability for Likert-type data. Our findings suggest that DASS-D, DASS-A, and DASS- S subscales have good internal reliability for screening common mental disorders in Malawi. A positive and statistically significant moderate correlation between DASS-D subscale and the EPDS was also observed.

Regarding the criterion validation, only the DASS- depression subscale and EPDS demonstrated satisfactory ability to discriminate cases from non-cases with no significant difference between their ability to detect either minor or moderate depression among women who have recently given birth. Therefore, health practitioners in this setting have a choice of whether to use the DASS-D subscale or EPDS for screening minor/major depression based on their preferences. We recommend future studies consider including uncomplicated strategies to maximise the use of the DASS-21 Likert response option in the low literacy population.

### **Abbreviations**

CMDs: Common Mental Disorders; DASS-21: Depression Anxiety Stress Scale- 21 items; EPDS: Edinburgh Postpartum Depression Scale; GK: Gladys Kusiwa; LMICs: Lower and Middle-Income Countries; ROC: Receiver Operating Characteristics; SCID: Structured Clinical Interview for DSM-IV; TK: Twisile Kalinga.

### **Supplementary Information**

The online version contains supplementary material available at <https://doi.org/10.1186/s12888-022-03994-0>.

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### **Authors' contributions**

EM, LML, JF, MM and KP were involved in the conception of research work and data collection. RS was involved in the design and statistical analysis. EM prepared figures, analysed the data and drafted the manuscript. All authors read and approved the final version of the manuscript.

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### **Availability of data and material**

The datasets generated and/or analysed during the current study are not publicly available. The main study (REVAMP trial) is still ongoing but is available from the corresponding author upon reasonable request.

### **Declarations**

#### **Ethics approval and consent to participate**

The protocol was approved by the College of Medicine Research and Ethics Committee, Malawi (P.02/18/2357) and the Walter and Eliza Hall Institute of Medical Research Ethics Committee,

Australia (WEHI REC 18/02). We confirm that all participants were given information about the study and either signed a consent form or printed their thumb print (as witnessed by an impartial observer) for those who could not write. All study procedures were conducted in accordance with the International Conference on Harmonisation Guidelines for good clinical practice and the Declaration of Helsinki.

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**Survival rate of HIV infected children under the age of 15 years on antiretroviral therapy at Ndirande Health Centre, Blantyre, Malawi**

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**Abstract.**

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Antiretroviral therapy is medication that treats but not kill Human Immunodeficiency Virus or cure acquired immune-deficiency syndrome. Globally 1.7 million children under the age of 15 years living with HIV, only 52% are on Antiretroviral therapy. In Malawi Human Immunodeficiency Virus is still an important barrier to development and every year around 10,000 children die of Human Immunodeficiency Virus. Children infected with Human Immunodeficiency Virus and initiated antiretroviral therapy soon after detection are expected to live much longer compared to those starting Antiretroviral therapy late.

In 2001, Ministry of Health introduced subsidized Antiretroviral drugs in 2001 and provision of Antiretroviral therapy services in 2004 expecting a change in survival rates. Despite the provision of Antiretroviral therapy services, only one study on survival rate was conducted in rural areas of southern part of Malawi. There are no such studies or report on survival status of children on Antiretroviral therapy in urban areas of Malawi. The study aimed at determining the survival rate of Human Immunodeficiency Virus infected children after being initiated on antiretroviral therapy at Ndirande Health Centre in Blantyre City located in southern part of Malawi.

The research used a retrospective cohort study. Client records and checklist were used to collect data. The study found that 30.1% defaulted while 41.3% were transferred out. Those that remained on Antiretroviral therapy, only 5.6%) died and 94.4% survived after antiretroviral therapy. This indicates that there are higher chances of survival of children initiated on Antiretroviral therapy and those that defaulted and transferred out require follow up.

**Key Words:** Human Immunodeficiency Virus, Acquired Immune Deficiency Syndrome, Antiretroviral therapy.

**Introduction**

For about more than thirty years now, antiretroviral (ARVs) are the cornerstone of HIV/AIDS management, as there is currently no cure nor vaccine available for HIV. ARVs treats the HIV infection by reducing the viral load. (aidsinfonet.org, 2014). The widespread introduction of ARVs have caused a substantially reduction of illnesses and deaths associated with HIV in recent decades.

By 2013 an estimated 35.0 million people worldwide were living with HIV and Sub-Saharan Africa accounted 71% of the global burden of HIV infection. (Kharsany & Karim, 2016). Globally almost 5% of people living with HIV are children under the age of 15 (Kharsany & Karim, 2016) Globally 1.8 million children living with HIV only 52% are on antiretroviral therapy (ART) (UNICEF, 2018).

To survive from HIV refers to the ability of the child to live beyond or longer than the expected period of not taking the HIV treatment (John, 2018). HIV infected individuals initiated on antiretroviral therapy (ART) soon after detection are expected to live much longer. ART prevent and reduce HIV-related morbidity and mortality; maintaining normal physical growth and neuro cognitive development (Affairs, 2018).

In 2001, the Ministry of Health (MoH) introduced subsidized antiretroviral therapy program for the prevention of mother-to-child transmission of HIV (Kabue, 2008). But still a lot of children (63%) in Malawi were HIV positive and on ART by 2017 (Arvert, 2017). However, countries work hard to detect the cases in time so as to bring forth the initiation of antiretroviral therapy earlier as possible to reduce morbidity and mortality rates among them as recommended by WHO (WHO, 2006).

Studies conducted following the recommendation of WHO for ART in infants and children supported that early initiation of ART prevent early mortality. In a study conducted in Ethiopia, mortality within the first six months of ART initiation was high (7.6%) (Kedir, et al., 2014). A similar study in Malawi recorded a cumulative incidence infant mortality of 5.2%, 7.1% and 7.7% after 1, 3, and 5 years, respectively (Brophy, et al., 2016). These findings reinforce the urgent need for early diagnosis and treatment to prevent pediatric death from HIV and AIDS.

In Malawi, different studies were conducted in rural areas in 2005, 2010 and 2017 to estimate HIV and AIDS in the country. For children living with HIV, 87 000 were recorded in 2005, 88 000 in 2010 and 71 000 in 2017. Newly infected children in 2005, 2010 and 2017 were 14 000, 12 000 and 4900 respectively. AIDS-related deaths among children was 11 000 in 2005, 7800 in 2010 and 3000 in 2017 (UNAIDS, 2018).

According to World Health Organization (2016) there are risk factors towards failure to survive ART among children like low CD-4 Count, low hemoglobin level at ART initiation malnutrition, and underweight for age. Other clinical that affect clients on ART are described as Stage I, Stage II, Stage III and Stage IV. Stage I is defined by being asymptomatic; Stage II by hepatomegaly, splenomegaly and other skin infection; Stage III by moderate malnutrition, candida, unexplained anemia etc. and finally Stage IV where the infected child start to show wasting, stunting, several malnutrition that doesn't respond to treatment (WHO, 2019). The clinical stages may also determine the ability to survive from HIV after initiating ART.

Another study was once conducted in the rural areas of the southern region Malawi on survival outcomes in a Pediatric Antiretroviral Treatment Cohort from October 2003 to September 2011. The results estimated 5.3% mortality rate at 1 year after enrolment and 6.6% every 12<sup>th</sup> month of following-up (Brophy & Hawkes, 2016). However, based on these findings there was need for further study on the local evidence on the survival status of children on ART in townships.

Expanded knowledge of baseline factors associated with early mortality rate among children on the HIV can improve local guidelines regarding the timing and choice of ART regimen. It is thus imperative from a public health perspective, to evaluate if the pediatric HIV and AIDS care, treatment and support services influence survival of children living with HIV.

In Malawi, despite the provision of ART services since 2004, Despite the provision of Antiretroviral therapy services, only one study on survival rate was conducted in rural areas of southern part of Malawi. There are no such studies or documented report on survival status of children on ART in cities. This study therefore is aimed at determining the survival rate of Human Immunodeficiency Virus infected children initiated on antiretroviral therapy at Ndirande Health Centre in Blantyre City.

### Methodology

This was a quantitative retrospective cohort study design. Study subjects were HIV-infected children aged less than or equal to 15 years at the time of ART initiation and accessing care at NHC during the period of January 2007 to December 2009. The subjects were extracted from Ndirande Health Centre ART Registers. A total of 63 study participants for the study were proportionally selected from a total of 170 children that were on ORT in the study period using Yamane formula (1967) at 95% Confidence interval (CI) with 0.05 precision level. The population was categorized into five stratum namely; infant (0-<1 years old) with 20 participants, toddlers (1-<3 years old) with 60 participants, preschooler (3-5 years old) with 34 participants, middle childhood (6-11 years old) with the 32 participants and young teens (12-15 years old) with population of 24 participants (Table 1)

Table 1: Strata of children enrolled in the study

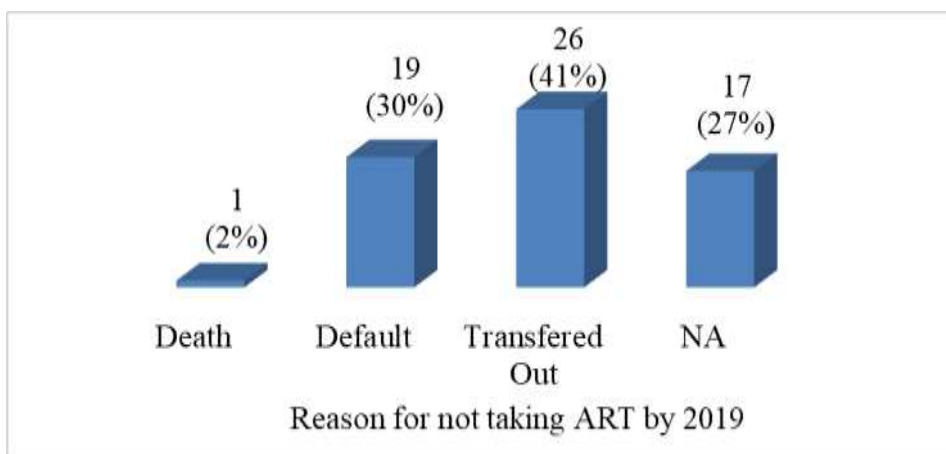
Stratum	Age (Years)	Population	Sample Size	Percentage
Infants	0 - <1	20	7	35
Toddlers	1 - <3	60	22	21
Pre-School	3 - 5	24	13	19
Middle Childhood	6 - 11	32	12	14
Young Teens	12 - 15	34	9	11
Total		170	63	100

A checklist was used to collected subjects' data which was filled based on the past records in the ART Registers. Data was analyzed using Statistical Package for Social Science (SPSS) version 20

### Results and Discussion

#### Antiretroviral Therapy Clients enrollment and ARV drug collection

The study had 63 study participants who were enrolled on ART in 2007, 2008 and 2009 and were followed up in 2019 after 12, 11 and 10 years respectively. The study found that the majority of the clients 21 (41%) were transferred out while 19 (30%) were defaulters and their status on ARV collection was not known. Only 1(2%) client died during the course of ART treatment while 17 (27%) clients were still on treatment by 2019. (Fig 1)



NA = Enrolled for other miscellaneous reasons

Figure 1: ARV drug collection for clients initiated on antiretroviral therapy (ART) by 2019

The other 17 (27%) clients who were enrolled because of other miscellaneous reasons (NA) had 5 (25%) children who were still on treatment and 12(75%) children who were not receiving treatment from NHC. In similar study conducted in Malawi among children enrolled on ART (n=2190), 732 (33%) children were lost to as either defaulters or transfer outs. (Brophy, et al., 2016)

**Clinical presentation of clients from commencement of ART and its effects.**

The study found that almost all children started ART with clinical condition. The majority were on WHO Stage 3 (38%) and with low CD 4 Count (27%). (Fig 2)

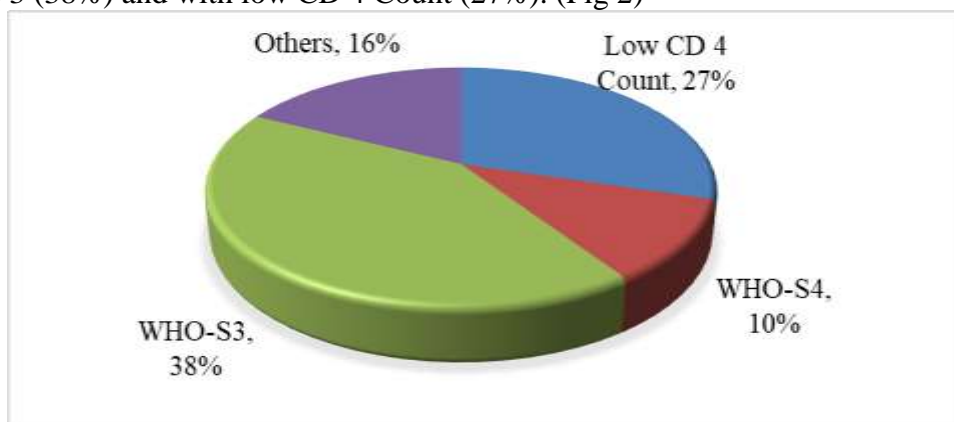


Figure 2. Clinical presentation of Children on initiation of Antiretroviral Therapy

The study participants (n=63) for this study were subdivided into four subgroups according to their clinical presentation during the ART therapy. The results also show that there was transferring out with almost all with clinical conditions with the majority being those on WHO Stage 4 (75%) and those with Low CD4 Count (67%).The majority that were transferred out and defaulted were those on WHO Stage 4 (75%) and WHO Stage 3 (50 %) respectively. (Fig 3)

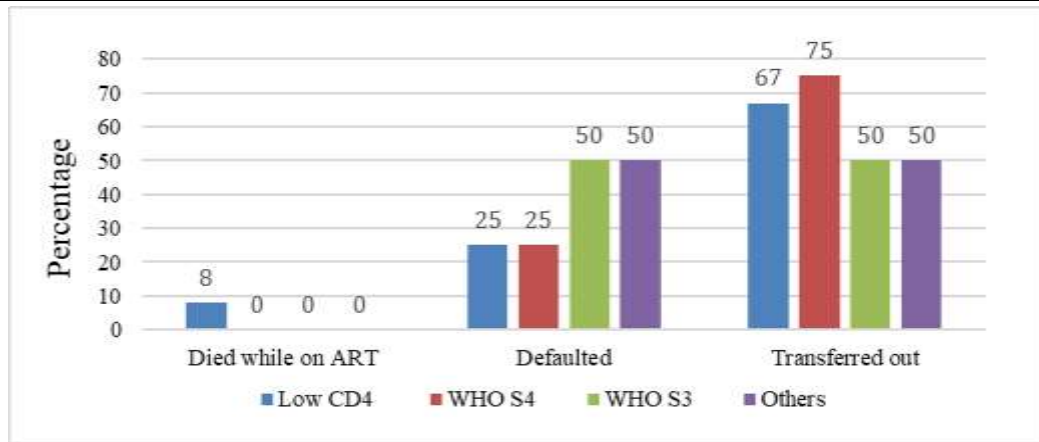


Figure 3. Effects of Clinical presentation of clients on ART.

The results are similar with those of a study in Ethiopia that showed that anemia, decreased CD4 cell count, advanced WHO staging were the predictors of mortality of children after ART initiation (Kedir, et al., 2014). In the study 55% were enrolled with decreased CD4 count as a body complication. 24 participants were enrolled on ART for being in WHO stage III and 25% (6 children) were on treatment the time the study was done. 6 participants were also enrolled on ART for falling under WHO stage IV, 2 (33%) children) were on ART treatment while 4 (67%) children making stopped ART.

On the reasons for being not on treatment by 2019 among participants who initiated ART with decreased CD4 count, WHO stage III, WHO stage IV and other miscellaneous reasons as a body complication respectively. Therefore, the study results have indicated body complications during the initiation of ART affected ARV quantity and frequency of children collecting ARV at Ndirande Health Centre.

**Survival status of HIV infected children after antiretroviral therapy.**

For the preciseness of the results, the analysis excludes 19 children that defaulted and 26 children that were transferred out within the study period and estimate the survival rate among the 18 participants who remained. Of all the 63 subjects, 18 participants were analyzed among 63 study participants since 45 children were lost to follow up. The results show survival rate of 94.4%. (Fig4)

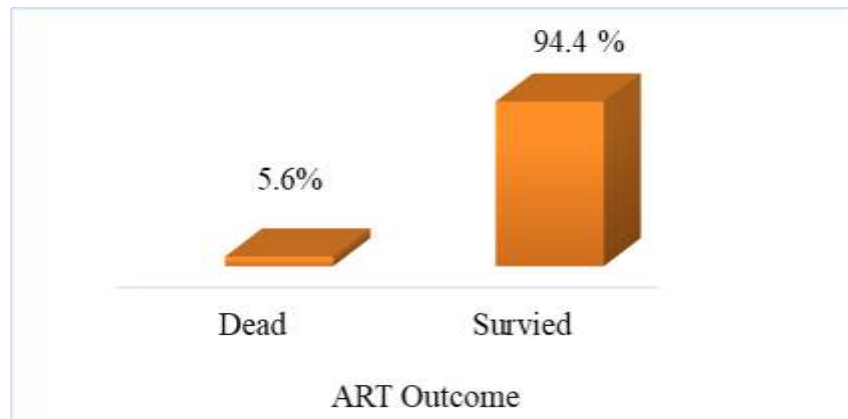


Figure 4.1: Survival rate of clients on ART

The study shows that survival rate of children enrolled on ART at NHC between 2007, 2008 and 2009 after being found with HIV was 94.4% after a follow up of 12, 11 and 10 respectively and the death rate was 5.6%. These results are different from retrospective studies that were done in South Africa and Malawi aiming to find the survival rates. In South Africa, there was a death rate of 4.7% in a follow up after 22 months and another death rate of 25.6% and the survival rate of 74.4% in a follow up after 10 years. (Zanoni, et al., 2011). In a study conducted in Malawi among children enrolled on ART, the survival rate was 91% in a follow up study after 8 years (Brophy, et al., 2016)

### **Conclusion and Recommendation**

The survival rate of HIV infected children who initiated ART in 2007 to 2009 at NHC was 94% and indeed early initiation of ART affects the survival status of HIV infected children on ART

The results of the study failed to generalize if body complication by the time of ART initiation really lead to mortality because the study had a high number of enrolled children that were lost as as defaulters and transfer outs. As such there is need to follow up the children on ART that are transferred out and confirm they are alive.

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## **The Effective Management of Common Psycho-Social Problems Among Adolescent Learners in Malawi**

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### **Abstract**

The main purpose of this study was to investigate an effective method of managing common psychosocial problems among adolescent learners in Malawi. Sequential exploratory mixed methods design guided the study. First phase utilised a qualitative method, where 18 key informants were targeted. The second phase was a quantitative method and targeted 317 adolescent learners from two secondary schools. Key findings: Firstly, the study found that adolescent learners had psychosocial problems and prevalence was as follows: depression (87%); suicidal thoughts (26.4%); substance use (31.3%); positive attitudes towards mental health problems (26.4%) and knowledge of mental health problems (23.3%). Furthermore, being male was associated with depression, substance use, knowledge about mental health problems, positive attitudes towards mental health problems; being younger adolescent (10-15 years) was associated with depression, knowledge of mental health problems, positive attitudes towards mental health problems; being an adolescent from rural area was associated with suicidal thoughts before intervention. Secondly, the study observed psychosocial service deficiencies within the Malawian secondary schools. Thirdly, the combined psycho-education and group counselling intervention were able to reduce the prevalence of psychosocial problems among adolescents. Furthermore, some tested variables, such as attitudes toward mental health problems, knowledge of mental health problems, and substance use, were statistically significant. Changes in other tested variables, such as depression and suicidal thoughts, were not statistically significant. The study findings will help relevant stakeholders to be aware of the adolescent psychosocial challenges and consider strategies of managing them.

**Key words:** Effective, management, psycho-social problems, adolescent, learners, Malawi.

### **Introduction**

Psycho-social challenges remain a big problem among adolescent learners globally (Azagba, Langille, & Asbridge, 2014; Carmona, Maxwell, Park, & Wu, 2020). Therefore, there is need to intervene in order to manage these problems. Global prevalence of depression among adolescents varies from 6% to 70% (Kutcher., Udedi., Gilberds., Brown., Chapota., & Perkins.,2017; Wichaidit., Pruphetkaew., & Assanangkornchai., 2019), psychoactive substance use varies from 5% to 80% (Beck & Legleye, 2009; Ogel, Corapcioglu, et al., 2004;Wichaidit et al., 2019), while prevalence of suicidal thoughts varies from 11.5% to 36.6% (Donath et al., 2019 & Voss et al., 2019). In SSA, the prevalence of depression among adolescents varies from 31.2% to 70% (Abdul Latiff, Tajik, Ibrahim, Abubakar, & Ali, 2016; Nakimuli-Mpungu et al., 2012) while psychoactive substance use varies from 4% to 50.5% ( Kuteesa., Weiss., Cook., Seeley., Ssentongo., Kizindo & Webb.,2020; Musyoka, Mbwanyo, Donovan, & Mathai., 2020) and prevalence of suicidal thoughts varies from 3.1 % to 31.3% (Kinyanda., 2011; Rudatsikira.,2007; Nalugya-Sserunjogi., 2016).

In Malawi, adolescents' prevalence of use psychoactive substances varies from 11.2% to 15% while depression varies from 18.9% to 70% (Kim et al., 2014; Kutcher et al., 2017; Kubwalo et al., 2013 & Muula, 2007) and suicidal thoughts is at 12.9 % (Shaikh., Lloyd & Acquah., 2016). The highlighted psycho-social problems can affect adolescents significantly. For instance, an adolescent learner with psycho-social problems can perform poorly in class and can be classified as failure (Fatoye & Morakinyo, 2002; Kuteesa et al., 2020; Madu & Matla, 2003; Morojele., 2016; Musyoka., 2020).

Further, literature shows that adolescent psycho-social problems can be managed by using psychological interventions like cognitive behaviour therapy, individual counselling, group counselling, psycho-education and problem solving therapy (Ahlen., Lenhard, & Ghaderi., 2019; Lai., Kwok., Wong., Fu., Law., & Yip., 2016). But, the efficacy rates of use of these single interventional approaches remain lower in management of psycho-social problems in general population including adolescent learners which ranges from 0.2% to 48.2% (Ahlen et al., 2019; Arora., Baker., Marchette., & Stark., 2019; Gates., Sabioni., Copeland., Le Foll., & Gowing., 2016(Fatoye & Morakinyo, 2002)). Therefore, there was a need to explore the possibility that the combined approach of group counselling and psycho-education could be more effective in management of adolescent psycho-social problems in secondary schools in different parts of the world including Malawi than a single approach of psychotherapy. Also, understanding the effective way of managing these psycho-social problems was important for being able to identify psycho-social needs for adolescent learners in order to provide relevant interventions to improve the wellbeing of adolescents.

However, there was a gap in the literature regarding the effective way of managing the psycho-social problems among adolescent learners. The findings of this study may not only be used to inform prevention and management interventions for psycho-social problems among this vulnerable population, but may also provide input for policy development. This is important, given that the current Malawi mental health policy (Malawi MHP, 2020) and national education policy (NEP,2013) do not have a clear policy guidance on management of psycho-social problems among adolescent learners.

### **Materials and methods**

Mixed-methods sequential exploratory study design and pragmatism research philosophy (Creswell et al., 2013; Ivankova et al.,2016). Pragmatism research philosophy underpins most mixed methods research (Parvaiz et al, 2016). Three research approaches were utilised: Constructivism, phenomenological and positivism.

Design was based on the nature of research questions which required quantitative and qualitative data generation strategies. The first phase of the study was a qualitative study while second phase of the study was a quantitative study. Study was conducted between Dec 2020 and April 2021 when covid-19 was at peak level. Qualitative study utilized a purposive sampling was used and 18 Key Informants were selected. The target participants were believed to have constructs and experiences of adolescent psycho-social problems in secondary schools and how best psycho-social problems are managed within secondary school context while in an adolescent quantitative study a random sampling technique was used. They were 12 streams from form 1 to form 4 at study site. Thus 3 streams per form/class at study site and out these streams a class was randomly selected and a total

of 317 participants were targeted in the study. This sampling method was chosen to select representative sample while reducing the chances of bias and thus identifying findings that are probably generalisable to targeted general population (Tellis,1997).

### **Population & setting**

The study participants were divided into two. The first phase were key informants and second phase were adolescent learners. Table 1 below shows the details of participants that were selected.

Table 1 The details of participants that were selected.

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Key informants -18	District Council
	Education division
	Mental health directorate
Adolescents -317	Aged 10 -19 years
	2 boarding secondary schools
	South East Education Division of Malawi.

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### **Data collection**

For a qualitative study. 18 Key Informants were sampled and In-depth interviews was conducted using a structured questionnaire. Open-ended questions were used and responses were documented, audiotaped and, then transcribed. For a quantitative study. 317 adolescents were targeted and the study targeted 8 streams of classes and were randomly sampled. Each stream had about 35-50 adolescents from Forms 1-4 (Year 1-4). Furthermore, a Quasi-Experimental Study was done in order to determine the effectiveness of the intervention. Study Group was 1 boarding school and received a 2 months intervention. 2 sessions/ week. Fidelity, a checklist was developed and participant attendance was recorded. The sessions included the causes, signs, symptoms and management of psycho-social problems. While a control group was 1 boarding school and no intervention was provided for 2 months but standard care continued. An evaluation study was conducted 2 days after the two months of intervention period. Furthermore, during baseline study 317 were sampled; 163 at study site while 154 at the control site. The evaluation study, 261 were sampled;158 at the study site and 103 at the control site.

### **Measures-adopted**

The following questionnaires were utilized in this study in order to assess psycho-social challenges: Socio-demographics questionnaire, Alcohol, Smoking and Substance Involvement Screening Test-(ASSIST-Y) For Young People questionnaire, Patient Health Questionnaire for Depression (PHQ-9), Attitudes Toward Serious Mental Illness Scale-Adolescent Version (ATSMI-AV) questionnaire, and Mental health knowledge was assessed using 20-Item Mental Health Knowledge questionnaire.

### **Data Analysis**

Qualitative data was collected from the key Informants. Data was coded, categorized, synthesized, theorized and compared to key passages of text. Data was analyzed based on the themes and contents that emerged from the responses. As a result, new codes were constructed to indicate

themes that were found in the data. After that, the data were recoded. After finding quotations relevant to the research themes, researcher studied in-depth interview transcripts and presented based on codes (Corbin, 1997).

Quantitative data was analyzed using SPSS v 26. Descriptive statistics; Frequency distributions and categorical variables of demographics like gender, age, and residence were analyzed. The associations between psycho-social problems as the dependent variables, while participant social demographic characteristics as independent variables were analyzed. Binary logistic models were developed.

### **Ethical Considerations**

Engagement with gatekeepers, Eastern Region Education Division Managers' office, and Targeted schools' management. Protection of participants; Informed assent was done (Masseti et al.,2018). Confidentiality and privacy were maintained at all times and it is important (Kalsem et al.,2018)

### **Results**

The observed that there was high prevalence of common psycho-social problems among adolescents. Adolescents were assessed in response to quantitative questions. Table 1 shows the details.

Table 1 Response to quantitative questions

Variable	Percentage (%) / Gender [Female (%)]
Substance use	31.3/24%
Depression	87/42%
Negative attitudes	73.6/26%
Knowledge	23.3/50%
Suicidal thoughts	26.4/37%

### **Associations**

The study found that being male, female, younger adolescent, and from rural area were associated with psycho-social problems. Table 2 below shows the details.

Table 2 Associated with psycho-social problems

Independent Variable	Associations – dependent
Male	Was associated with depression (AOR=1.055, 95% CI= (0.404-2.755), suicidal thoughts (AOR=1.205, 95% CI= (0.588-2.469), substance (ab)use (AOR=3.026, 95% CI= (1.436-6.378), knowledge, and positive attitudes (AOR=1.491, 95% CI= (0.752-2.959).
Female	Was associated with negative Attitudes (AOR=1.825, 95% CI= (0.868-3.841).
Younger adolescent (10-15 years)	Was associated with depression(AOR=1.795, 95% CI= (0.563-5.719), suicidal thoughts (AOR=1.813, 95% CI= (0.296-3.852), knowledge (AOR=1.704, 95% CI= (0.780-3.719), and positive attitudes (AOR=2.496, 95% CI= (1.209-5.157).
Rural area	Was associated with suicidal thoughts (AOR=1.288, 95% CI= (0.624-2.660), knowledge (AOR=1.325, 95% CI= (0.629-2.793) and positive attitudes (AOR=1.706, 95% CI= (0.810-3.592).

Management of psycho-social Problems-Manager’s perspective in response to qualitative questions. KIIs- were asked broad questions and then specific questions about psycho-social problems. The study observed psycho-social service deficiencies. For example, Participant 1 *‘there is no time allocated to counseling services in school. This is a challenge for adolescent learners with psycho-social challenges to access psycho-social services in schools’* while Participant 2 *“There is need for mental health service in schools; sometimes learners have psychological issues that contribute to poor performance.”* And Participant 3 *“teachers lack capacity to conduct psycho-education and group counseling sessions in schools”*.

Furthermore, the effect of combined psycho-education and group counselling approach (psycho-social intervention) was observed to be associated with improvement of psycho-social problems except with depression. Table 3 below show the details.

Table 4 The effect of combined psycho-education and group counselling approach

VARIABLE	BEFORE(Female)	AFTER(Female)	CHANGE
Suicidal thoughts	26% (37%)	24% (49%)	2%
Substance use	31% (24%)	26% (44%)	5%
Positive attitudes	26% (36%)	55% (46%)	29%
Knowledge	23% (50%)	70% (43%)	47%
Depression	87% (42%)	88% (46%)	1%

## **Conclusion**

This is the first study that aimed at exploring an effective way of managing common psycho-social problems among adolescent learners in Zomba, Malawi. Psycho-social problems among adolescent learners are a global problem, associated with a range of adverse outcomes. They thus require urgent attention from the education, social welfare and public health sectors. This study has revealed high rates of psycho-social problems among adolescent learners attending boarding secondary schools in Zomba, Malawi. These findings are consistent with findings from other SSA studies. Due to the high levels of psycho-social problems among adolescent learners, education, social welfare, health care institutions and practitioners need to find new ways to identify, contain and provide adequate intervention and support for the adolescent learners. The study findings will help relevant stakeholders to be aware of the adolescent psycho-social challenges and how to manage them.

The results could be affected due to various reasons and not limited to the following; the time when the evaluation study was conducted. It was conducted a week before end of term test and the researcher's suspicion is that either adolescents were anxious about the impending examinations or there was no continued psycho-social support among adolescents by relevant stakeholders. The study was conducted during the period when Covid-19 prevalence was very high in the country and most the people were hopeless about the future because it was not clear when the pandemic will come to an end. This could also have affected the adolescents. Further, this study was conducted during the period when there was a national wide secondary teachers strike while adolescents were kept in school. This could also have affected the results of the study. In addition, the duration of the psycho-social intervention was only for two months. Therefore, the intervention period might not be sufficient and hence future studies should focus on increasing the duration of the psycho-social intervention among adolescent learners.

However, for future studies it is important to consider individual counselling as an additional approach when conducting a similar study. It might be helpful to compliment the combined approach of group counselling and psycho-education psycho-social intervention. In addition, there is need for teacher refresher trainings about the psycho-social intervention during the intervention period. Also, the use of peer intervention approach instead of using teachers as implementers of the psycho-social intervention among adolescent learners.

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**SOCIAL SCIENCES, HUMANITIES AND  
INCLUSIVITY**

## **Assessing the Prevalence of Board Performance Evaluation Practices in Malawi**

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### **Abstract**

Board performance evaluation is a critical tool for the improvement of the effectiveness of the entire Board because it measures the contribution that the Board makes towards the attainment of the institutions' strategic goals and also prescribes capacity building measures directed at addressing any identified gaps. In the end, the Board's leadership, teamwork, accountability, decision making, communication as well as efficiency gets better and more importantly governance failures which may lead to fraud reduces. The purpose of this study was to assess the prevalence of board performance evaluation practices in Malawi with a view to identifying any policy, practical and academic implications. Data for the study was collected through a semi structured questionnaire which was administered to randomly sampled respondents drawn from board members and senior management of listed companies, private companies, statutory corporations and NGOs/CSOs. Results of the research indicate that many institutions in Malawi (62%) are undertaking Board performance evaluation with some (28%) not undertaking it and yet others (10%) not knowing if the practice has ever or is taking place in their entities. The research recommends that regulatory bodies like the Malawi Stock Exchange, the Reserve Bank of Malawi, Department of Statutory Corporations and the NGO Board should review the Code of Best Practice for Corporate Governance in Malawi, build capacity of the various Boards on the process of undertaking an effective Board performance evaluation and enforce implementation so as to improve the effectiveness of the Boards to effectively contribute to the socio-economic development of the country and in the end realization of the MW2063.

**Keywords:** Board, Board Performance, Evaluation, Effectiveness, Strategic Goals

### **Introduction**

Board performance evaluation is a fundamental practice meant to improve the effectiveness of the entire Board as it not only measures the contribution that the Board makes towards the attainment of the institutions' strategic goals but also prescribes capacity building measures aimed at addressing any capacity gaps that may have been identified by the process (Rasmussen, 2010). Apart from reducing and correcting corporate governance failures and scandals of big businesses, a properly designed and carried out Board performance evaluation can also grow the Board's leadership, teamwork, accountability, decision making, communication as well as efficiency (Kiel and Nicholson, 2005).

To properly grasp the meaning of Board effectiveness, there is consensus amongst many scholars (Nicholson & Kiel, 2004; Ong & Wan, 2003 and Lorsch, 1997) that an effective Board is one that has successfully played its strategic roles of control (monitoring management), strategy (providing direction) and service provision (advisory) through execution of its tasks and in the end is able to contribute to the achievement of strategic goals of an entity in a transparent

manner. Besides, use of effective Board decision making processes is also critical for the Board to be effective in their roles (Huse and Gabrielsson, 2012). In this context, Board Decision making processes refer to decision making processes of the Board (Zahra & Pearse, 1989) which can be broken into: (a) the healthy and sometimes rigorous discussions on corporate issues and problems so that decisions can be reached and supported (Anderson & Anthony, 1988) and (b) the organizing and running of the Board which need to be performed so that the objectives of the entity are achieved (Dulewicz, MacMillan & Herbert, 1995). Wageman, (1995) and Jehn and Mannix, (2001) suggest that effort norms, cohesion, conflict or debate, and presence and usage of various skills are some of the key dimensions of such Board decision making processes.

Often times, strategic goals of an organization are a function of the key stakeholders interest (Mayor, 2017); for example, private companies will mostly but not always be inclined to maximizing shareholders wealth, whereas public companies and Non Profit making entities will chiefly aim at maximizing service provisions. Depending on the nature of the organization, strategic goals must be broken into elements that can be measurable so they can be used as benchmarks to gauge directors' performance.

As pointed out earlier, an effective Board must be able to contribute to achievement of strategic goals in a transparent manner. Transparency is viewed from two perspectives (Ong & Wan, 2003): the ability of the Board to provide complete information to its stakeholders and also the timeliness of the provision of that information. Financial statements with the usual income statement, balance sheet, statement of cash flow, statement of changes in equity and notes are considered to be complete information whereas dissemination of this information within six months from the end of the financial year is, by and large, deemed to be timely.

However, important as the Board performance evaluation practice is, little is known about its occurrence amongst entities in the key sectors of the Malawi economy. This study, therefore, aimed to determine the current prevalence rate of board performance evaluation in Malawi so as to provide recommendations to corporate governance and other policy holders in key sectors of the economy including regulators, board members and academicians.

The remainder of this paper is organized as follows: section two reviews literature on the concept of Board performance evaluation, its regulation and prevalence. This is followed by an explanation of the methods that were used to collect data for this research in section three. Section four presents the results of the study and corresponding discussions of their implications and finally conclusions, recommendations, implications of the study and areas for further research are contained in section five.

### **Materials and methods**

The research methodology adopted for this study is discussed in this section. Data for this research was collected through a semi structured questionnaire which was administered to board members drawn from Malawi Stock Exchange listed companies, private companies, statutory corporations and NGOs who were selected using a formula by Yemane (1967). Using Yamane (1967) formula, the sample size was determined at 95% level of confidence and assumed  $P=0.5$ . P value is a measure of the probability that an observed difference could have occurred just by random chance.

The formula is as follows:

$$n = \frac{N}{1 + N(e)^2}$$

Source: Yamane (1967)

Where n = Sample size; N = Population; e = level of precision. When these are substituted we get: N = Population = 9 Board members \* 356 entities = 3, 204 Board members; e = 0.05; n = 356 respondents. Adding 10% and 30% to the sample size to compensate for respondents that the researcher had failed to reach and those who had not responded respectively (Israel, 1992) the sampled size came to say 500 (125 Companies were reached). This means that the sample size for this research was 500 respondents from 125 Companies, 4 Board members from each Company. Data collected for the study was analysed using descriptive statistics and SPS software. Chi Square Tests were carried to determine if the responses were statistically different or not.

## Results and Discussions

In this section, findings of the survey are presented and discussed. Specifically, respondents are characterized and interpreted and finally, results of the prevalence of Board Performance Evaluation practices in Malawi are presented and interpreted.

### Demographic Factors

A total of 174 participants took part in this study with male respondents (71%) being in majority. Interestingly, most of them were aged between 40 and 59 years (77%), with masters' degree (65%) and had also served on Boards for a period ranging from 3 to 10 years (64%). Surprisingly, the majority of the respondents came from Non-governmental Organizations (31%). The remaining participants were drawn from State Owned Enterprises (28%), Private Companies (26%) and Listed Companies on the Malawi Stock Exchange (15%). Figures 1 – 5 depicts the rest of the characteristics of the respondents in this research.

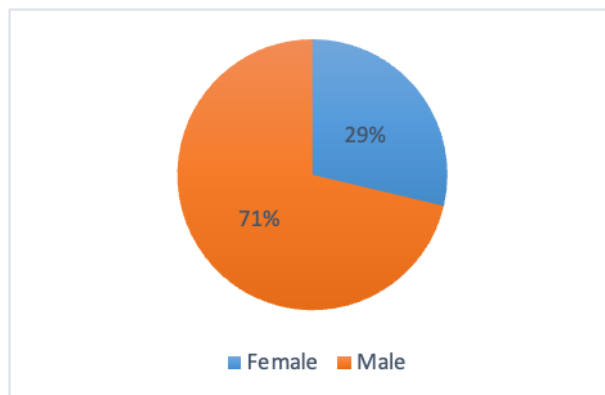


Figure 1: Gender of Respondents

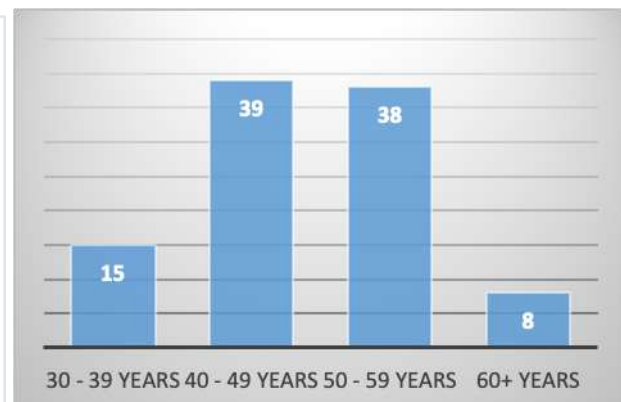


Figure 2: Age Category of Respondents

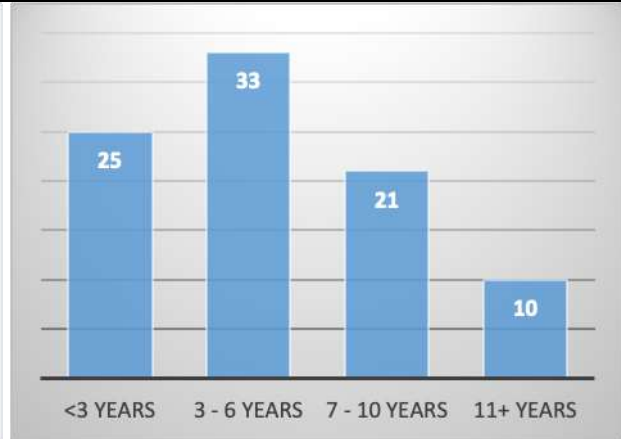
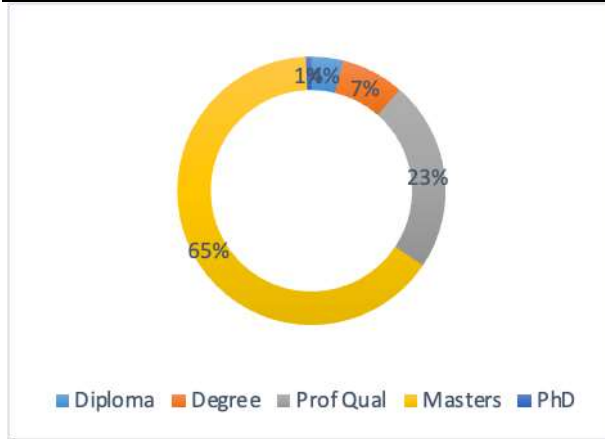


Figure 3 Education Levels of Respondents

Figure 4 Period of Respondents Board Membership

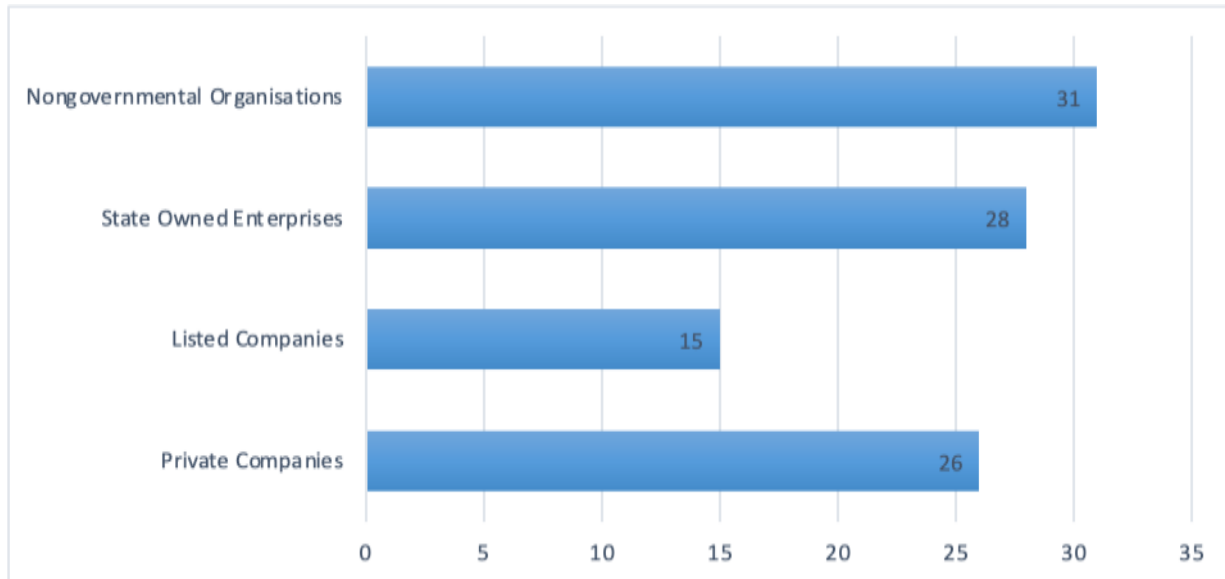


Figure 5 Type of Entity from which Respondents were drawn from

The low women participation (29%) in this study means that their representation at Board level is equally low, despite them being in majority in Malawi (51%) according to the 2018 NSO Census. This could partly be a reflection of the current Board of directors’ recruitment policies being implemented in most entities in Malawi, which represents a sharp disparity to a number of legal and policy instruments advocating for gender equality (Constitution of Malawi – Sections 20, 24 and 41, Sustainable Development Goal # 5, Gender Equality Act, 2013, National Gender Policy and Malawi 2063 Agenda). Nonetheless, at 29%, female participation was not bad considering where the country is coming from as far as women participation in higher positions is concerned.

Furthermore, it was encouraging to note that most respondents were aged between 40 and 59 years, with master’s degree and had also served as Board of directors between 3 and 10 years. This is a welcome development as it implies that most respondents in this research were mature,

well-educated and experienced enough in corporate governance issues and therefore able to strategically apply their minds and consciously reflect on issues based on both their education and previous experience on the Boards thereby increasing the credibility of the results in this study. Nevertheless, considering that the results have further indicated that 31% of respondents had been serving on Boards for more than seven years, there are higher chances of members compromising their independence due to familiarity and therefore this may hinder their efficient oversight and control roles (Solomon, 2017) or not being able to bring in new innovative ideas.

Finally, as earlier intimated, most respondents in this research came from the NGO sector, State Owned Enterprises, and Private Companies. The other respondents that took part in this study came from Listed Companies. The dominance of participants from the NGO sector means that there are more NGOs in Malawi, seconded by State Owned Companies then Private Companies and lastly Listed Companies as evidenced by entities registered with the Malawi Confederation of Chambers of Commerce and Industry (Private Companies), Department of Statutory Corporation (State Owned Enterprises) and NGO Regulatory Authority (NGOs) and Listed Companies (Malawi Stock Exchange). On one hand, the mushrooming of NGOs in Malawi could be a response to the change in policy by Donors to stop providing budget support to Government following the rampant corruption in Government and instead channel resources through NGOs. On the other, the dwindling of private companies in Malawi is a worrisome development considering that Private Companies are the “engines of development in any country” as they contribute a great deal to the socio-economic development by way of job creation, payment of taxes, provision of goods and services, and community development through Environmental Social and Governance (ESG) initiatives amongst others.

### **Prevalence of Board Performance Evaluation**

The aim of the research was to assess the prevalence of Board Performance evaluation practices in Malawi. Respondents were asked to state whether (a) their entities have ever undertaken a Board performance evaluation, or (b) they have not ever taken a Board performance evaluation, or (c) they don't know if a Board performance evaluation has ever been undertaken.

### **Entities that Undertook Board Performance Evaluation**

Figure 6 presents results of the respondents on Board Performance Evaluation in their entities.

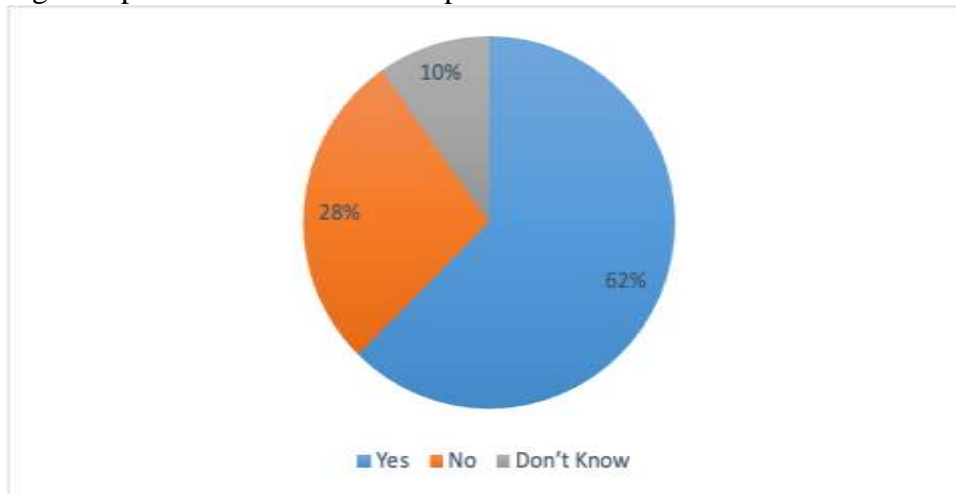


Figure 6 Respondents Views on Board Performance Evaluation in their Entities

The results show that 62% of the respondents have ever undertaken a Board performance evaluation in their entity, whilst 28% have not ever carried out one and 10% don't know. Results of a Chi-Square test reveal that those who indicated that their entities have ever undertaken a Board performance evaluation and those who said they have not ever undertaken one are statistically different, N108, Chi-Square=23.07,  $P < 0.001$ . This means that most entities in Malawi do undertake Board performance evaluations.

However, considering the mixed bag of entity performances in Malawi, with a few doing well (largely Listed Companies) and the majority with average to poor performance (mostly Private Companies, State Owned Enterprises and NGOs), it is more likely than not that entities which are currently undertaking Board Performance evaluations are not benefiting from the difference that an effective Board performance evaluation exercise is meant to bring about in form of improved Board effectiveness leading to better contribution to the achievement of entities strategic goals (Rasmussen, 2010). This is evidenced by the current state of affairs in Malawi where, the performance of most State-Owned Enterprises, Private Companies and NGOs alike is characterized by poor performance, failure to adapt to changing and complex environment, poor service delivery, and corruption including lack of accountability which in some cases lead to donor suspension of funds.

#### **Entities that did not undertake Board Performance Evaluation**

28% of the respondents indicated that entities they serve have never undertaken a Board performance evaluation (figure 6). Amongst these entities, who reported that their board's performance has never been evaluated, 23% were from Private Companies, 4% from Companies Listed on the MSE, 28% from State Owned Enterprise, and 45% from NGOs as depicted in figure 7.

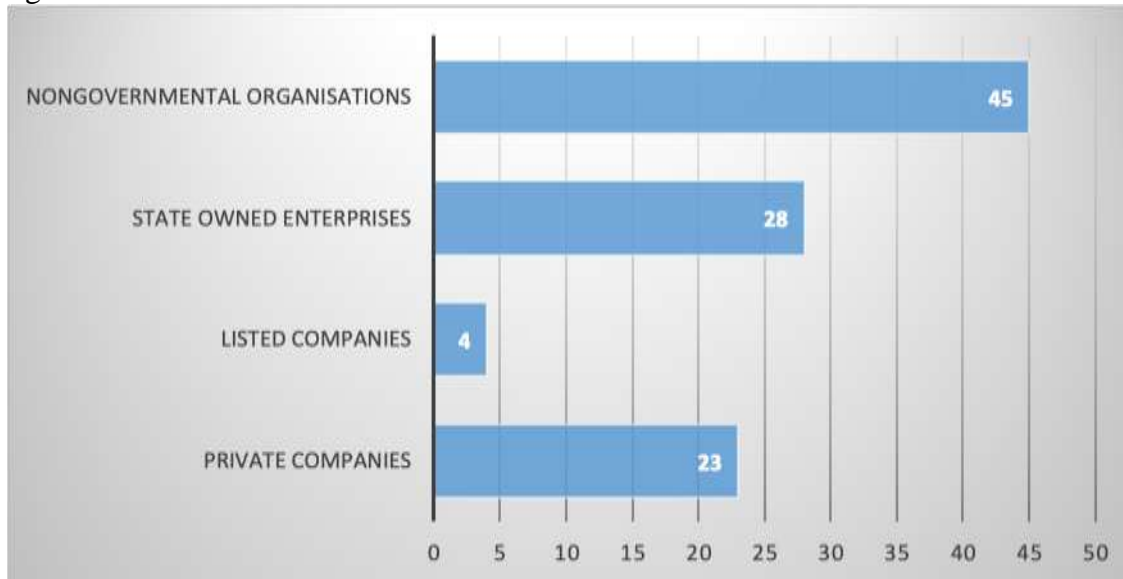


Figure 7 Type of Entities from where Respondents who had never undertaken Board Performance were drawn

This means that, on one hand, the majority of entities that do not undertake Board performance evaluation are from the NGO sector seconded by State owned enterprises, contrary to the requirement of the Malawi CODE II on Board performance evaluation which is, unfortunately, not legally binding on NGOs or any entity in Malawi. On the other hand, despite the Malawi Code II not being legally binding, most listed companies do undertake Board performance evaluations presumably on account of the public scrutiny they are subjected to as public companies who force them to comply with good corporate governance practices as demanded by the Malawi CODE II, which in the end pays them through good performance.

### **Conclusion**

The aim of the study was to determine the prevalence of Board performance evaluation practices in Malawi. Data was collected during the month of July 2022 from a sample of directors drawn from private companies, listed companies, state owned enterprises and Non-governmental/Civil Society Organization. The research has provided strong empirical evidence that most entities in Malawi undertake Board performance evaluations.

Although the study has established that many entities are carrying out Board performance evaluations, to increase its effectiveness, the following recommendations are being made:

- (a) Entities must come up with Board recruitment policies that will ensure that the composition of the Board takes into account gender equality, age diversity and experience as there is strong empirical evidence that suggest that presence of women on the Board improves decision making as women have been proved to be generally more financial risk averse than men (Byrnes *et al*, 1999) and less over confident (Barber and Odean, 2001). Similarly, involving the youth on the Board increases energy to innovation and success (Houle, 1990).
- (b) Considering that the study has demonstrated that there are less private companies in the country (compared to NGOs and state owned enterprises), this research strongly recommends that an investigation into factors that hinder incorporation or accelerate closure of companies be undertaken with a view to coming up with measures to address them, considering that private companies play a significant role in the socio-economic development of a country.\
- (c) Considering that entities that are undertaking Board performance evaluation are not benefiting much from the process, there is a strong need to understand the process they are following to undertake the evaluation with a view of identifying any gaps in the process so as to benefit them. This can only be achieved if entities undertake the Board evaluation process as a means to improving Board efficiency and not as an end in itself or a “tick the box” exercise (Conger and Lawler III, 1998),
- (d) Finally, since there are a number of entities that do not undertake Board performance evaluations and others who don’t know about it, there is need for regular guidance, sensitization and training from policy holders (regulators) on the importance of carrying out a Board performance evaluation.

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## **Heritage Language and Conflictual Ethnic Identity: A Case Study of Chichewa-Speaking Zimbabweans**

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### **Abstract**

The current study explores how heritage language proficiency affects the ethnic identity of young university-going Malawian-Zimbabweans students who have maintained a high level of heritage language proficiency. The study is particularly instrumental because usage of Chewa as a heritage language is fraught with complex issues affecting their relation to the dominant culture and their position in Chichewa-speaking culture. The study uses migration, heritage language use and proficiency, and ethnic identity construction as theoretical framework. The objective was to explore the perceptions of young Malawian-Zimbabweans told Chewa as their heritage and how the language affects their identity. A mixed-method approach focused on in-depth interviews triangulated with quantitative data from a survey questionnaire to investigate meanings of heritage language use and its impact on identity formation. One-hundred and thirty-two youths in Harare, Mutare and Bulawayo completed the questionnaire. Twenty-four took part in-depth interviews to discuss connotations, viewpoints, views, and principles undergirding the use of Chewa. Respondents felt an array of emotions related to their use of Chewa as a heritage language ranging from pride to shame considering the ‘othering’ of Malawian-Zimbabweans. The study reveals that a high level of heritage language proficiency is not necessarily associated with a heightened sense of ethnic identity for the selected students. Interview data suggest that participants’ perceived expectations from society in general contribute to identity conflicts. A path to maintaining heritage language should start from creating a safe environment, especially in schools where heritage language speakers are protected from negative stereotypes.

**Keywords:** Heritage language, Malawian-Zimbabweans, ethnicity, cultural identity, Chichewa, heritage language proficiency

### **Introduction: Malawian-Zimbabweans - The Migrant ‘Other’**

Malawian-Zimbabwean youth grow up in a complicated political, administrative and cultural context (Daimon 2016; Muzondidya 2007; Mashiri 2010; Groves 2012). Often their citizenship is in limbo, they face harassment during times of political competition, and as progeny of immigrants they are generally looked down upon, castigated by the political elite and marginalised from citizenship (Daimon 2016; Mashiri 2010). It is important to better understand how multilingual youths perceive themselves and come to terms with their identity while living in challenging social contexts. The study examined the multifaceted nature of ethnic identity these young people hold and its link to the Chichewa language. Thus, factors such as perceived self-identity, and the dominant culture are closely examined.

The term Malawian-Zimbabwean is used in this study to mean people whose ancestry is of Malawian origin but have Zimbabwean citizenship (Mashiri 2010). Malawian-Zimbabweans face denigration which is visible through labelling and stereotyping intended to disparage them.

Labels such as ‘Mabhurandaya’ (in reference to Malawi’s largest commercial city), and ‘Manyasalande’ (implying those from Nyasaland which was Malawi’s colonial name). These two labels were clearly intended to remind Malawian-Zimbabweans of the poverty stricken nature of their original homeland in comparison to resource filled Zimbabwe. Even worse is the label ‘vateera njanji’ meaning those who followed the railway line on foot to get to Zimbabwe. Other labels were intended to emphasize the Malawian-Zimbabweans as aliens. These include ‘mabvakure’ meaning those from far away, ‘marudzi’ meaning foreigners or aliens and ‘mabwidi’ (stupid social failures who lack an ancestral home).

In addition to the preceding, Malawian-Zimbabweans face uncertainty about their citizenship. According to Muzondidya (2007), starting with the British colonial administration, Malawian migrants were registered as aliens. Rutherford (2008, p.83) notes under the white Rhodesia rule, the practice of registering Malawian migrants continued. The same practice was inherited by the independent Zimbabwe government in 1980. This means that most Malawian-Zimbabweans have an uncertain legal citizenship in Zimbabwe.

The post-colonial state did not offer Malawian migrants any route to citizenship. Muzondidya (2007) argues that the post-colonial state adopted an exclusionary view to citizenship that gave citizenship rights to ‘native African’ or ‘vana vevhu/abantwana bomhlabathi’. As both Muzondidya (2007) and Daimon (2018) note, ‘vana vevhu/abantwana bomhlabathi’ were specifically the Shona/Ndebele group. Thus, a separation was created between the indigene Shona/Ndebele, and the African migrants from other countries such as Malawi, Mozambique and Zimbabwe. This dichotomy, according to Daimon (2018, p.1098), places Malawian-Zimbabweans “. . . at the mercy of autochthonous hegemonic power and living on the margins in states of unbelonging.” Makoni (2011) argues that Malawian-Zimbabweans occupy an ambiguous legal and cultural space as alien immigrants even though Chichewa is a dominant language in some areas.

### **Theoretical Framework**

This study is concerned with effects of heritage language on the ethnic identity construction of third and fourth generation language speakers of ChiChewa in Zimbabwe. In determining the foregoing, the study will examine the socio-cultural context in which these young Malawian-Zimbabweans learn to speak ChiChewa and use the language. The findings will be examined within the context of ethnic identity construction, heritage language use and identity conflict theories.

### **Ethnic Identity and Heritage Language**

As a logical progression from the above, heritage language speakers must negotiate and navigate life through social contexts that are dominated by speakers of the main language (Peyton, Ranard & McGinnis, 2001). In the case of Malawian-Zimbabweans, this is English, Shona and Ndebele. They must locate their identity within these social contexts dominated by speakers of a language different from their heritage language. This comes with noticeable issues regarding power relations and social status in the society. It is from this point of view that understanding the identity and identity construction of heritage speakers becomes important. Researchers of

ethnicity and heritage language link the development of positive ethnic identity to heritage use (Phinney, Romero, Nava , & Huang, 2001; Tse, 1997).

Contrary to the above, other studies indicate that proficiency levels in heritage language are not necessarily accurate in measuring the ethnic identity (See Kim & Chao 2009). Further, other studies (see Brown 2007) found that other young heritage language speakers only use their proficiency in the heritage language to gain access to and participate in cultural activities without raising ethnic consciousness. Other studies have not indicated links between heritage language use and ethnic identity development or consciousness (Smolicz, 1992; Mah 2005).

### **Identity Conflict**

Erikson (1968) argues for the importance of a supportive social environment for bilingual and bicultural children. Brown (2003) argues that bilingual/bicultural children should be monitored since they face a more complicated situation in negotiating personal values and expectations from the two different cultures. The situation for bilingual/bicultural children is complicated by the perception that the dominant culture and language is more prestigious and of high status than their own heritage culture and language. Thus, as Tse (1998) notes, these children usually feel more drawn to and compelled to adopt the dominant culture and dominant language. This has a negative impact on the development of a positive identity towards the heritage language and culture.

### **Material and methods**

#### **Research Design**

This is an exploratory rather than a hypothesis-driven study. A qualitative approach was designed that focused on in-depth interview to investigate meanings, ideas, beliefs, and values, allowing deeper examination of youth perceptions concerning heritage language use and its impact on identity formation in Southern Africa. The intent and purpose of the data gathering methods was to answer the following research questions:

1. In what way does heritage language proficiency influence young Malawian-Zimbabwean to develop a sense of cultural identity?
2. What are the characteristics of cultural identity of Malawian-Zimbabweans who maintain the ChiChewa language?

For the sake of convenience, this study adopts the United Nations' definition of youth as '... an individual female or male aged between 15–24 years'<sup>2</sup>. This definition implies that youth is a transitional state, since persons younger than 15 years are considered children and those older than 24 are considered adults.

#### **Participants Selection and Sample**

Beginning in November 2020, the researcher purposefully selected 24 to interview in-depth on the same subject of Chewa as a heritage language. See Table Two below for an age and gender profile of the in-depth interview participants. Each participant had to meet the following criteria:

- a. Speak Chewa, and use it extensively;

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<sup>2</sup> <https://documents-dds-ny.un.org/doc/UNDOC/GEN/N81/165/83/PDF/N8116583.pdf?OpenElement>

- b. Born and raised in Zimbabwe;
- c. At least one parent must be Malawian-Zimbabwean who uses Chewa regularly;
- d. be in the age range specified for the study, which is 18-24;
- e. be in a university or in post-secondary school education or training.

As a Malawian who was born and raised in Zimbabwe, the researcher was able to recruit the participants through his connections to Malawian-Zimbabweans in Harare, Mutare and Bulawayo.

### **Data Collection**

The researcher travelled from Lilongwe, Malawi to Harare, Mutare and Bulawayo in Zimbabwe nine times during this period to collect data. The research process began in mid-May 2021 and April 2022. The researcher conducted one-on-one interviews with the 24 selected participants. The interviews were guided by a semi-structured in-depth interview guide. All participants choose to do the interview in English; however, during the interviews, participants would frequently switch to ChiShona or ChiChewa. Each in-depth interview lasted between 60 minutes and 90 minutes.

### **Data Processing and Analysis**

All in-depth interviews were audio-taped and transcriptions made of the proceedings. The recorded interviews were transcribed into verbatim data. Each interview was saved as a separate Word document. The 24 Microsoft Word documents were then uploaded into the qualitative data analysis software, QDA Miner. Using the software as a coding tool, the data were broken down and placed under various emerging themes.

### **Ethical Consideration**

No deception was used to identify the participants in this study. Respondents were advised that they were under no obligation to participate in the research and that they could withdraw at any time. Since participation was voluntary and anonymous, no information that could be used to identify the participants was collected.

### **Results**

In three main themes, the data analysis revealed how young Malawian-Zimbabweans identify themselves, and how the ChiChewa language positively or negatively impacts on the cultural identity formation. First, participants felt forced to assume a dual cultural identity due to the lowly status of the ChiChewa language in Zimbabwe and due to the dominance of ChiShona. Participants identified as Malawian-Zimbabweans because they spoke ChiChewa, but more crucially because their ancestral homes (kumudzi) are in Malawi. Further, lacking such ancestral homes (kumusha) in Zimbabwe exposes them as immigrants.

### **Cultural Identity: To be or Not to Zimbabwean?**

Even though the participants were in no doubt about their citizenship, P4/M's reply revealed the complex and ambivalent feelings that the participants felt about their cultural identity. Assuming a Malawian cultural identity was viewed almost universally as a burden. Even though all participants are legal Zimbabwean citizens, they felt hard pressed to identify with any of the ethnic groups in the country. The following remarks signify this: argued:

*I have no ancestral home in Zimbabwe. I can't help feeling Malawian (P4/M).*

*I feel as though I am compelled by forces around me to identify as Malawian from a cultural point of view . . . even though I know that I am a Zimbabwean (P9/M).*

Thus, for these participants, cultural identity is something that has been forced upon by fate. Even though they remain legal citizens of Zimbabwe, family and the dominant culture detect that they remain culturally of Chewa stock. There is an almost resigned acceptance of a Malawian cultural identity in the face of subtle rejection from the dominant culture and family circumstance. Thus, they identify with Malawian culture because it is what is expected of them. The above situation is a reflection of identity conflicts as Erikson (1963) and Phinney (1990) argue. As Karpava (2021) argues, second and third generation heritage language speaker can suffer negative self-esteem and internal conflict if they experience discrimination from the dominant culture. While conflict is inherent during identity formation, it is even more pronounced for those who speak a heritage language (Karpava, 2021). Given rejection from the dominant culture, Brown (2009) notes how second or third generation immigrants also face societal pressure to conform to the heritage language culture rather than to the dominant culture. Brown (2009) also demonstrates that such pressure emanates from the use of heritage language and maintenance of heritage culture at home.

### **Influences of Heritage Language on Ethnic Identity**

The youthful respondents in this study indicated that being able to speak Chichewa made them identify more with the larger Chichewa speaking people in their immediate community and farther. Other studies (See for example) have found that there is a link between heritage language proficiency and ethnic identity. What is unclear is whether this is positive or negative. Brown (2009) and Yu (2015) were unable to establish this properly with indications that such ethnic identity could actually be negative. However, participants in this study were able to establish a positive identity. Witness the following remarks:

*The reason why I can be confident about my Malawian ancestry is because I speak the Chichewa language; otherwise there is no difference between me and any other Shona boy out there.*

*I am in touch with my Malawian side . . . because of the language.*

It would appear as though these participants' confidence in their ability to speak the Chichewa language resulted in a better-defined self-concept of their place in the dominant culture and the culture of their heritage language. It is unclear if this was helpful in negotiating the conflicts of everyday life. What is clear is that for some of the respondents, the ability to speak the heritage language did not mean that they positively identified with being of Malawian origin.

### **Pride and Belonging**

Some of the participants spoke of their ability to speak ChiChewa as an integral part of their cultural identity and heritage. Further, they tended to view this ability as a powerful marker of belonging to a distinct group of people albeit one that was silenced. They tended to view belonging to the imagined community of ChiChewa speakers in Zimbabwe as a form of security and a mark of visibility amid a dominant culture that looks down on them. This, in turn, gave rise to defiant pride in their linguistic heritage. Some participants spoke of being able to read the Bible in ChiChewa and teaching Sunday school and catechism at church. Witness the following remarks:

*Whenever I meet other speakers, it is a great joy to speak the language because it means that at least we're distinct from the Shona.*

*. . . we have a language even though it is despised and ridiculed.*

Being able to speak ChiChewa fluently brings a sense of connection to Malawi for all the participants. The participants are now able to connect with relatives in Malawi through mobile telecommunications. The sense of pride does not just stem from belonging and connectedness. It also stems from learning Chewa culture in Chichewa.

### **Shame and Alienation**

Unfortunately, feelings of pride and belonging exist alongside feelings of shame and alienation. The participants opened up about the feelings of shames generated by the perception of ChiChewa as a lowly language, spoken by a lowly people. These feelings went in two different directions. First, knowing and speaking the language brought shame because it became an immediate marker in the dominant culture that signified them as people who do not belong to Zimbabwe therefore objects of derision. Second, low proficiency in the language brought shame to the participants for not knowing their own language and culture well.

Earlier sections of this article discussed the traditional practice of ethnic contempt that is practiced between the Shona and the Chewa in Zimbabwe (Mashiri 2007). The participants in this study have all felt the stinging contempt of the dominant culture towards ChiChewa and its speakers. The ChiChewa language is the most obvious marker of a Malawian-Zimbabwean. Both the language and its speaker become objects of scorn. Witness the following remarks:

*. . . my friends would hear my parents speaking in ChiChewa . . . and I would be brutally mocked at school for it.*

*. . . the teacher began speaking to me in broken ChiChewa. It was all intended to humiliate me . . .*

*They speak broken Chichewa to you . . . it just feels like a vicious verbal attack.*

The preceding demonstrates feelings of shame at the lowly status of their heritage language. Some of those feelings persisted into adulthood. Terms such as 'humiliate', 'attack', 'contempt', 'mockery' used in the preceding quotations illustrate the symbolic violence and verbal aggression employed by the dominant cultures on these youthful Malawian-Zimbabweans.

### **Discussion**

In ensuring the sound development of ethnic identity, one option for ethnic minorities is to adopt a dual or hyphenated identity, for these participants, Malawian-Zimbabweans. Of course, this raises the questions of whether hyphenated identities are the choice of the heritage language speaker or imposed by social and legal circumstances. Identity development is socially constructed with language playing a part. The participants in this study clearly assert their Zimbabwean citizenship and choose to identify themselves as such. At the same time, they know the dominant culture imposes on them an ethnic identity. This study has also established that proficiency in the heritage ChiChewa language is not a guarantee for strong identity feelings. Even those participants that expressed high ChiChewa proficiency felt the disorienting perception and confusion and conflict with respect to ethnic identity.

This study has shown that society exercises a great influence on these individuals, negatively impacting the way ethnic minority students feel about their ethnicity. Therefore, the public needs to share some level of responsibility as to the way heritage language speakers feel. If the great

majority of the public accepted ethnic diversity and practiced tolerance, heritage language speakers would not feel different about themselves.

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## **Interrogating Causal Links Between Government Expenditures and Funding Sources. Catalyst for Private Sector in PPPs. A Case of Malawi.**

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### **Abstract**

This empirical study examines the causal links between monthly government expenditure and tax revenues, grants and loans at consolidated national level for Malawi Government using data sets from 2004 to 2007. The data and models are subjected to statistical tests like Stationarity; Granger Causality; Autoregressive; and Autocorrelation (1st order). Findings show no causal link between government expenditures and tax revenues supporting hypothesis that “Government expenditures and Tax Revenues are decided independent of each other” while loans and grants Granger cause expenditures. Revenue and expenditure independences denote the government budget was under control or affected by divergent interests and agendas. Unidirectional loans and grants causalities to expenditures imply Malawi economy is small and weak, with budget deficits only bridged by intensified revenue collection and prudent expenditure decisions. Such studies establish government’s financial capacity to fulfil financial obligations in Public-Private Partnerships which also guides private sector in deciding extents of their participation.

**Keywords:** government-expenditure, tax-revenue, causality, economy, public-private partnerships.

### **Introduction**

Gounder et al. (2007) proclaims that governments aspire to achieve economic growth with low debts and friendly fiscal policies. Increase in taxes for accommodating government spending affects the capital investments by investors as they fear subsequent higher taxes. Malawi experienced growth in expenditure as a percentage of GDP since its independence attributed to growths in government revenue, government services driven by population growth, services containing unemployment and increased government employment. Goetz (1977) established that different states’ ideologies, systems and theories underpin fiscal policies regarding government taxes and expenditures. Moisiu (2001); Baffes and Shah (1994) in their studies found empirical inconsistencies to substantiate ideologies and theories backing government fiscal policies moderating taxes and expenditures hence the need for more research to attain consistency. Variations imply that states are prone to divergent findings hence there is no blanket application to them all.

There are various interlinks between states’ ideologies and economic, political and financial systems. Fiscal Illusion theory links government growth to convoluted tax systems that mask the costs of public goods (Goetz, 1977). However, empirical support for these theories has variations leading to some loss in their quick progress hence warranting more research so that consistency is achieved (Moisiu, 2001; Baffes and Shah, 1994). Understanding the government budgetary process and rational influence on fiscal choices are dependent on the ability to predict the impacts of policy on the behavior of government sectors. This can offset influences of temporal policy measures like temporal cuts in grants, changes in taxation rules and changes in business tax revenue sharing

among government sectors. Nevertheless, understanding causality links and relationships between government expenditures and adjustments in various funding sources may help in making informed decisions when it comes to policy formulation and implementation. Most literature in the area of government spending has focused on factors attributing to growth in government expenditures. Empirical studies have shown that in most resource endowed countries; the tax revenue-spend hypothesis usually holds since they enjoy high proceeds from foreign exchange earnings that determine their spending pattern. For least developed countries, the links and relationships have not been fully established to substantiate the rapid growth in expenditures and policy orientation so that knowledge gaps are bridged through formulation and implementation of pertinent fiscal policies that can win private sector's trust to invest in public-private partnerships and re-invest their returns.

The major purpose of this study is to examine the causal links and relationship behavior between Malawi government expenditures and revenue sources, that support financial year budgets; to inform expenditure plans, taxation structure, annual fiscal budgets and fiscal policy for the country. This paper tries to examine and establish policies (spend-and-tax; tax-and-spend or fiscal synchronization) as they apply to Malawi and establish relationships between government expenditures and various government funding sources that support the government budget. For this, consolidated monthly national financial time series data is collected from 2004 to 2007 and analyzed to establish prevailing causalities. Bivariate and multivariate models are formulated with grants and loans as complementary variables, making the budget complete.

The rest of the paper is structured as follows: Section-2 reviews the existing literature and underlying hypotheses. Section-3 describes the sample and variables. Section-4 details the research methodology. Section-5 discusses the empirical findings. Section-6 concludes the paper and Section-7 provides references.

### **Materials and methods**

This study used bivariate and multivariate Granger causality models adopted from the works by Darrat (1998) in Turkey and Moalusi (2004) in Botswana. This acts as a benchmark to avoid the problem of omission of variables, a persistent problem in the earlier studies. Granger test is used because it is a simple test and widely accepted as a reliable test for causality between two variables. Bivariate and multivariate models include grants and loans as additional explanatory variables, being funding sources for Malawi government expenditures. Their inclusion is backed by Sobhee (2004) who recommended inclusion of necessary funds for small economy governments to avoid the situation of fiscal deficit.

In both bivariate and multivariate models, selected model specification tests like stationarity, granger causality, autoregressive, autocorrelation-1st order (Durbin – Watson), F-statistics and Wald Chi-square ( $\chi^2$ ) tests are applied to check the serial correlation and over-identification issues. The insignificant autoregressive terms (AR) of Durbin–Watson test indicates the absence of Serial Correlations. The insignificant p-values of Sargan test indicate no over-identifications issues while Durbin-Watson test with significant p-value implies the overall robustness of the model results.

### **Model specifications**

#### **Bivariate Distributed Lag models**

Adopted from L.M. Koyck approach (1954), are defined as in Equation 1 below: -

$$G_t = \beta_0 + \sum_{i=1}^{n1} \beta_{1i} G_{t-i} + \sum_{i=1}^{n2} \beta_{2i} TR_{t-i} + \varepsilon_1 \quad (1)$$

Where: G = government expenditure; TR = government tax revenue; and  $\varepsilon_1$  = white noise error term. The equation (1) represents causality from tax revenue (TR) to government expenditure (G) in presence of one month lagged government expenditure.  $H_0$ : TR does not granger cause G. The hypothesis be accepted if  $\sum \beta_{2i}$  are not significantly different from zero simultaneously. The model for the other  $H_0$ : G does not granger cause TR (TR being dependent variable) in presence of one month lagged TR, a second hypothesis, is as in Equation (2) below: -

$$TR_t = \phi_0 + \sum_{k=1}^{m1} \phi_{1i} TR_{t-k} + \sum_{k=1}^{m2} \phi_{2i} G_{t-k} + \varepsilon_2 \quad (2)$$

Where  $\varepsilon_2$  is a white noise error term. The  $H_0$  be accepted if  $\sum \phi_{2i}$  are not significantly different from zero simultaneously.

### Multivariate Distributed Lag models

Adopted from L.M. Koyck approach (1954), are defined as in equations 3 and 4 below: -

$$G_t = \beta_0 + \sum_{i=1}^{n1} \beta_{1i} G_{t-i} + \sum_{i=1}^{n2} \beta_{2i} TR_{t-i} + \sum_{i=1}^{n3} \beta_{3i} GR_{t-i} + \sum_{i=1}^{n4} \beta_{4i} L_{t-i} + \mu_t \quad (3)$$

$$TR_t = \phi_0 + \sum_{k=1}^{m1} \phi_{1i} TR_{t-k} + \sum_{k=1}^{m2} \phi_{2i} G_{t-k} + \sum_{k=1}^{m3} \phi_{3i} GR_{t-k} + \sum_{k=1}^{m4} \phi_{4i} L_{t-k} + \nu_t \quad (4)$$

Where: GR = Grants; L = Loans;  $\mu_t$  and  $\nu_t$  = white noise error terms. For equation (3),  $H_0$  : TR does not Granger cause G in presence of GR and L.  $H_0$  be rejected if  $\sum \beta_{2i}$  were significantly different from zero as a group. For equation (4),  $H_0$  : G does not Granger cause TR in presence of GR and L. The null hypothesis be rejected if  $\sum \phi_{2i}$  were significantly different from zero as a group.

Maddala (2008) and Gujarati (2006) urge that stationarity tests be done before performing causality test to avoid lagged, dynamic and non-stationary relationships between dependent and independent variables in regression models. Non - stationary data set be differenced to the appropriate level or proven to co-integrate/at equilibrium with another data set/variable data. E-Views software is used to perform the analyses.

## Empirical results

### Test for Data Stationarity

The respective stationarity test models for the variable time series in this study (G, TR, GR, and L) were formulated and run through Unit Root test (Augmented Dickey-Fuller/DF Test as per Dickey and Fuller, 1979 & 1981) as in Table 1 below.

Series Code	ADF Value	Prob.	Reject Null Hypothesis	ADF-1 Value	Prob.	Reject Null Hypothesis
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<b>G</b>	-2.964720	0.0474	**	and	***	-8.821088	0.0000	*	**	and	***	
<b>TR</b>	1.497296	0.9880				-15.07087	0.0000	*	**	and	***	
<b>GR</b>	-4.302667	0.0015	*	**	and	***	-6.789933	0.0000	*	**	and	***
<b>L</b>	-5.089485	0.0002	*	**	and	***	-7.378363	0.0000	*	**	and	***
1% Critical Value: -3.592462; 5% Critical Value: -2.931404; 10% Critical Value: -2.603944												
*: Significant at 1%;      **: Significant at 5%;      ***: Significant at 10%												

(Source: Author's compilation)

The results of data series for the variables indicate to be stationary. ADF test at levels show that the null hypothesis is rejected for G at 5% and 10%; TR not rejected; GR at 1%, 5% and 10% and L at 1%, 5% and 10% levels of significance. ADF at first difference indicate that all variables are stationary at all level of significance. In general, all variables are stationary at both levels and first difference except for TR, only stationary at first difference. Therefore, co-integration test was not run and the error correction model (ECM) not used in the study.

### Granger Causality Tests

As in Gujarati D.N. (2006) and Maddala G.S. (2008) the tests were run on both bivariate and multivariate models with government expenditure and tax revenue as dependent variables alternatively while grants and loans used as control variables in the multivariate models. Results are in table 2: -

**Table 2: Granger Causality Test Results for Bivariate and Multivariate Models**

Null Hypotheses, $H_0$	Lags: 1		Reject Null $H_0$	Lags: 2		Reject Null $H_0$
	F-Statistics	P-Value		F-Statistics	P-Value	
<b>Bivariate Models:</b>						
<i>Dependent Variable: G</i>						
TR does not Granger Cause G	0.72236	0.40043	No	0.1138	0.89275	No
<i>Dependent Variable: TR</i>						
G does not Granger Cause TR	0.00429	0.94813	No	0.9274	0.40458	No
<b>Multivariate Models:</b>						
<i>Dependent Variable: G</i>						
TR does not Granger Cause G	0.72236	0.40043		0.1138	0.89275	No
GR does not Granger Cause G	9.91918	0.00309	Yes	6.07639	0.00523	Yes
L does not Granger Cause G	20.1463	0.000059	Yes	8.18667	0.00114	Yes
<i>Dependent Variable: TR</i>						
G does not Granger Cause TR	0.00429	0.94813	No	0.9274	0.40458	No
GR does not Granger Cause TR	1.23504	0.27307	No	1.43408	0.25127	No

L does not Granger Cause TR	2.40698	0.12867	No	3.24699	0.05021	Yes, at 10%
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(Source: Author's compilation)

The results show that both bivariate and multivariate models do not have enough evidence to reject the two null hypotheses that tax revenue (TR) does not Granger Cause government expenditure (G) and government expenditure (G) does not Granger Cause tax revenue (TR) on specification of lags 1 and 2 hence they are independent of each other. Adjustments in grants and loans tend to have some granger causality on government expenditure (G) at lags 1 and 2.

## Bivariate and Multivariate Distributed Lag Models' Results

### Model Estimation and Interpretation

Bivariate distributed lag (1) or autoregressive model results for government expenditures (G) and Tax Revenues (TR) - equations (1) and (2) are provided as below: -

$$G_t = 2354.843 + 0.202405TR_{t-1} + 0.611242G_{t-1} \quad (1)$$

$$se = (1306.708) \quad (0.238146) \quad (0.127793)$$

$$t = (1.802119) \quad (0.849917) \quad (4.783055)$$

$$R^2 = 0.448183 \quad d = 1.897733$$

$$TR_t = 1172.987 - 0.003936G_{t-1} + 0.789776TR_{t-1} \quad (2)$$

$$se = (614.7964) \quad (0.060126) \quad (0.112046)$$

For bivariate models: From Equation (1), government expenditure (G) at time t is positively and significantly affected by own expenditure and total revenue (TR) at one period lag (t-1) but the effect is not statistically significant. For total revenue (TR), Eq (2), there is negative relationship between one period lagged (t-1) government expenditure, G (- 0.003936) and total revenue (TR) at time t, a unit increase in government expenditure (over-expenditure) at one period lag (t - 1) would reduce total revenue by a multiplier of 0.003936 at time t, though the G effect is statistically insignificant. For multivariate distributed lag (1) or autoregressive model results for government expenditure (G); Tax Revenue (TR); Grants (GR); and Loans (L) – equations (3) and (4) are as shown below: -

$$G_t = 2460.037 + 1.097029G_{t-1} - 0.327065TR_{t-1} - 0.171163GR_{t-1} - 1.012416L_{t-1} \quad (3)$$

$$se = (1145.617) \quad (0.264192) \quad (0.257720) \quad (0.234263) \quad (0.337775)$$

$$t = (2.147347) \quad (4.152393) \quad (-1.269071) \quad (-0.730645) \quad (-2.997312)$$

$$R^2 = 0.641630 \quad d - stat. = 2.05317$$

$$TR_t = 1184.877 + 0.666138TR_{t-1} + 0.112910G_{t-1} - 0.046026GR_{t-1} - 0.237264L_{t-1} \quad (4)$$

$$se = (641.0693) \quad (0.144216) \quad (0.147838) \quad (0.131090) \quad (0.189014)$$

$$t = (1.848282) \quad (4.61902) \quad (0.763745) \quad (-0.351101) \quad (-1.255276)$$

$$R^2 = 0.630414 \quad d - stat. = 2.568616$$

For Eq. 3, negative relationships exist with tax revenue, grants, and loans signifying that a unit increase in each of the cited explanatory variables at time lag of one month (t-1) lead to respective coefficient-based decreases in G in the subsequent month. Loan is the sole variable that is statistically significant. In Eq. 4, only one period lagged (t-1) tax revenue has a significant impact on tax revenue during the subsequent month(t). The results in both bivariate and multivariate

models with one period lagged dependent variables, are alike and support the hypothesis that there is no causality of any direction between government expenditure (G) and tax revenue (TR). Causality is only within a variable with current changes depending on the same variable at one period lag. This might suggest the controlled nature of fiscal system or policies, ceiling based.

### **Test for Autocorrelation - Model Robustness**

Bivariate and multivariate models underwent Autocorrelation (Durbin – Watson) Test, the Difference Method, and results are as presented below: -

#### **Bivariate Models**

$$G_t = 1757.577 + 0.78272G_{t-1} + 0.030304TR_{t-1} + [AR(1) = -0.162483]$$

$$se = (1241.353) (0.134558) \quad (0.216489) (0.176293)$$

$$t = (1.415856) (5.816964) \quad (0.139979) (-0.921663)$$

$$R^2 = 0.508629 \quad D-W \text{ stat.} = 2.065459 \quad \text{Prob (F - stat)} = 0.000000$$

$$h - \text{statistics} = -0.48 > -1.96$$

$$TR_t = 374.5787 + 0.9319TR_{t-1} + 0.008072G_{t-1} + [AR(1) = -0.537466]$$

$$se = (375.6089) (0.077378) \quad (0.040621) (0.142269)$$

$$t = (0.997257) (12.04352) \quad (0.198721) (-3.777824)$$

$$R^2 = 0.687533 \quad D - W \text{ stat.} = 2.69263 \quad \text{Prob (F - stat)} = 0.000000$$

$$h - \text{statistics} = 2.677 > 1.96.$$

Both bivariate models proved not having enough evidence for problem of autocorrelation (neither positive nor negative) as computed h– statistics is greater than that from tables (-1.96 or 1.96), hence the models are robust and capable of forecasting.

#### **Multivariate Models**

$$= 2003.937 + 1.166173 - 0.415828 - 0.114258 - 0.872929 + [AR(1) = -0.240012]$$

$$se = (995.6871) (0.249177) \quad (0.22571) \quad (0.232349) \quad (0.319097) \quad (0.165945)$$

$$t = (2.012617) (4.680102) \quad (-1.84231) \quad (-0.49175) \quad -2.735624 \quad (-1.446329)$$

$$= 0.690362 \quad D - W \text{ stat.} = 2.178861$$

$$= 551.1355 + 0.928689 - 0.030593 + 0.064987 + 0.003979 + [AR(1) = -0.532631]$$

$$se = (425.1608) \quad (0.110005) \quad (0.123831) \quad (0.119668) \quad (0.157133) \quad (0.147991)$$

$$t = (1.296299) \quad (8.442282) \quad (-0.247059) \quad (0.543061) \quad (0.025325) \quad (-3.599067)$$

$$= 0.697704 \quad D - W \text{ stat.} = 2.587316$$

Both multivariate models proved to not having enough evidence of problem of autocorrelation (neither positive nor negative) – D – W stat around 2 hence they are robust and capable of forecasting.

### **Conclusion**

This study interrogated the causal links between government expenditures and funding sources, a scenario for Malawi, in line with the methodology employed by Darrat (1998) and Moalusi (2004). Besides bivariate models, Koyck Approach (1954), distributed lag multivariate models were formulated. In the Distributed Lag multivariate models, grants (GR) and loans (L) are treated as control variables for ease of causality link analysis and their inclusion serves the purpose of avoiding the problem of omission of variables (funding sources supporting government expenditures). Time series aggregated monthly financial data at national level was used. E-Views statistical package was used to run the analyses.

Findings from bivariate and multivariate models provide alike results indicating that there is no causal link between tax revenues and expenditures in the scenario of Malawi for the period 2004/01 to 2007/08. This supports the hypothesis/theory that there is no causal link/interdependence between government expenditure and revenue. These findings are in line with those by Hoover and Sheffrin (1992) in a study on the US for the period 1970 to 1990. There are unidirectional causalities from grants and loans to expenditures in multivariate distributed lag (1)/ autoregressive models implying changes in lagged loans and grants affect current expenditures.

In practice, the negative relationship in multivariate model of government expenditures, as in Buchanan and Wagner (1978), suggested that deficits in Malawi Government budget can be corrected by raising more funds from taxes. Collecting more tax revenues and compliance to expenditure ceilings may, in the long-run, reduce dependence on grants and loans; and over-expenditure syndrome. Independent changes in revenues and expenditures (inconsistent with the fiscal synchronization hypothesis) point to situations where budget processes are seriously affected by divergent interests and agendas; and attempts to create causal interdependence between spending and taxing decisions with no tangible results.

Unidirectional causality from grants and loans to expenditures, in multivariate distributed lag (1)/autoregressive models reflect that Malawi's economy is small in size, dependent on exogenous support, weak and experiencing flypaper effect since past grant/loan innovations influence present expenditures.

Establishing government expenditure-revenue links portray government's financial capacity to fulfil financial obligations like in Public-Private Partnerships which also guides private sector in deciding extents of its participation. Government can gradually shift from exogenous financial and budgetary support by tightening tax evasion loopholes, engaging private sector players in PPPs for efficiency gains in managing existing public assets for provision of services at a fee or creating green assets and manage products or services based on an agreed viable business model.

Further research studies are recommended on long span time series and longitudinal data to establish prevailing government fiscal policies and theories practiced overtime for ease of forecasting the future scenarios.

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## **Motorcyclists Risk Perception and Implications for Risk Communication: A Study of Lilongwe Urban and Rural Motor Cycle “Kabaza” Operators.**

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### **Abstract**

The study intended to explore the relationship between driving-violation behaviours and the perceived causes of motorcycle accidents, and then to assess the contributions of each factor to the risk of active involvement in accidents among motorcycle taxi (kabaza) operators in both Lilongwe urban and rural areas. The study proceeded from the assumption that there is a relationship between driving-violation behaviours and risk perception. Theoretically, the study is guided by risk perception and risk communication frameworks. The main objective of the study is to explore risk perception and its relation to traffic rules violations among motorcycle taxi operators with a view to understanding implications for risk communication. Seventy-eight motorcyclists in seven different sites in Lilongwe were asked to complete a four-part questionnaire. The responses were analysed using measures of central tendency. Further, 28 radio programme producers and announcers in diverse community radio stations and 12 motorcyclists took part in-depth interviews. A third of respondents have been involved in at least one crash/fall during last 12 months. The majority indicated that their own risky driving behaviours were the main cause. Mass media producers reported that they were not really interested in conscientizing motorcyclists of safety measures on the road. The study lays the foundation for curriculum of information that professional mass communication can use as the foundation for a road safety campaign to alert motorcyclists. Mass communication professionals can use this information to approach experts in road traffic for more information and road safety tips for mass communication programming to reach motorcyclists.

**Keywords:** Motorcyclists, perception, Malawi, risk, behaviour

### **Introduction**

This extended abstract seeks to present findings on research done on motor cycle taxi (kabaza) operators risk perception and violation of traffic rules. The intent and purpose was to understand why motor cyclists hold such perception and commit such traffic offences because other studies done in other parts of the world have established that there is a link between traffic risk perception and traffic rules violation. For example, Cheng, Liu, Tulliani (2015) found that driving-violation behaviours and risk perceptions are significant predictors of involvement in motorcycle accidents. These authors found that motorcyclists involved in accidents demonstrated more aggressive behaviours. In addition, these motorcyclists exhibited lower perceptions of risk from both driving and environmental factors.

Another reason of doing this study relates to how mass communication can be used to educate motor cyclists on traffic safety. Since risk perception is a major foundation for risk communication (Bianco, Trani, Santoro, & Angelillo 2005). Further, proof from various studies demonstrate that expert

communication of risk is very important in educating people to avoid dangerous situations and adopt preventive measures against risk (Marynissen, & Ladkin 2012).

This study is particularly pertinent for Malawi. Malawi is among those countries with a high number of traffic accidents in the SADCC region. According to the World Health Organisation (WHO) about 20 road traffic collisions occur every day in Malawi. Further, estimates that of these, two end up being fatal and two end up as serious injuries. In addition, WHO also estimates that 1000 people are killed in road traffic accidents in Malawi every year (WHO). WHO blames the lack of a national strategic plan for road traffic accidents prevention, lack of capacity in the relevant institutions, and poor data collection and dissemination of road traffic accidents. Given the above statistics, it becomes clear that road safety is a major problem in Malawi.

With the continued rise of motor cycles, the number of motor cyclists involved in road accidents as also risen. One of the reasons why motorcyclists contribute to the high number of road accident fatalities is because they are vulnerable road users with very limited protection (Daniello, Swanseen, Mehta, & Gabler, 2010). Fatigue is also likely to be an issue for those motor cyclists who actually use the motor cycle to earn a living or those who work long hours and technical jobs (Oxley, Yuen, Ravi, Hoareau, Mohammed, Bakar, & Nair, 2013).

The population growth in both the urban and rural area of Lilongwe has fueled the growth of both the bicycle and motor cycle taxi (Kabaza) industry. Further, motor cycles are being viewed increasingly as an easy way of negotiating the intractable traffic congestion in Lilongwe City. Indeed, the motor cycle is viewed by both farmers and businessmen as an easy way of transporting portable goods into the rural areas. Motor cycles have become relatively affordable and readily available from Chinese vendors in Lilongwe and in neighbouring Mozambique. Based on the preceding factor, the motor cycle taxi business has boomed in both the urban and rural areas of Lilongwe.

The primary aims of this study, therefore, were to explore the relationship between driving-violation behaviours and the perceived causes of motorcycle accidents, and then to assess the contributions of each factor to the risk of active involvement in accidents among motor cycle taxi (kabaza) operators in both Lilongwe urban and rural areas. Further, the study aimed to understand how best to reach motor cycle taxi operators with vital education on traffic safety based on their perception of risk and actual riding behaviours. The study proceeded from the assumption there would be a relationship between driving-violation behaviours and risk perception. Specifically, the study sought to:

- a. Uncover the extent to which motor cyclists engage in risky driving when operating their motor cycles.
- b. Understand how motor cyclists perceive risk when operating their motor cycles.
- c. Ascertain the best ways to reach motor cyclists with information on road traffic safety.

### **Existing Knowledge:**

Mobility is an important and prominent activity for survival in today's modern world. The American Occupational Therapy Association (2002) defined mobility as "moving oneself in the community and using public or private transportation." Thus, individual mobility is also important because it is major marker of individual independence. Viewed in that context, citizen need mobility to earn a living, remain connected to friends and family and to achieve leisure aims. Further, given the varied

economic status and ergonomic needs of different citizens, choice of mobility and transportation becomes very essential (Di Stefano, Stuckey & Lovell, 2012).

Given the above, professional communicators have an important role to play in modern society by providing important information to mobile citizens on the risk inherent different forms of transportation and how that risk can be mitigated (American Occupational Therapy Association 2005). Of course, since professional communicators are not necessarily experts in traffic safety, they have to cooperate with the relevant experts in doing this. How due to their expertise in mass communication, they role remains essential (Di Stefano, Stuckey & Lovell, 2012). The role of professional communicators in communicating road traffic risk is bound to grow in importance following the Global Status Report on Road Safety published by the World Health Organization (2015) which estimates that road traffic accidents will cause a fifth of death worldwide by 2030.

As noted earlier, motor cyclists are more at risk of being killed or injured in accidents than any other road user. Again, as noted earlier, motorcycles are gaining increasing importance as a means of transportation in Lilongwe. This rise in importance is not surprising considering worldwide trends in transportation (See Nwandoli, 2014). The motor cycle is one of the most popular means of ensuring community mobility in many Asian and African countries (Bray & Holyoak 2015; Kumar, 2011). Thus, as noted earlier, the potential harm associated with any given traffic accident is usually greater for motorcyclists and their passengers, since they are not protected by the vehicle structure. For example in China and Taiwan, motor cyclists account for over 50% of traffic deaths; in Hong Kong, motor cyclists are involved in more than a third of accidents; while in Australia, motorcyclists are 30 times more likely to be killed and 37 times more likely to be seriously injured than car occupants (Cheng, Liu, Tiulliani).

Related to the above is the risk taking associated with motor cyclists. It is almost a truism in driving cycles that motorcyclists are frequently perceived as “speed rebels” and “risk takers”. It is not uncommon to see a motorcyclist travelling faster than cars, overtaking more often, and pulling into smaller gaps in traffic. Such a risky behaviour is directly related to driving violations (Parker, Reason, Manstead, & Stradling, 1995), which can be defined as deliberate deviation from those practices believed necessary to maintain the safe operation of a potentially hazardous system. Studies indicate that there is a relationship between driving violations and accidents (Lucidi et al., 2010).

Risk perception is also related to motor cyclists’ involvement in traffic accidents as Nia and Nesva (2007) argue. Perception of traffic risk is defined by Kanellaidis, Zervas and Karagioules (2000) as a subjective interpretation of the risk involved in various situations depending on the driver’s ability to perceive such risks correctly. For example, according to the World Health Organisation (2015) younger and novice motorcyclists are overrepresented in terms of the number of traffic accidents because they characteristically underestimate the risk of an accident and tend to perceive situations as relatively low risk compared with other drivers.

## **Materials and Methods**

### **Questionnaire**

A four-part questionnaire was developed for purposes of collecting data. The first part was purposes of collecting demographic information. The second and third part was adapted from two questionnaires used for similar purposes in Asia (Cheng, Liu & Tuillaini, 2015; Cheng & Ng, 2012).

Permission was sought and received from the original authors of the two questionnaire. These two parts dealt with participants' perception of the causes of motorcycle accidents and their driving violation behaviours while operating their motorcycles. The fourth part of the questionnaire dealt with the responds preference of communication channels and road traffic information needs.

### **Sampling**

The participants representing Lilongwe urban were drawn from motor cycle taxi operators from Area 25 Market, the mini-bus stage opposite Lilongwe Teacher Training College, Kanengo M1 junction, Chilinde Mini-bus stage and Kaphiri Market along M1 after St. John Secondary School on the way to Blantyre, and on all triangular points on the junction of the M1 road and Chidzanja Road. A total of 78 questionnaires were administered and collected from these participants. Other participants to represent Lilongwe rural were drawn from Mitundu Market, Bunda Trading Centre, Chiseka Trading Centre, Pondaumali Trading Centre and Nanjiri Trading Centre, Nathenje Trading Centre, Kamphata Trading Centre and Nkhoma Market. A total of 110 questionnaires were administered and collected. This means that 188 participants took part in the survey. It was quite possible for respondents to self-administer the questionnaire since it had been translated into Chichewa, the researcher and his assistants chose to administer it to minimize on uncompleted and unreturned questionnaires.

### **Data Analysis**

Data analysis for this study is ongoing. Using SPSS as a tool, measures of central tendency have been used to generate descriptive statistics for all variables. It is hoped that a bivariate-correlation analysis will then be carried out to evaluate any correlation between the three dimensions of perceived causes of motorcycle accidents and the driving violations carried out while riding a motorcycle. This will be followed by an independent t-test to evaluate any significant differences between motorcyclists who were involved in accidents and motorcyclists who were accident free, in terms of these dimensions and behaviours. For the prediction of a motorcycle accident, univariate logistic regressions will be performed to examine the effect of different demographic variables, alignment with the different dimensions of perceived accident causes, and the extent of driving-violation behaviours. T-tests will be performed to understand the difference between urban and rural motorcyclist with regards to information needs and channels.

### **Results/Findings:**

#### **Ordinary Driving-Violation Behaviours**

Clearly, the findings above indicate that a preponderance of motorcyclists have tendency towards of violating basic traffic rules. The urban based motorcyclists have a higher tendency than those that are rural based. The only instances when rural motorcyclists tend to break more traffic rules is driving down the wrong side of a road. This may be due to that there is more traffic on urban roads than on rural road which gives rural motorcyclists greater freedom to operate on the wrong side of the road. However, the traffic infraction that urban motorcyclists commit are particularly egregious considering their penchant to make illegal U-turns, over-speeding, and driving too close to other vehicles (See Table 1 below).

**Table 1 Driving Violation Behaviours**

<b>Item</b>	<b>Agree</b>	
	<b>Rural</b>	<b>Urban</b>
Sounded your horn to show your annoyance to another road user	48	63
Made an illegal U-turn	72	89
Driven above the speed limit in order not to be late for an appointment	44	78
Driven as fast on a wet road surface as on a dry one	34	58
Disregarded traffic lights at a robot stop	12	85
Moved abruptly from the left into the right lane in order to exit a roundabout or take a turn	73	92
Driven too close to the vehicle in front of you	11	67
Driven the wrong side of a road	82	54

### **Aggressive Driving-Violation Behaviours**

Both rural and urban drivers also indicate having engaged in aggressive driving behaviour. Again the urban motorcyclists indicate a higher tendency for this behaviour. The most worrisome figures indicate motorcyclists’ tendency to drive off the road during traffic jam in urban areas. Similar figures are indicated for ignoring red traffic lights. Here the difference between the rural and urban motorcyclists can be attributed to the fact that there are no traffic lights in the rural areas. Aggressive tendencies towards other drivers including insults and driving too close to each other. But other behaviours should be more worrisome since motorcyclists in both rural and urban areas tend to operate their motorcycles even after consuming alcohol. This the only category in which rural motorcyclists tend to beat their urban counterparts (See Table 2 below).

**Table 2 Aggressive Driving-Violation Behaviours**

<b>Item</b>	<b>Agree</b>	
	<b>Rural</b>	<b>Urban</b>
Crossed a continuous white line to overtake at a bend or steep slope and you couldn’t see in front	51	56
Overtaken even though there were other vehicles coming the other way	34	67
Engaged in a race with other motor cyclists or drivers of other vehicles	56	34
Insulted another driver who angered you	36	87
Crossed double white lines to overtake even though there were other vehicles approaching	34	87
Driven off the road when caught in a traffic jam	78	92
Exceeded the speed limit in an urban road (by >20 km/h)	37	56
Overtaken even when close to turning	23	53
Ignored a red light	12	92
Overtaken the driver in front when he/she was driving at the speed limit	48	87
Driven after drinking alcohol	69	31

### **Driving-Related Potential Causes**

The motorcyclists have a highly developed perception of what is most likely to cause road accidents from a driving-related point of view. The urban motorcyclists have a high developed sense than their rural counterparts. The urban motorcyclists tended view these driving-related potential causes in high percentages well into the nineties. Unsafe overtaking was viewed as most dangerous potential cause of accidents. However, drink driving was a close second at 96 percent. For rural motorcyclists, not signaling was viewed as most dangerous driving-related potential cause of accidents at 76 percent. However, surprisingly, the drink driving was not viewed as a dangerous activity as the urban motorcyclists did. Only unsafe overtaking was perceived as less dangerous (See Table 3 below).

Table 3: Causes of Road Accidents

Item	Agree	
	Rural	Urban
Driving too close to the vehicle in front	72	91
Speeding	74	92
Drink driving	69	96
Driving when tired	73	92
Not concentrating fully	71	92
Unsafe overtaking	64	97
Not signaling	76	94

### **Environment-Related Potential Causes**

If the motorcyclists had a heightened perception of driver-related potential causes of accidents, their perception of accident causing environmental factors was even more heightened. Again the urban motorcyclists proved to have a higher sense of dangerous environmental factors. The urban motorcyclists viewed road types and road surface conditions as being potential causes of road accidents. However, for rural motorcyclists weather conditions had to be closely monitors because they are the most dangerous indicators of potential road accidents at 98%. For urban motorcyclists by 97%, they perceived other road users as the most important potential cause of accidents. The different between the two sets of motorcyclists can be attributed to the factor that Malawi's urban areas are highly populated with a large number of vehicles and pedestrians on the road. The urban motorcyclists have to navigate through all these road users (See Table 4 below).

Table 4 Environment-Related Accident Causes

Item	Agree	
	Rural	Urban
Weather conditions	98	92
Type of road (such as urban, rural, highways, etc.)	88	96
Road-surface conditions	83	96
Other road users	81	97

### **Belief-Related Potential Causes**

Malawians are a religious people with beliefs higher powers. This is reflected in the high number of motorcyclists at 89% in the urban areas and 92% in the rural areas who believe that evil spirits are responsible for accidents. Further, 89% of motorcyclists in rural areas and 85% in the urban areas perceive bad luck as an important factor in road accidents. However, more credible perceptions

prevail when it comes to driving experience because 98% of urban motorcyclists and 91% rural motorcyclists perceive lack of driving experience as major cause of road accidents (See Table 5 below).

Table 5 Belief-Related Potential Causes

Item	Agree	
	Rural	Urban
Accidents are often unexplainable	78	67
Accidents are caused by an evil spirit	92	89
Improper driving attitudes	65	94
Lack of driving experience	91	98
Bad luck	89	85

### Conclusion

The study lays the foundation for curriculum of information that professional mass communication can use as the foundation for a road safety campaign to alert motorcyclists. This is important because professional mass communicators have access to and use of mass communication channels. However, they are not professional road traffic educators. Mass communication professionals can use this information to approach experts in road traffic for more information and road safety tips for mass communication programming to reach motorcyclists.

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## **The Welfare of Children Living with incarcerated Mothers in selected Prisons of Malawi**

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### **Abstract**

The study focuses on assessing the welfare of children living with imprisoned mothers in selected prisons of Malawi. It aimed at assessing whether children's right to food, education and accommodation are respected in the named prisons. It also aimed at assessing the challenges faced by the prison and social welfare authorities in the implementation of policy and laws concerning children living in prison with their incarcerated mothers. The study was conducted in the Mpyupyu prison, Domasi, and Chichiri prison. The study was qualitative in nature. It focused on case study design. It used semi-structured interviews, focus group discussions and observations from a sample of twenty five (25) respondents. The sample comprised of 12 incarcerated mothers living with their children in prison, 10 prison wardens, 2 officers in charge and 1 Director of Social welfare Department. The three prisons were sampled using convenience sampling while homogenous purposive sampling was used to sample all the respondents. Data was analysed using thematic approach. The study has established that Children therefore, depend on the food portions given to their mother which are undoubtedly too small for both the mother and child to be satisfied. The study has also established that prisons has no access to early childhood education. The study recommends that the Malawi Prisons Act of 1966 must be revised to cater for children's needs of food, early childhood education and accommodation.

**Key words:** Social, psychological, educational, spiritual, Circumstantial children: Incarcerated, Welfare:

### **Introduction**

In recent years, the media has been washed with information of life of prisoners in Malawi prisons. Most reports indicate that the most appalling conditions existing in these prisons. Of the major concern has been the continued overcrowding, poor diet, lack of adequate medical facilities and generary a poor standard living Stapleton (2005). In Malawi, prisoners are kept in prisons and the Government Every year allocate funds to the budget of prisoners. However, , there is a strong indication that the government cannot on its own cannot manage to look into the plight of prisoners. The prisoners have different rights. The prisons keep both male and female offenders. However, there are women who gives birth while in prison. Children born in prisons live with their mothers in the prisons living in the same prison conditions. It has been observed that Children of incarcerated parents are a group who experience serious emotional, behavioural and psychological suffering that often receives little attention because they are not viewed as a victim when their parents are incarcerated (Rosemary Sarri (2009). the children's welfare which include education is not taken care of in the prisons. It is from this background that this paper would like to assess the education of the incarcerated child in some of the prisons in Malawi.

The problem statement of this paper is that the innocent children who are allowed to live in prison with their mothers also suffer from the same harsh prisons conditions in which their convicted mothers live in. Hence, the children are punished for crimes they never committed. Living in these

bad conditions in prison may negatively affect children's survival. Again, there is very little limited body of knowledge that has examined the welfare of children living in prison with incarcerated mothers worldwide and in Malawi is not an exception. The main aim of this paper is to assess the education of children living with incarcerated mothers in selected prisons of Malawi. The following were the objectives of this study:

- To assess the education of children living in prison with their incarcerated mothers
- Establish experiences of children living with incarcerated mothers in selected prisons in Malawi
- to assess whether children living in prison with their incarcerated mothers have their right to education respected and fulfilled.

### **Materials and methods**

This study adopted the case study design. Creswell (2001) defines a case study design as “a qualitative approach in which the investigator explores a bounded system...through detailed, in-depth data collection involving multiple sources of information...” According to Bromley (1990), a case study is a “systematic inquiry into an event or a set of related events which aims to describe and explain the phenomenon of interest.” Therefore, a case study design was the best-suited research design to use in this study because it will help the researcher to collect data through interviews, observations and documents.

The target population in this research study were all the mothers residing with their children in prison, all the prison wardens found in the female wing of the prison, the prison officers in charge at Domasi and Chichiri prison, the Director of the Social Welfare Department who directly deals with children in prison.

### **Sampling procedure**

Domasi prison, Chichiri prisons and mpyumpyu prisons were purposively chosen because both have female inmates who have their children living with them. The Mothers were selected because they are the caregivers to these children living in prison hence, they have first-hand information on the feeding, education and accommodation of the children. The children are too young to give any meaningful information. Furthermore, the prison wardens were sampled because they are the ones who work directly with the inmates on a daily basis and are fully aware of the services offered by Malawi Prison Service (MPS). The Director of the Social Welfare Department is fit to be sampled because his department has the responsibility of ensuring that the needs of children especially vulnerable ones are catered.

### **Methods of collecting data**

This study used qualitative methods of collecting data, which include reviewing books and documents; individual interviews with the officer in charge of both Domasi Chichiri prisons and the Director of Social Welfare department. Focus Group Discussions were used on a group of prison wardens as well as a group of mothers living with their children in prison. The methodological tools used to collect data were both primary and secondary.

### **Data Analysis**

In this study, data was analysed qualitatively using thematic approach. This approach as noted by Bernard (2000) is performed through the process of coding data in six phases to create established

meaningful patterns. These phases are: familiarization with data, generating initial codes, searching for themes among codes, reviewing themes, defining and naming themes, and producing the final report. The following is a description of the six stages involved in the thematic approach:

### **Discussion and Results**

The first objective of this study was to assess the education of children living in prison with their incarcerated mothers. Interviews were conducted in prisons with mothers with children in prison. One of the respondents reported that she had given a birth to a girl child and now the girl is four years old.

Table 1 Children Found in Domasi Prison

<b>AGE</b>	<b>SEX</b>	<b>DURATION IN PRISON</b>
1 year	Boy	6 months
2 years	Girl	2 months
4 years	Girl	3 years
4year 6 months	Boy	1 year 6
4 year 7 months	Girl	8 months
3 years	Girl	1 year 3 weeks

Table 1 above shows that four (4) out of eight (8) which represents 50% of the children found living in the Domasi prison was actually born in the prison. This is evident when one compares their age and the duration in prison. The study revealed that the prison life is the only life they had been exposed to so far. They have never interacted with children outside the prison because they do not have access to the “outside world.” One 1-year-old boy representing 12.5% has lived in the prison for 6 months while a 2 years old girl also representing 12.5% has lived in prison for 2 months. 4-year-old boy representing 12.5% has been in prison for 3 years while a 1year 7 months old girl (12.5%) has lived in prison for 8months.

Table 2 Children Found in the Chichiri Prison

<b>AGE</b>	<b>SEX</b>	<b>DURATION IN PRISON</b>
4 years	Boy	8 months
3 years	Boy	6 months
4 months	Girl	6 months
3year 6 months	Boy	1 year 6
4 year 7 months	Girl	8 months
5 months s	Girl	2 months

The table 2 shows that two (2) children, that is one girl and one boy, which represent 50%, were born in the prison while one girl and one boy have lived there for 6 months and 2

months respectively and this represents another 50%. The study revealed that the 3-year-old girl's mother who had lived in prison with her child for 6 months had not yet been sentenced but was still on trial. This means that she was not yet found guilty but her child was already being subjected to the harsh prison conditions.

Table 3 Children Found in the Mpyumpyu Prison

<b>AGE</b>	<b>SEX</b>	<b>DURATION IN PRISON</b>
2years	Boy	8 months
4 years	boy	6 months
9 months	Girl	2 months
3year 6 months	Boy	1 year 6
4 year 7 months	Girl	8 months
3 months s	Girl	2 months

Table 3 shows children born in mpyumpyu prison and are living with their mothers in prison. It shows that half of the children are supposed to attend early grade school or nursery school, which at this prison, there is no school for such children.

#### **Findings on access to early childhood education for circumstantial children**

The findings revealed that the children living with their incarcerated mothers at Domasi Prison and Chichiri prison have no access to early childhood education services, which are provided by anon-governmental organisation called Mother of Millions. However, when the study further inquired about the quality of education being offered at the nursery school inside the Domasi Prison two prison wardens lamented that there was nothing much happening. The exact words of one of the prison wardens were as follows;

...I think there is no quality education here; I would say this is more of a day care centre where children just come to play with toys. There is a lot of noise from the female inmates and I think all this hinders proper learning.

The researcher also observed that the school did not seem to have enough teaching and learning materials hence the quality of education may be questionable. However, two (2) incarcerated mothers in the Domasi prison (8%) had divergent views concerning the quality of education offered. They said that there was high quality of education being offered because the teacher only has one pupil to teach who is aged 3 years old because other children are too small to learn. This means that the teacher can concentrate very well on teaching one learner. The smaller children spent much of their time playing at the learning Centre.

Four (4) prison wardens (16%) further lamented in the focus group discussion that the children need to mingle with other children from outside the prison so that they can develop normally. He further said that all that children see in the prison is "fighting and insulting" hence; they may end up learning the bad behaviour. The research findings concerning access to early childhood education in the Domasi Prison were that there was no learning centre for children in the prison. In other words children did not have access to early childhood education. When asked whether the children had access to early childhood education, one of the key informants had this to say:

*No, when a child is four years old they are taken to nearby orphanages where they stay and get education as for us as prison service we do not have a school. As you can see, there is nothing here now.*

However, the research findings revealed that one girl aged four (4) was still living in prison with her mother, which is contrary to what the key informant said above, that children are taken out of prison at the age of four years to be educated at orphanages. In line with lack of access to education by children living in the Domasi prison, one of the mothers lamented about the situation. To illustrate this, the female inmate made the following remarks:

*Bwana ife ana athu akuvutika kuno kulibe ma sukulu. Anawa siolakwa ayi koma akuvutika chifukwa cha milandu ya makolo. . Tkupempha ku boma kuti atithandizeko pa nkhani ya maphunziro a ana athu. Sukulu ndiyofunika kwambiri pa Umoyo wa munthu.* (Interviewee 15 November 2022)

When the above statement is translated in English, this is what one of the mothers said; Boss, our children are suffering. Here there are no schools. These children did not commit any crime, but they are being punished because of our crimes. We are asking the government to help us on this matter by building schools for these innocent children. Education is something that is very important in every person's life.

The study inquired whether there were any plans to build a school for children in the Chichiri Prison. A key informant said they did not know any plans to build a school by the Malawi Prison Services but they were aware of a well-wisher who promised to build a school and a play area for the circumstantial children.

The researcher further probed the respondents on what should be done to address the lack of education in the Domasi prison, in response, one of the prison wardens (4%) commented that; Since the government sends teachers here to teach the inmates, they can either send some teachers to teach the children or take us to school to study early childhood teaching so that we come and teach the children right here in prison. I think that can work very well, since we work right here in prison. (Interviewee 7, November 2022)

In summary, the findings on access to education by children living in prison with their incarcerated mothers revealed that in the Domasi and Chichiri Prisons children are not accessing education. However, the research revealed that in the Mpyumpyu prison, children did not have access to education but a well-wisher promised to build a school. Currently, she comes and gather the children under the tree with her own resources such as baby toys, children books and teach the children. I requested to meet that woman who upon interviewing her was found she is not qualified teacher but has a zeal to help the children who are suffering in prisons because of their mother's sins.

### **Challenges in the Implementation of Policies Regarding Education**

The national policy on education in Malawi of 2010 called educating our future gave increased emphasis on the need for early childhood education. The policy states that early Childhood education plays an important role in the multi-dimensional development of young Children. Additionally, the revised sixth national development plan of 2018- 2022 (RSNDP) has one of the

objectives focusing on increasing access to early childhood education among other things. As earlier mentioned, this study revealed that the circumstantial children living in the Domasi, Mpyumpyu and Chichiri prisons do not have access to early childhood education. When asked why this was the case, a key informant lamented that there was no funding to build a school for the children. The following is what they said;

*The challenge we have to implement that law of access to early childhood education is that we do not have the money. If we had money, am sure we could have built a small nursery right in the prison.*

### **Unequal Access to Early Childhood Education for Circumstantial Children**

The study established that there was early childhood education being offered in the Mpyumpyu Prison. A learning centre was not established but a well-wisher woman volunteers herself to teach the children under the tree. The woman is not employed but work as a volunteer. This is similar to a study conducted in Zimbabwe by the MLHR (2013) where volunteers called Miracle Missions established an early Childhood development facility (Kindergarten) at Chichiri Prison so that the children of incarcerated female inmates could have a place to play instead of being in the cells with their mothers the whole day.

Sadly, despite early childhood education being offered, the findings revealed that the quality of education was questionable owing to the fact the researcher could not see proper teaching and learning materials in the classroom. The other reasons advanced for the doubt in the quality of education were that most of the children in the Mpyumpyu prison that is 3 out of 4 representing 75% were too young to undergo any serious learning. Therefore, the children spent most of the time playing with toys. One three (3) year old girl was the one who had meaningful learning owing to her age. Moreover, the findings also showed that the doubt in the quality of education being offered was because the prison was a noisy place therefore, quality education was being hindered.

Looking at the situation in the Domasi Prison, the study established that there was no early childhood education being offered. The reason advanced for this lack of access to early childhood education was lack of funding from the government. The study further revealed an ironic phenomenon in that the Ministry of Education endeavours to respect the right to education of all female inmates by sending teachers to teach them inside the prison.

However, the Ministry of Education has failed to do the same for the innocent children who live in prison with incarcerated mothers. These children are being treated worse than criminals are because their convicted mothers serving different sentences in prison are having their rights to education respected while the children's right to early childhood education is being denied.

A critical reflection of the situation described above raises a number of questions. Is the Ministry of Education aware that there are children living in prison with their mothers or have they just decided to ignore the prevailing situation? What is the MPS doing about the lack of early childhood education for circumstantial children? What is the Ministry of Community Development doing about the welfare of circumstantial children since it is the Ministry directly responsible for these vulnerable children? All these unanswered questions call for the need of all stakeholders to find a lasting solution to this lack of early childhood Education in the Chichiri prison.

Additionally, the findings on lack of access to education at Domasi Prison are not in line with Piaget's theory of cognitive development used in this study. Piaget argues that the environment one grows up in affects their cognitive development. This study has established that the prison is not a conducive place to raise a child due to the bad conditions therefore; early childhood education becomes that stimulating agent to positively affect a child's cognitive development hence it must be accessed at all costs for the benefit of the child. The findings show that the second research objective was answered. The research objective was to assess whether children living in prison with their incarcerated mothers have their right to education respected and fulfilled.

The study has established that the RSNDP, which advocates for early childhood education could not be implemented in prison due to lack of funding. However, the researcher is not in agreement with the excuse given above owing to the fact the MPS can lobby the Ministry of education to send teachers to teach the children just like they are able to send teachers to teach the inmates. The researcher is of the view that lack of political will may be the real reason why the MPS and the Ministry of education have failed to provide education for the circumstantial children.

### **Conclusion**

This study has shed light on the welfare of children living with their incarcerated mothers in selected prisons of Malawi. The specific prisons where the study was conducted were Chichiri, Domasi Prison and Mpyumpyu. The objectives of the study was to assess the education of children living in prison with their incarcerated mothers and to establish experiences of children living with incarcerated mothers in selected prisons in Malawi.

Concerning access to education, the study established that children in the Domasi, and Chichiri prisons have no access to early education hence their right to education is being violated. However, the lack of provision of early childhood education in the Domasi, Chichiri and Mpyumpyu prisons is a serious violation of children's right to education stipulated in the UNCRC. The sad part is that the study also showed that there were no plans whatsoever by the Malawi Government to build a school for children in future. This means that this situation may remain unchanged forever unless something is done to address the situation. The study also revealed that the Ministry of Education sends teachers to teach inmates and they are even able to write final national examinations right in prison. However, the ministry of education has failed to send teachers to teach children. Looking at the situation one can conclude that there is no political will to provide early childhood education to children. It seems the ministry of education has simply ignored the plight of circumstantial children and this must be addressed promptly.

Concerning the provision of early childhood education, the study established that though the RSNDP advocates for the provision of early childhood education to all children, it could not be implemented in prison due to lack of funding. It is hard to believe the excuse of lack of funding because the Ministry of Education is able to send teachers to teach the inmates so why would they fail to do the same for children? Perhaps lack of political will would be the real reason why implementation of the RSNDP has failed.

A focus group discussion with 8 mothers who have children in the prison one of them had to say like this,

*Ine kupezeka kuberekera mu ndende chifukwa amuna anga anandithawa kupita ku Mozambique ndiye pamene amathawa anali ataba zithu za anthu. Anandisiya ndiri woyembekezera ndiye apoisi anabwera kudzagwira ine mmalo mwa amuna anga. Mpaka ndinabereka ana amapasa, bamboo awo mpaka lero sakuppezeka.* I found myself delivering in prison because my husband was a thief and stored and ruined going to Mozambique. By the time he was going to Mozambique, I was expectant and I bore twins but their father is at large in Mozambique

I further asked them their experience with children. One of the respondents had to say this, the problem is on food, the food I receive very small and I share with my children. Children are not given special food. it's only some churches who visits the prison bring assorted items for the children.

### **Recommendations**

Basing on the findings discussed, the researcher recommends the following:

- The government should reconsider on laws that governs the welfare of children living together with the incarcerated mothers in prisons
- The government should build nursery schools in prisons of Malawi
- The MPS must involve the social welfare department in the welfare of children living in prison with their mothers so that together they create a conducive environment for children in prison.
- The MPS must lobby civil society organisations to build schools for children in prison and also build special mother and child units since there is inadequate funding by the government

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**TRADE, INDUSTRIAL DEVELOPMENT AND  
TOURISM**

## **Inorganic-Organic Hybrid Interpenetrating Polymer Networks (IPNs) and containing Borosiloxane Linkage**

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### **Abstract**

Inorganic-organic hybrid polymers combine inorganic and organic structures in a molecular scale to form composites of polymers or glass like materials due to the very different formation reactions of inorganic and organic networks. Though the synthesis of a large number of such polymers have been reported there appears to be no information on the synthesis of Inorganic-Organic Hybrid Inter Penetrating Networks containing borosiloxane linkage. Incorporation of borosiloxane is expected to impart thermooxidative stability and ceramic residue of these polymers. In the present study, Inorganic-organic Interpenetrating polymer networks (IOH-IPNs) containing borosiloxane linkage, were synthesized and evaluated as adhesive and coatings. Organic polymer network was obtained by reacting Aradite GY 250 or Araldite EPN1179 with aromatic diamines in 1,4-dioxane. Inorganic polymer network was obtained by reacting tetraethylsilicate or organoalkoxysilanes with boric acid under nonaqueous sol-gel process in 1,4-dioxane. Attempts were made to synthesize, Simultaneous-IPNs, Sequential-IPNs and Semi-IPNs through suitable choice of monomers and sequence of addition of monomers. These IPNs were characterized by IR and Thermogravimetric analysis. Selective systems were chosen for evaluation as coatings and adhesives. A transparent coating was obtained from GY250, APTES, and Boric acid (Polymer 1) with MTEOS, VTEOS, and Boric acid (Polymer 2) in 1,4-Dioxane and ethanol.

**Keywords:** Interpenetrating polymer networks (IPNs), Poly(borosiloxane), non-aqueous sol-gel process, organic-inorganic hybrid polymers

### **Introduction**

A polymer is a long-chain molecule made up of smaller unit molecules called monomers. Polymers differ from other molecules in that the long-chain character makes the chains to become tangled in solution or solid state. Since the molar masses of polymers are typically higher than ordinary molecules, they are non-volatile for all practical purposes [1]

Polymers are classified into organic and inorganic polymers [2]. Organic polymers are materials consisting primarily of carbon atoms in their main chains joined together or sometimes separated by heterogeneous atoms like oxygen or/and nitrogen (originate from plants, animals, microorganisms, and petroleum) [1]. Despite the great importance of organic polymers, they have some limitations; for example, most organic polymers backbones react with oxygen or ozone and their beneficial properties are lost over a long period [1]. Inorganic polymers contain inorganic elements such as silicon, boron, zirconium etc and a range of transition metals in their backbones bound together or

separated by heterogeneous atoms such as oxygen or nitrogen. Inorganic elements produce different combinations of properties in polymers than in carbon atoms. Examples of inorganic polymers include polyphosphates, polysiloxanes, polysilanes, polyphosphozanes, polyborozanes etc. [1].

### **Inorganic- Organic Hybrid polymers**

The polymers formed between inorganic and organic compounds are known as inorganic-organic hybrid polymers (IOHPs) and they are created, for example, by colloidal synthetic methods, also known as colloidal solution gel processing or chemical nanotechnology. Its exceptional character results from its structural units connected at a molecular scale resulting in highly homogeneous and very transparent materials. IOP hybrids also combine the preferred properties of inorganic and organic polymers. They are manufactured from organically modified metal and silicon alkoxides in a two-step process [3].

### **Interpenetrating polymer networks (IPNs)**

Interpenetrating Polymer Networks (IPNs) are polymers that have more than one network, these networks have chemically different phases and are partly interlocked on a molecular level. However, the IPNs though not covalently joined to each other they cannot be separated from each other without breaking their chemical bonds. The interlocking occurs through the physical crosslinking of the constituent polymers. The interconnection of the networks happens at the molecular level [4]

### **Interpenetrating Organic-Inorganic Hybrid Networks**

Organic-inorganic IPNs are two polymers where one can be an organic polymer and the other an inorganic polymer or two hybrid polymers interlocked at a molecular level. The concept of IPN was first reported in 1914 by Aylsworth. He prepared it by mixing natural rubber, sulfur, and partially reacted with phenol-formaldehyde resins [5]. However, Inorganic-organic hybrid IPNs were first reported by Novak *et al* [6,7]. Ellsworth and Novak [6] synthesized transparent compounds by the simultaneous application of substitutional transpolymerization of aqueous ring opening of cycloalkenyl monomers and the hydrolysis and condensation of tetraalkylorthosilicates.

Different synthetic steps give completely different microstructures; for example, sequential reaction steps will give completely different microstructures from simultaneous reaction steps. The final structure of products is highly dependent on the synthesis method and the nature and concentration of components. In most cases, epoxy resin is used as the organic component responsible for the organic network while silicon alkoxide functions as an inorganic component [8].

IPNs can be classified according to how they are synthesized: Sequential IPNs - synthesized one after another polymer; Simultaneous IPNs - all the monomers that are supposed to form the two polymers are mixed with any activator if necessary and cross-linkers. The reactions take place simultaneously, but the reactions do not overlap or interfere with each other. [4,9].

IPNs can also be classified as True IPNs; a mixture of two similar polymers that are not cross-linked that do not have covalent bonds between the two network polymers and have one mechanical relaxation.

Full IPNs: the two polymers exist as cross-linked networks, with no bonds between the two polymers. Both phases are cross-linked and two interlocked networks will result [10,11] and Semi-

IPNs are a combination of polymers in which at least one is a cross-linked polymer and the others are linear or branched polymers. [4,9,10].

IPNs can be used as sound and vibration damping materials due to the wide area of their glass transition temperature, they can also be used as high reflectance index optical materials, hard coatings, tinted glass, as protective coatings from corrosion on aluminum surfaces [12].

### **Poly(borosiloxane)**

Poly(borosiloxane)s which contain Si-O-B linkages in the backbone are synthesized by reacting boric acid or its derivatives with organoalkoxysilanes by sol-gel process. In recent years attention is focused on obtaining these polymers by reacting boric acid with organoalkoxysilanes under nonaqueous solventless process. These polymers on heat treatment in inert atmosphere give SiBOC ceramics which possess better high-temperature stability, creep resistance, and thermooxidative stability compared to those of siliconoxycarbide (SiOC) ceramics [13].

### **Epoxy-Amine reaction**

Polyfunctional amines are common curing agents that are used to make a variety of thermosetting organic polymers based on the epoxy amine system. The addition of epoxy to an amine group can be defined by a two-step reaction pathway:

In the first step, there is a formation of a compound with a diol and a secondary amine through epoxy ring-opening. Secondly, the secondary hydrogen of the amine reacts slowly, therefore, the second step has a lower rate of reaction. The applications of Epoxy-Amine compounds include; coatings to protect polymeric substrates, restorative materials, adhesives etc [12].

### **Non-aqueous sol-gel reactions**

In non-aqueous sol-gel chemistry, the precursor transformation occurs in an organic solvent in the absence of water. In aqueous sol-gel processes, oxygen is provided by water molecules to form the oxidizing compound, while in non-aqueous process, where there is no water, oxygen is supplied by solvents such as ethers, alcohols, ketones, aldehydes, or the precursor organic component (alkoxides or acetyl acetones) to form nanoparticles [13, 15, 16].

In view of the properties and advantages of IPNs several IPNs for different combinations and linkages have been synthesized. Most IPNs synthesized contain Si-O-Si, Si-C linkage and are prepared in basic or acidic medium containing NaOH and HCl or H<sub>2</sub>SO<sub>4</sub>, also cross linkers are used as linking agents. But there is no report on the synthesis of IPNs with polyborosiloxane (Si-O-B). In the present research, we have synthesized Inorganic-organic IPNs containing borosiloxane linkage by adopting different approaches and evaluated them as adhesives and coatings. The incorporation of Si-O-B linkage is expected to impart improved adhesion and thermooxidative stability. These hybrid IPNs can also serve as precursor for ceramics.

### **Objectives and scope**

The objectives and scope of the work are the following:

- i) To synthesize IPNs containing borosiloxane linkage by different methods using boric acid and amine/epoxy-functionalized alkoxysilanes by the non-aqueous sol-gel process.

- ii) To characterize these IPNs by different spectroscopic studies and thermal analysis.
- iii) To study the applications of these IPNs as adhesives and coatings.

## Materials

Table 1: Organic system components

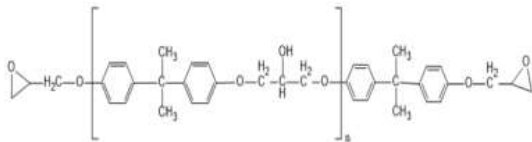
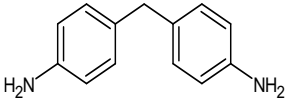
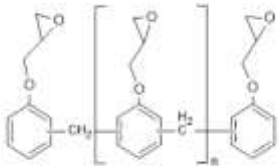
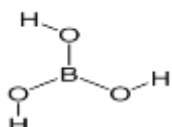
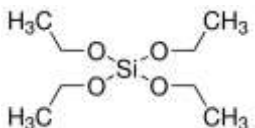
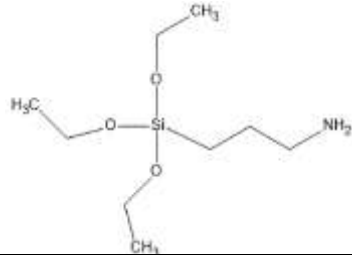
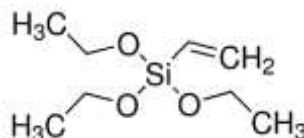
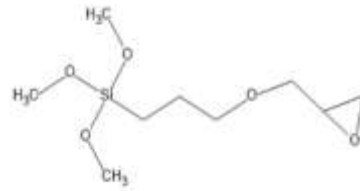
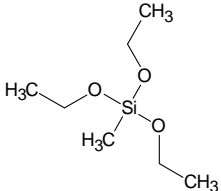
Name	Structure	Properties
Araldite GY250 (Diglycidyl- ether of Bisphenol-A)		<ul style="list-style-type: none"> <li>➤ Chemical composition: <math>C_{21}H_{24}O_4</math></li> <li>➤ Molecular weight: 340.4g/mol</li> <li>➤ Epoxy equivalent: 186.04g/eq</li> </ul>
4,4-Diamino- diphenyl- methane (DADPM)		<ul style="list-style-type: none"> <li>➤ Chemical composition: <math>C_{13}H_{14}N_2</math></li> <li>➤ Molecular weight: 198.269 g/mol</li> <li>➤ Minimum purity: 98%</li> </ul>
Araldite EPN1179 (Novolac epoxy)		<ul style="list-style-type: none"> <li>➤ Chemical composition: <math>C_{19}H_{20}O_4 \cdot [C_{10}H_{10}O_2]_n</math></li> <li>➤ Molecular weight: <math>312.3 + [162.2]_n</math></li> <li>➤ Epoxy equivalent: 175.44g/eq</li> </ul>

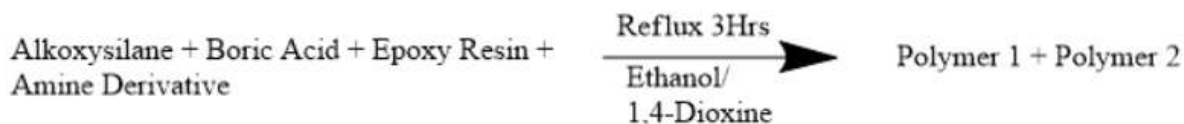
Table 2: Inorganic system components

Name	Structure	Properties
Boric Acid		<ul style="list-style-type: none"> <li>➤ Chemical composition: <math>B(OH)_3</math></li> <li>➤ Molecular weight: 61.83g/mol</li> <li>➤ Minimum purity: 99.5%</li> </ul>
Tetraethyl- orthosilicate (TEOS)		<ul style="list-style-type: none"> <li>➤ Chemical composition: <math>C_8H_{20}O_4Si</math></li> <li>➤ Molecular weight: 208.33g/mol</li> </ul>
3-Aminopropyl-triethoxysilane (APTES)		<ul style="list-style-type: none"> <li>➤ Molecular formula: <math>C_9H_{23}NO_3Si</math></li> <li>➤ Molecular weight: 221.4g/mol</li> <li>➤ Minimum purity: 98%</li> </ul>
Vinyltriethoxysilane (VTEOS)		<ul style="list-style-type: none"> <li>➤ Chemical composition: <math>C_8H_{18}O_3Si</math></li> <li>➤ Molecular weight: 190.3g/mol</li> </ul>
3-Glycidoxypropyl-trimethoxysilane (GPTMS)		<ul style="list-style-type: none"> <li>➤ Chemical composition: <math>C_8H_{18}O_3Si</math></li> <li>➤ Molecular weight: 236.68g/mol</li> </ul>
Methyl triethoxysilane (MTEOS)		<ul style="list-style-type: none"> <li>➤ Chemical composition: <math>C_7H_{18}O_3Si</math></li> <li>➤ Molecular weight: 178.30g/mol</li> <li>➤ Minimum purity: 98%</li> </ul>

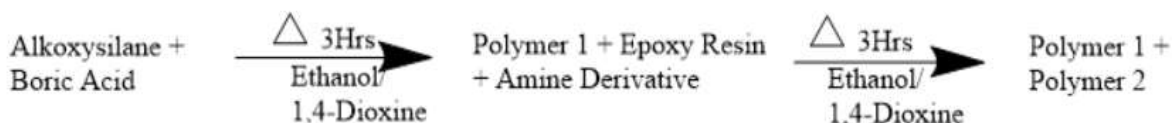
## Synthesis

The following flow charts show how synthesis was done either by simultaneous or sequential methods. Either ethanol or/and 1,4-Dioxane are used as solvents for the synthesis. The choice of the solvent dependent on the solubility of the components.

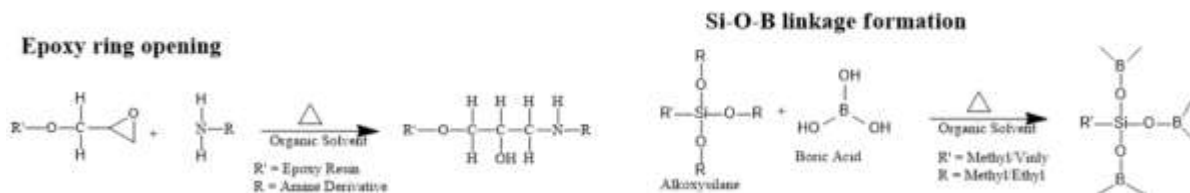
### Synthesis of simultaneous IPNs containing Borosiloxane linkage



### Synthesis of sequential IPNs containing Borosiloxane linkage



## Reaction Scheme



## Experiments

The following experiments were conducted using different monomer/reactant combinations and methods for synthesizing IPNs:

1. Synthesis of Simultaneous IPNs from Bisphenol A diglycidyl ether (GY250) and Diaminodiphenyl methane (DADPM) (Polymer Network 1) with Vinyltriethoxysilane (VTEOS) and Boric acid (Polymer Network 2) in 1,4-Dioxane (**VGDB**)
2. Synthesis of Simultaneous IPNs from GY250 and DADPM (Polymer Network 1) with Tetraethoxysilane (TEOS) and Boric acid (Polymer Network 2) in 1,4-Dioxane.
3. Synthesis of Sequential IPNs from APTES and GY250 and Boric acid (Polymer Network 1) with GY250 and DADPM (Polymer Network 2) in 1,4-Dioxane (**AGBC/L1-IPN**).
4. Synthesis of Sequential IPNs from 3-Aminopropyltriethoxysilane (APTES), (3-Glycidoxypropyl) trimethoxysilane (GPTMS) and Boric acid (Polymer 1) with (3-Glycidoxypropyl) trimethoxysilane (GPTMS), DADPM and Boric acid (Polymer 2) in ethanol (**L6-IPN**)
5. Synthesis of Sequential IPNs from EPN1179 and DADPM (Polymer Network 1) with VTEOS, and Boric acid (Polymer Network 2) in 1,4-Dioxane (**L2-IPN**)
6. Synthesis of Sequential IPNs from GY250 and DADPM (Polymer Network 1) with MTEOS and Boric acid (Polymer Network 2) in 1,4-Dioxane (**L3-IPN**)
7. Synthesis of Sequential IPNs from EPN1179 and DADPM (Polymer Network 1), VTEOS, MTEOS and Boric acid (Polymer Network 2) in 1,4-Dioxane (**L4-IPN**)
8. Synthesis of Sequential IPNs from GPTMS, DADPM, and Boric acid (Polymer 1) with MTEOS, VTEOS, and Boric acid (Polymer 2) in 1,4-Dioxane and Ethanol (**L5-IPN**)
9. Synthesis of Sequential IPNs from GY250, APTES, and Boric acid (Polymer 1) with MTEOS, VTEOS, and Boric acid (Polymer 2) in 1,4-Dioxane and ethanol (**L7-IPN**)

### **Aluminium surface preparation and bonding**

Aluminum coupons (of dimension 100 mm x 25 mm x 2 mm) were chosen as the substrate for evaluation of adhesive lap shear strength. First the area that was to be bonded was abraded with abrasive emery paper (No. 320) and the surface was cleaned with trichloroethylene to remove contamination with grease, if any. The coupons were then soaked in acid solution (50 ml conc  $\text{H}_2\text{SO}_4$  + 10 g sodium dichromate in 150 ml distilled water) for 20 minutes at 65 – 70°C (chemical etching). The coupons were then soaked in hot distilled water (65 - 70°C) for 20 minutes to remove all the traces of the acid. Finally, the coupons were dried in an air oven at 60°C for 1h, then cooled to room temperature and then used for bonding. For evaluation of adhesive lap shear strength, on the freshly cleaned aluminium surface, a thin layer of the polymer solution under study was applied using a spatula onto two aluminium coupons and they were bonded in such a way the overlap area is ~ 25 mm x 12.5 mm. The bonded coupons were stacked together and kept in a lever press. A load of 5 kg was applied and the whole assembly was kept in an air circulating oven. The following cure schedule was followed: The coupons were cured at different temperature intervals. They were kept at constant temperature for 30 minutes and soaked for 10 minutes. They were finally cured at 200°C. They were allowed to cool then mounted on the UTM for adhesive lap shear testing.

### **Instruments and characterization**

The chemical structures of the prepared samples were identified by FTIR which were recorded on a PerkinElmer Spectrum IR ES Version 10.6.0. Thermal properties were characterized by Perkin Elmer Pyris1. TGA was performed at a heating rate of 10°C/min for each sample in nitrogen atmosphere. The adhesive lap shear strength was evaluated carried out using the Universal Testing Machine (Make: Innotech Engineering, New Delhi) The test speed was set at 10 mm/min.

### **Results and Discussion**

The IPNs were synthesized from boric acid with different combinations of alkoxy silanes and also from amine derivatives and epoxy resins. The formation of Si-O-B linkages is confirmed by the presence of absorption band at 884  $\text{cm}^{-1}$ . The disappearance of a peak at around 916  $\text{cm}^{-1}$  indicates that the epoxy ring is opened. The presence of the absorption bands between 3000 and 3500  $\text{cm}^{-1}$  shows the presence of N-H bond and O-H bond.

### **Thermogravimetric analysis (TGA) results**

#### **Table 3: Thermogravimetric Analysis of IPNs**

Exp No	1	3		4		5	6	7	8	9		
Sample Name	VGDB -Gel	VGDB -C	AGBC -BC	AGBC -C	L1-IPN	L6-IPN	L2-IPN	L3-IPN	L4-IPN	L5-HP	L52-IPN	L7-IPN
T <sub>i</sub> (°C)	400	364	380	372	358	365	355	368	349	376	405	481
T <sub>f</sub> (°C)	564	564	524	520	584	550	620	605	602	597	590	690
T <sub>Max</sub> (°C)	430	452	450	445	428	448	433	443	431	463	420	580
Ceramic residue at 800 °C (%)	48.9	56.1	9.6	16.3	28.0	50.7	45.0	37.0	51.0	48.0	23.9	32.2

From Table 3, for the IPNs synthesized the initial degradation temperature (T<sub>i</sub>) ranges from 349°C to 481°C, final degradation Temperature (T<sub>f</sub>) ranges from 520°C to 690°C, Maximum degradation temperature (T<sub>max</sub>) ranges from 420°C to 580°C and the ceramic residue at 800°C ranges from 9.6% to 56.1%.

In the initial stage, the loss in weight mostly is due to solvent and the ethanol that is formed from the reaction between B-OH and Si-OMe/ Si-OEt. The degradation is mainly due to the loss organic moieties of the polymers.

From the TGA results in Table 3, Compounds from Experiments 1, 2, 4, 5, 6, 7, 8 and 9 have more percentage of ceramic residue than Experiment 3. Experiment 1, 56.1%; Experiment 4, 50.7%; Experiment 5, 45.0%; Experiment 6, 37.0%; Experiment 7, 51.0%, Experiment 8, 48.0%, Experiment 9, 32.2%; while Experiment 3, 16.3%.

IPNs from experiments 1, 4, and 7 have ceramic residue of greater than 50%, therefore, they possess good properties as precursors for ceramics since they withstand high temperatures.

### Coatings

The polymeric solutions were poured onto petridishes and allowed to air dried and then dried at 200°C. IPNs from Experiments 1, 2, 5, 6, and 7 undergo phase separation on drying while the rest do not undergo phase separation. Because of phase separation, all these IPNs become opaque on drying, therefore, they cannot be used for coatings while the rest can be used for coatings but keeping in mind the thickness of the coatings. For IPNs from Experiment 3, 4, 8 and 9 the absence of phase separation is due to cross-linked that exist between the two polymers [17]. Figure 1 shows coatings from IPNs from Experiment 1 and 9



**Figure 1: Coatings**

### Adhesives

Adhesive strength is the ability of an adhesive to stick to a surface and be able to bond the two surfaces together. It is determined by finding the maximum tensile lap shear strength which is required to unstick or detach the adhesive. It is measured in MPa (Mega Pascal) or N/mm<sup>2</sup>. Polymeric sample from Exp. 9 was used the evaluation of adhesive lap shear strength (Table 4).

Table 4 Adhesive Lap Shear Strength of L7-IPN (Exp. 9) on Aluminium substrate

Sample	Standard Area (mm <sup>2</sup> )	Actual Area (mm <sup>2</sup> )	Load (kg)	Peak Force (N)	Tensile Strength (MPa) or (N/mm <sup>2</sup> )
1	312.5	329.75	67.3	660.21	2.00
2	312.5	401.75	127.4	1249.79	3.11
3	312.5	320.75	59.5	583.69	1.82
<b>Average</b>					<b>= 2.31</b>
<b>Standard Deviation</b>					<b>= 0.698</b>

The average adhesive lap shear strength is 2.31 ± 0.698 MPa. An adhesive with a lap shear strength of 2.31 MPa can be used in a variety of applications that require a strong bond between two surfaces, for example in industrial manufacturing, construction, and household repairs.

### Summary and conclusion

In the present research, Inorganic-organic Interpenetrating polymer networks polymers containing borosiloxane linkage have been synthesized and evaluated as adhesive and coatings. IPNs have been synthesised using different combinations of alkoxysilanes, aromatic amines, epoxy resins (Araldite GY250 and Araldite EPN1179) and boric acid through non-aqueous sol-gel process. The results reveal that other combinations of the monomers have high ceramic residue compared to others. It has also revealed that some IPNs especially from Experiment 9 which was sequentially prepared from GY250, APTES, and Boric acid as Polymer 1 and MTEOS, VTEOS, and Boric acid as Polymer 2 in 1,4-Dioxane and ethanol (L7-IPN) can be used in coatings. However, the compounds synthesized possess poor adhesive properties on Aluminium substrates.

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## **URBANIZATION AND RURAL DEVELOPMENT**

**Investigating Fiscal Autonomies for Local Authorities in the Face of Decentralization:  
Towards Optimal Devolution and Participation in Public-Private Partnerships. A Case of  
Selected Local Authorities in Malawi.**

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**Abstract**

This empirical study strives to establish the extent of fiscal autonomy for selected Local Authorities (LAs) after decentralization processes. Multiple regression model is formulated and data sets for variables of annual expenditures, annual locally generated revenues, remitted annual capital funds and remitted annual operational funds for X and Y LAs spanning 2004/05 to 2020/21 gathered and analyzed. The model and data undergo statistical tests of Stationarity; Heteroscedasticity; Homoscedasticity; Double Log Linear; Multi-collinearity; Autocorrelation; Model Structure Stability; and Significance of splitting Data (Differential Intercept) as per LAs. Findings indicate that the sampled LAs are in the right path to attaining fiscal or financial autonomies. Nonetheless, contribution of Locally Generated Revenues to overall annual expenditures remain least, as compared to other funding sources, suggesting the need for LAs to be more innovative in broadening revenue bases and careful in expenditure decision-making (fiscal policies) to lessen over-reliance on financial transfers from central government. This, eventually, instills LA's financial capabilities to offset financial obligations and attempt to participate in Public-Private Partnerships for creation of capital assets that broaden revenue base.

**Keywords:** LA expenditures, regression, fiscal policy/autonomy, decentralization, public-private, partnerships.

**Introduction**

Most countries in Sub-Saharan Africa adopted decentralization of management to institutionalize democratic governance and foster efficiency and effectiveness in delivery of public services that are a proxy to national development. The rationale being that it triggers collective achievements politically, administratively and socioeconomically (McLure, 1995a). Kiggundu (2000) puts enhanced accountability, transparency, balanced power distribution, and tangible democratic participation as political benefits from decentralization. Socioeconomically, decentralization is perceived to provide a vehicle that catalyzes autonomous distribution of incomes and wealth. Administratively, it eases workload for the non-devolved institutions (UNDP 2000; Divya - CBGA 2012: 9; ICESCR, 1966: 11; PWESCR, 2015; PSAM, 2019).

In spite of wide adoption of decentralization concept and advocacy across different countries and along the government systems, researchers have argued that there is no homogeneity regarding benefits accrued and cascaded downstream local structures as they are characterized by exploitation and being agents of economic power dictating institutions. In developing countries, structures constituting local government systems continue depending on central governments for financial resources, managerial and administrative capacity, policy formulation and operationalization (Sharma, 2000; Chikulo, 2000). OECD (2004) and Fessha and Kirkby (2008) found more variations in local governments' financial autonomies in developing countries because their subnational

governments get a larger portion of their revenues from non-own income resources (through tax-sharing and grants from central governments) hence the need for country specific studies. There is not yet an empirical study conducted to substantiate purported and intended fiscal autonomies as one of the outcomes from the decentralization processes across countries, within the Ministries, departments, agencies and Local Authorities in Sub-Saharan Africa and Malawi, in particular. Absence of empirical frameworks, systematic approaches, techniques and tools to analyze and document extents to which decentralization has achieved intended results of fiscal or financial autonomy (FA) necessitated this study. It is envisaged that outcomes of this study shall act as a guide to gauge whether the decentralization process is moving towards the optimum goal of LAs getting weaned from overdependence on central government financial transfers.

This study aims at establishing the extent of fiscal/financial autonomy for selected Local Authorities (LAs) after decentralization processes and examining adequacies in expenditure assignments, by central government, relative to ideal expenditure responsibilities in a decentralized system of intergovernmental financial transfers, at LA level. Multiple regression model is formulated and data sets for variables from X and Y LAs spanning 2004/05 to 2020/21 gathered and analyzed. Further statistical tests are done. The rest of the paper is structured as follows: Section-2 reviews the existing literature and underlying hypotheses. Section-3 describes the variables, study period, sample, and data. Section-4 details the research methodology and model specifications. Section-5 discusses the empirical findings. Section-6 concludes the paper and Section-7 provides references.

### **Materials and methods**

There has been research bias towards revenue autonomy when it comes to assessing FA of LAs, with little consideration of expenditure autonomy. Satola *et al.* (2019) echoes the need to take on board all possible revenue sources as they comprise FA drivers, since revenue generation is highly linked to financial autonomy and implying revenue autonomy (level of own revenues) has an influence in determining FAs of LAs. However, execution of activities that respond to the needs of local people do not solely depend on funds from own revenues but fiscal policy also plays a role through transfers and grants from central government. The extent of fiscal decentralization has mostly been determined by calculating the local government proportion of total government expenditures and consolidated government revenue (Stegarescu, 2005; Akai *et al.*, 2007). OECD (1999, 2001, & 2002) termed the aforementioned measures as crude and misleading giving way for more valid international comparisons of fiscal autonomies in public sector decentralization set up. Guengat and Uhaldeborde (2003); and Gilbert (1999) advocate for autonomy in financial terms comprising local expenditure autonomy (the freedom to determine the nature of goods and services, from local public budget, that must be financed and the funds spent on each of them), local revenues/tax autonomy (the right and ability to finance independently the plan of delegated expenditures approved by the voters and linked to the types of local taxes and fees /the weight of own-source tax revenue in the total budget or expenditure) and budget autonomy (the freedom to act simultaneously on both the revenue and expenditure sides of the budget to dissipate vertical fiscal imbalances, imbalances from over-dependency on fiscal support from central governments). The autonomies are modelled to determine extent of the right for local authorities to attain a statistically sound, dynamic and predictable budget while discharging financial responsibilities.

To make sure that the formulated Classical Linear Regression Model (CLRM) is robust and abides by Ordinary Least Square (OLS) assumptions, the model undergoes the entire required statistical tests of Unit Root/Time Series Data Stationarity for variables, Heteroscedasticity, Model Re-specification, Multicollinearity, Autocorrelation-1<sup>st</sup> order (Durbin-Watson), Data Structure Stability/Chow Test and the possibility of splitting the model/differential intercept coefficient (Maddala, 2008 and Gujarati, 2006). E-Views software is used to perform the analyses whereby F-statistics and Wald Chi-square ( $\chi^2$ ) tests are also applied to check the serial correlation and over-identification issues. The insignificant autoregressive terms (AR-1) of Durbin–Watson test indicate the absence of Serial Correlations. The insignificant p-values of Sargan test indicate no over-identification issues. Durbin-Watson test with significant p-value implies the overall robustness of the model results.

**Model specifications**

**Multiple Regression Model**

To understand how changes in various expenditure financing sources contribute to fiscal/financial autonomies for Local Authorities (LAs), a multiple regression model is formulated as follows: -

$$Exp_t = \alpha_0 + \alpha_1 LR_t + \alpha_2 CF_t + \alpha_3 OF_t + \xi_t \quad (1)$$

Where:  $Exp_t$  = Local Authority expenditure at time t;  $LR_t$  = Credited Local Revenue(s) at time t;  $CF_t$  = Credited Capital Fund(s) at time t;  $OF_t$  = Credited Operational Fund(s) at time t;  $\alpha_i$  = Coefficients; t = Time, years in this study: 1, 2, ~.n; and  $\xi_t$  = white noise error term at time t.  $H_0$ : The coefficient is equal to zero, for a variable under consideration ( $H_0 = \alpha_1 = \alpha_2 = \alpha_3 = 0$ ).

The null hypothesis would be accepted if values of respective coefficients are statistically not significantly different from zero. Maddala (2008) and Gujarati (2006) urge for stationarity tests to avoid lagged, dynamic and non-stationary relationships between dependent and independent variables in regression models. Non - stationary data set be differenced to the appropriate level or get proven to co-integrate/at equilibrium with another data set/variable data.

**Empirical results**

**Test for Data Stationarity**

The respective stationarity test models for the variable time series in this study (Exp, LR, CF, and OF) were formulated and run through Unit Root test (Augmented Dickey-Fuller/DF Test as per Dickey and Fuller, 1979 & 1981) providing results as in Table 5.1 below.

Table 1 Unit Root Test Results

Series Code	ADF Value	Prob.	Reject $H_0$	ADF-1 Value	Prob.	Reject $H_0$
<b>Exp</b>	-2.954721	0.0464	** and ***	-7.722077	0.0000	* ** and ***
<b>LR</b>	1.477296	0.9990		-14.06076	0.0000	* ** and ***
<b>CF</b>	-4.202558	0.0014	* ** and ***	-5.678822	0.0000	* ** and ***
<b>OF</b>	-5.057494	0.0001	* ** and ***	-6.257252	0.0000	* ** and ***

Note: 1% Critical Value: -3.592462; 5% Critical Value: -2.931404; 10% Critical Value: -2.603944

\*: Significant at 1%; \*\*: Significant at 5%; \*\*\*: Significant at 10%

(Source: Author’s compilation)

The results of data series for the variables indicate to be stationary. ADF test at levels,  $H_0$  is rejected (data is stationary) for **Exp.** at 5% and 10%, **OF** at 1%, 5% and 10% while **LR** not rejected

at the three levels of significance. ADF at first difference shows stationarity for all variables at all level of significance. Therefore, the co-integration test was not run and the error correction model (ECM) is not used in this study.

### Linear Model Estimation

$$Exp_t = 2041.638 + 0.441267 LR_t + 0.794738 CF_t + 1.144888 OF_t$$

$$se = (613.4580) \quad (0.108967) \quad (0.065657) \quad (0.094668)$$

$$t = (3.328082) \quad (5.884953) \quad (12.10445) \quad (12.15912)$$

$$R^2 = 0.868893 \quad D-W \text{ stat.} = 1.972251$$

All the explanatory variables are statistically significant and have a positive relationship with the dependent variable (*Exp.*) as portrayed by respective coefficients. Though LA expenditures in a self-sustained and resource autonomous LA are dependent on own revenues raised, the scenario as per model results is contrary, implying the revenues raised cannot sustain the expenditures. This justifies the inclusion of other sources of financing expenditure, as explanatory variables.

### Heteroscedasticity Test for Linear Model

White Heteroskedasticity (cross terms) test on the above estimated linear model was run with the  $H_0$ : The estimated model does not have a problem of heteroscedasticity (opposite of *homoscedasticity*: constant data mean and variance over time). Results are in Table 5.2 below: -

Table 2 Linear Model White Heteroscedasticity Test Results

F-statistic	12.04826	Probability	0.000000
Obs*R-squared	33.49691	Probability	0.000109

(Source: Author's compilation)

Though  $F = 12.04826 > F(3, 30) > 4.51$  (at 0.01) and  $\chi^2 = 33.4969 > \chi^2(3, 33) = 18.49$ , the respective probabilities of obtaining these numbers are zero  $(0.00) < 0.05$  which is the critical level of significance. Therefore,  $H_0$  is rejected since there is evidence of heteroscedasticity problem.

### Heteroscedasticity Problem Solving (Variance Stabilizing, Transformation or Obtaining Homoscedastic Mean & Variance) and Model Re – specification.

Due to heteroscedasticity, the model (eq.1) was re-specified from linear in variance (LIV) to log-log (double log/log linear) form (elasticity or percentage change measurement of dependent variable for a given/unit percentage change in explanatory variable). The transformed model and results are presented below.

$$\ln Exp_t = \alpha_0 + \alpha_1 \ln LR_t + \alpha_2 \ln CF_t + \alpha_3 \ln OF_t + \xi_t \quad (2)$$

### Double Log (Log – Linear) Model Ordinary Least Square (OLS) Analysis Results

After re – thinking the model, OLS analysis was run and the results are as below:

$$\ln Exp_t = 2.79735 + 0.031628 \ln LR_t + 0.086431 \ln CF_t + 0.648585 \ln OF_t$$

	se	= (1.010079)	(0.00842)	(0.01572)	(0.114433)
	t	= (2.769438)	(3.756278)	(5.498117)	(5.667804)

$R^2 = 0.584988$                       D – W stat. = 1.108027

From results, a percentage increase in each of the explanatory variables lead to respective (coefficient based) positive percentage increase in the dependent variable, LA expenditure (lnExp at a specific time, t). Coefficients for all explanatory variables are statistically significant implying percentage adjustments in each independent variable have significant percentage change on the dependent variable, (ln Exp<sub>t</sub>)

**Heteroscedasticity Test for Double Log/Log – Linear Model**

Cross terms heteroscedasticity test results are shown in Table 5.3 below:

Table 3                      Double Log Model White Heteroscedasticity Test Results

F-statistic	1.089066	Probability	0.396054
Obs*R-squared	9.845992	Probability	0.363096

(Source: Author’s compilation)

From the results, both F-statistic and Chi-square values are less than the respective critical values from Tables (F=1.089066 < 2.92;  $\chi^2=9.845992 < 18.493$ ) at 5% level of significance and the respective probabilities of obtaining these values are well above the critical percentage of 5% hence accepting the  $H_0$ :The model does not have problem of heteroscedasticity. Therefore, the re-specified model can proceed to the next stage of testing.

**Multicollinearity Test for the Double Log Model**

Estimated Model: lnExp C lnLR lnCF lnOF  $R^2_{\ln Exp} = 0.584988$ .

Table 4                      Multicollinearity Test Summary for Double – log Model.

Regressor	Equation Specification	$R_i^2$	$R_i^2 < R^2_{\ln Exp}$
lnOF	lnOF C lnCF lnLR	0.171882	Yes
lnCF	lnCF C lnOF lnLR	0.162177	Yes
lnLR	lnLR C lnCF lnOF	0.023433	Yes

(Source: Author’s compilation)

From outcomes, none of regressors if regressed on other explanatory variables gives  $R_i^2 > R_{\ln Exp}^2$  (0.584988) hence there is no problem of multicollinearity in the double – log model hence can proceed to the next stage.

### **Autocorrelation Test for the Double Log Model**

The model was subjected to 1<sup>st</sup> order [AR (1)] autocorrelation test and summary of results presented below: -

Estimation Command: LNExp C LNLN LNCF LNOF AR(1)

Estimation Equation: LNExp = C(1)+C(2)\*LNLN+C(3)\*LNCF+C(4)\*LNOF+[AR(1)=C(5)]

Durbin-Watson stat	2.092312	Prob(F-statistic)	0.000000
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SubstitutedCoefficients: LNExp = 3.863191543 + 0.5462160564\*LNOF + 0.05760734085\*LNCF+ 0.02960343995\*LNLN + [AR(1)=0.5206363858]

$\ln Exp_t = 3.863192 + 0.546216 \ln OF_t + 0.057607 \ln CF_t + 0.029603 \ln LR_t + [AR(1) = 0.520636]$

It is noted that the d-statistic is around 2 (2.09) which is a zone of neither positive nor negative autocorrelation. Besides, d-statistic 2.09 > both Table d-stat values ( $d_L=1.27$ ,  $d_U=1.65$ ) implying no evidence of positive first-order serial correlation. Further, the prob (F-statistics)  $0.00 < 0.05$  (critical level of significance) for the  $H_0$  implying no autocorrelation in the model since there is no evidence to prove so.

### **Data Structure Stability/Chow Test for the Model.**

The test was run to find if there is stability of coefficients for the longitudinal and time series data set over the time period under consideration characterized by LA partaking in partial implementation of policies championing macroeconomic stability (towards stable currency exchange rates, reduced inflation rate to single digits), remarkable GDP growth rates, stable national consumer price index (NCPI) and others. The assumption being that, basing on economic indicators in Malawi, efforts in stabilizing economy at all levels reached a point where stability in variables for the model under consideration got reached. Chow-Test results are in Table 5.5 below:

Table 5 Chow – Test (Break Point: 2013M01) Results for Double – log Model

F-statistic	2.408547	Probability	0.057374
Log likelihood ratio	13.37748	Probability	0.020087

(Source: Author’s compilation)

The data structure stability test shows that from 2004, there was prevalence of data instability in variables under consideration in the model until 2008 as evidenced by none of the points in the specified duration yielding prob.(F-statistic) of more than 0.05 (critical level of significance). This might be due to the long - run efforts in trying to stabilize the economy. 2008 then acts as the structure stability breakpoint for the data sets for variables under consideration hence having data categories of 2004/5 to 2007/08 and 2008/09 to 2020/21.

**Models for Split Data (Alternative for Treating Data Instability and Stability Categories/Sets.) for the Two Sampled LAs.**

**(a) Model for Data Spanning 2004/05 to 2007/08**

$$\ln \ln Exp_t = 2.830815 + 0.508043 \ln OF_t + 0.227922 \ln CF_t + 0.048674 \ln LR_t$$

se =	(1.644979)	(0.189126)	(0.034746)	(0.011186)
t =	(1.720882)	(2.686273)	(6.559616)	(4.351268)

$R^2 = 0.699165$       D – W stat. = 1.979133

**(b) Model for Data Spanning 2008/09 to 2020/21**

$$\ln \ln Exp_t = 2.697773 + 0.544165 \ln OF_t + 0.193585 \ln CF_t + 0.058892 \ln LR_t$$

se =	(1.598606)	(0.178163)	(0.034279)	(0.01042)
t =	(1.687578)	(3.054315)	(5.647311)	(5.651718)

$R^2 = 0.723695$       D – W stat. = 1.9924

Coefficients for Independent variables are statistically significant with the intuitive implying that a unit percentage change in each variable has a positive percentage change in  $\ln Exp_t$ .

**Testing Significance of Splitting Data by Introducing Dummy Variable (Differential Intercept Coefficient), An alternative for Data instability.**

This test was undertaken to find out if it is statistically significant to split the data into two categories as per the previous split models. A dummy variable was introduced to see if one data set category is statistically different from the referential (base) data category. The model taking care of the dummy variable is as presented below whereby D = 1 for expenditure before 2008/09 and 0 if it is the expenditure after 2008/09.

$$\ln \ln Exp_t = \alpha_0 + \alpha_1 D_i + \alpha_2 \ln OF_t + \alpha_3 \ln CF_t + \alpha_4 \ln LR_t + \xi_t \tag{3}$$

$$D_i = \begin{cases} 1 & \text{if exp enditure before 2008 / 09} \\ 0 & \text{if exp enditure after 2008 / 09} \end{cases}$$

$$H_0: D_i = 0.$$

The analysis results for the model are as presented below:

$$\ln G_t = 4.956292 - 0.153792 D_2 + 0.409428 \ln OF_t + 0.081706 \ln CF_t + 0.029124 \ln LR_t$$

se =	(1.665829)	(0.09541)	(0.186025)	(0.015691)	(0.008401)
t =	(2.975271)	(-1.611903)	(2.200931)	(5.207055)	(3.466587)

$R^2 = 0.61091$       d – statistics = 1.131758

From the results, the mean LA expenditure for the period before 2008/09 is lower than that of after, as depicted by negative differential coefficient (negated coefficient for the dummy variable, x). Moreover, the coefficient for the dummy variable does not have significant impact on the dependent variable ( $\ln Exp$ ) hence the overall (over the whole data set) double-log model stands out to be the reliable, with stable coefficients. Therefore, the final model befitting the data under model specification and projections of Amounts for Respective Funding Sources for the Annual Budget remains the initial Double Log (Log-Linear) Model, provided below: -

$$\ln Exp_t = 2.79735 + 0.648585 \ln OF_t + 0.086431 \ln CF_t + 0.031628 \ln LR_t$$

$$se = (1.010079) \quad (0.114433) \quad (0.01572) \quad (0.00842)$$

$$t = (2.769438) \quad (5.667804) \quad (5.498117) \quad (3.756278)$$

$$R^2 = 0.584988 \quad D - W \text{ stat.} = 1.108027$$

## Conclusion

This study examined fiscal/financial autonomies of selected Local Authorities (LAs) in the Republic of Malawi following processes of decentralization. Classical Linear Regression (log-linear/double log) Model was formulated and validated using longitudinal and time series financial data for the selected LAs.

Findings from the formulated Log-Linear (Double-Log) Model and data sets support the earlier suggestion that local authorities are making strides towards achieving financial/fiscal autonomies as evidenced by unit percentage changes in all explanatory variables under consideration in the model, Local Revenues (LR) especially, triggering respective percentage changes in selected LAs' expenditures.

Based on coefficients or elasticities of locally generated revenues (LR) and capital funds (CF), which are by far less than 0.1, the study recommends the sampled LAs to make further strides in achieving financial autonomies or capabilities to finance a higher proportion of their budgets by intensifying mechanisms of either reducing defaulters in remitting fees/revenues, or hatching and implementing innovations that can broaden local tax revenue base. LR is the only independent variable or budget funding source in the model that can be controlled by the LAs unlike entrusted responsibilities in form of financial transfers (grants, operational funds, capital funds) from central government.

The suggested initiatives and innovations and abiding by spending autonomies may, in the long-run, reduce over-dependency on transfers from central governments and over-expenditure syndrome. This will, eventually, enable LAs attain optimal devolution and attract stakeholders in private sector to participate in Public-Private Partnerships (PPPs) at that level, whenever calls are made. Higher coefficient of LR signals capabilities of LAs to meet financial obligations in PPPs or any other entrepreneurial partnerships.

The study recommends Malawi's National Public-Private Partnership Commission (NPPPC) to devise deliberate modalities of devolving PPP models downstream Ministries, Departments and Agencies (MDAs) up to platforms constituting Local Government Systems so that viabilities of such entrepreneurial options can be weighed for well informed decisions on business ventures that can foster their financial and expenditure autonomies. LAs are also urged to engage private sector in managing services of existing physical assets for gains in efficiencies and profits.

The study recommends further research on long span time series and broader longitudinal data by taking on board a wider sample of LAs for development of more reliable and inclusive model.

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