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DISSERTATION SUBMISSION

Title: The impact of fall armyworm on small-scale farmers in the Thulamela Local Municipality, in the Limpopo Province of South Africa

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Submitted in fulfillment of the requirements in respect of the (Masters) degree (with specialisation e.g. Disaster Management) in the Department of Disaster Management Training and Education Centre for Africa in the Faculty of Natural and Agricultural Sciences at the University of the Free State.

Supervisor: Dr Tlou Raphela-Masuku

DECLARATION

I, Maria Mafadza, student no: 2009093853, herewith affirm that this mini dissertation titled ***The Impact of Fall Armyworm on Small-Scale Farmers in Thulamela Local Municipality, in the Limpopo Province of South Africa***, for Master's in Disaster Management at the University of the Free State is my own and has not been previously presented for a qualification at any other institution of higher education.

I also declare that all sources have been acknowledged through in-text referencing and have included a complete list of references.

10/02/2025

Maria Mafadza **Date**

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ABSTRACT

The outbreak of the fall armyworm (*Spodoptera frugiperda*) in many African countries has seriously threatened millions of small-scale farmers' food and income security (Prasanna et al., 2018). Fall armyworm are observed as a threat in the Southern African regions because maize, preferred by the pest, is the staple food in South Africa. The study sample comprised of 100 respondents from the Shayandima communities, and a semi-structured questionnaire was used to collect data from this community. The study used Statistical Package for Social Scientists (SPSS) version 29 to analyse quantitative and qualitative data. The study assessed the impact of fall armyworms on the livelihoods of Shayandima communities by applying the Chi-square test and regression analysis to establish the relationship between dependent and independent variables. The study findings show that more women in the area participated in farming than men. Furthermore, the study found that Shayandima communities are dominated by people 65 years of age and above compared to the younger age group. This might be translated into the fact that the youth lack interest in farming and seek their attention in other fields, whereas elderly people demonstrated passion for farming. Our study findings regarding the high impacts of fall armyworms on farms reported by the surveyed farmers could threaten maize production and the livelihood of numerous farmers who rely on maize production for income as most farmers studied grow maize as their main crop. The study also shows that the farmers are psychologically affected as the pest continues to affect their economic livelihood. Though the majority of the respondents confirmed they knew of the existence of the fall armyworm pest, they indicated that they need to be capacitated on early detection techniques as well as other ways to control the pest spread. The study recommends that the government of South Africa must ensure to empowerment women in rural farming by providing more resources, prioritise in developing and implementing policies for women's empowerment. Studies have also neglected research on mental readiness for disaster that could be caused by pest infestation around poor communities in South Africa. The future study should recommend correlations between gender, level of education, marital status, employment status, and farming within the study community.

Keywords: Fall armyworm, livelihoods, food security, mental health, mitigation

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ACRONYMS

Department of Agriculture (DoA)
Department of Agriculture, Land Reform and Rural Development (DALRRD)
Disaster Management Act (DMA)
Ecosystem-based Disaster Risk Reduction (Eco-DRR)
Fall Armyworm (FAW)
Food and Agricultural Organization (FAO)
Integrated Pest Management (IPM)
Key Performance Areas (KPAs)
Limpopo Department of Agriculture and Rural Development (LDARD)
National Disaster Management Framework (NDMF)
National Disaster Management Centre (NDMC)
Post Traumatic Stress Disorder (PTSD)
Pressure and Release (PAR)
Sendai Framework on Disaster Risk Reduction (SFDRR)
Southern African Development Community (SADC)
Statistical Package for Social Scientists (SPSS)
South Africa Human Rights Commission (SAHRC)
South African Weather Services (SAWS)
Sub-Saharan Africa (SSA)
Sustainable Development Goals (SDGs)
World Trade Organisation (WHO)

CHAPTER 1: INTRODUCTION

1.1 Introduction

The fall armyworm, *Spodoptera frugiperda* is a polyphagous moth, an invasive pest that is native to tropical and subtropical regions of America (Suby et al., 2020; Wang et al., 2023). The total economic loss due to fall armyworm is estimated to be US$ 200 million globally, equivalent to 0.08% of the global gross domestic product (Abro et al., 2021). In Sri Lanka, a total of 40000 hectares of 20% maize are infested with fall armyworms, with an economic loss of 1-3 billion in Asia since infestation and U$D 2400-4000 billion per year loss (Secretariat, IPPC, 2021). In Africa, a significant economic loss of approximately $9.4 billion annually was estimated in 33 countries due to fall armyworm damage (Eschen et al., 2021).

Limited studies in South Africa, particularly Limpopo Province have been carried out on fall armyworm targeting small-scale farmers, however, the studies lack tangible evidence on economic loss due to fall armyworm (Makgoba et al., 2021; Nethononda et al., 2023; Price, 2021). This study was conducted to obtain data from the small-scale farmers on the impact of fall armyworm, in Thulamela Local Municipality, hence it will address the shortfall identified. In South Africa, it has not yet been estimated how much losses were accounted for which may impact food security.

Fall armyworms threaten the livelihoods of various farming communities across the globe, causing significant damage to maize crops, that rely on maize production as a stable food and for income (Bannor et al., 2022; Prasanna et al., 2021). Yield losses as a result of the fall armyworm in African communities may lead to food insecurity (Bannor et al., 2022; Kansiime, Rwomushana, and Mugambi, 2023). Due to the massive impact on economic livelihood, some studies have associated fall armyworm invasion with potential health risks, including depression and other severe conditions that can affect farmers' well-being (Chiswell, 2023; Daghagh Yazd, Wheeler, and Zuo, 2019; Younker and Radunovich, 2021). Therefore, analysing existing studies on the impact of pests on farmers is crucial, as it adds more literature on the neglected mental health impacts of these pests on the farmers. Food safety enhances livelihoods and food security and critically influences national food systems' economic success (WHO, 2022).

1.2 Description of the study area

The study was carried out at Thulamela Local Municipality in Shayandima communities which fall within Thohoyandou town in the Limpopo Province of South Africa. According to Thulamela Municipality IDP (2022/23 – 2026/2027), it is one of the four municipalities in the Vhembe district and covers 2893.936 km2 (2893 393 hectares). It falls within the Vhembe District Municipality, is situated in the northeastern part of Limpopo Province, and is considered subtropical (IDP, 2022/23 – 2026/2027). According to Statistics South Africa's mid-year population estimates (StasSA, 2019), Limpopo recorded approximately six (6) million people which is 10.2 percent of the South African population. Limpopo Province is a huge contributor to economic growth in the agricultural sector including Thulamela Municipality which depends mostly on farming for their livelihoods and food security (IDP, 2022/23 – 2026/2027).

The study area consists of four blocks comprising 106 plots of approximately 1.20 hectares each. The blocks are identified as block 1 with 25 plots, block 2 with 35 plots, block 3 with 13 plots, and block 4 with 33 plots. Farmers grow their crops using irrigation water which flows through a concrete furrow to the various plots. The main source of water supply is from boreholes.

The small-scale farmers grow maize and vegetable crops such as groundnut, potato, onion, millet, soybean, tomato, cabbage, and mustard green (*mutshaini*) in their farms. Farmers sell their produce such as sweet corn and vegetables to the local market. However, the main challenge they are facing is that fall armyworm has directly affected their crop produce. For instance, farmers reported that the quality of their produce i.e. sweet corn had a worm inside resulting in their customers expecting a price cut. The quality of vegetables makes it difficult for farmers to market the produce at a good price affecting their livelihoods. Fall armyworm affected their livelihoods as it reduced their yields and increased maize production costs (Thovhogi et al., 2022).

The one interesting recent call to action that is most relevant to this study is the universal call to action to end poverty, protect the planet, and improve the lives and prospects of everyone, everywhere (Sustainable Development Goals (SDGs). The SDGs fit into this study because undeclared disasters or rather crises including fall armyworm outbreaks across the globe are stressful, cause enormous loss, threaten food security, affect livelihoods, and have an effect on mental health (Kassie et al., 2020; FAO, 2020; Price, 2021). The determination to achieve SDGs 1 and 2, which are zero hunger and no poverty can only be fulfilled if agriculture and food systems become sustainable, so that food

supplies are stable, and all people have access to adequate nutrition and health (FAO, 2017).

The currently running international framework applied to this study is the Sendai Framework. The Sendai Framework on Disaster Risk Reduction (2015-2030 SFDRR) whose main purpose among others is to reduce disaster risk and loss of lives, livelihoods, and health, socio-economic, cultural, and environmental assets of persons, communities, etc., (UNISDR, 2015) fits well to the concepts of this study.

1.3 Climatic conditions of Thulamela Local Municipality

The area experiences extremely hot climatic conditions with all-year sunshine (Uhunamure et al., 2021; SAWS, 2023). More so, it is envisaged that the climate type falls within the sub-tropical climate, with an average rainfall of 300–1000 mm per year (Uhunamure et al., 2021; SAWS, 2023). Despite the summer months, the heat is often interrupted by rainfall and short thunderstorms (October to March). The average temperature ranges from 27 °C to as high as 45 °C (Uhunamure et al., 2021; SAWS, 2023). The fall armyworm has been reported to adapt, reproduce, and survive in hot conditions. Therefore, this climatic condition provides a suitable advantage for this pest to develop, survive, establish, and form a formidable pest for farmers in the province (Du Plessis and van den Berg, 2020).

The mountainous areas receive an enormously high amount of rainfall yearly, with an average of about 1329 mm (Uhunamure et al., 2021). Therefore, seasonal average humidity falls within 80% in the summer and about 38% in the winter (Uhunamure et al., 2021; SAWS, 2023). The soil is characterised as sandy loamy in the west and north. However, most parts of the province are dry with occasional drought season (Uhunamure et al., 2021). Indeed, Erasmus (2017) reported that the life cycle of the fall armyworm is about 24 to 30 days in higher temperatures and humidity.

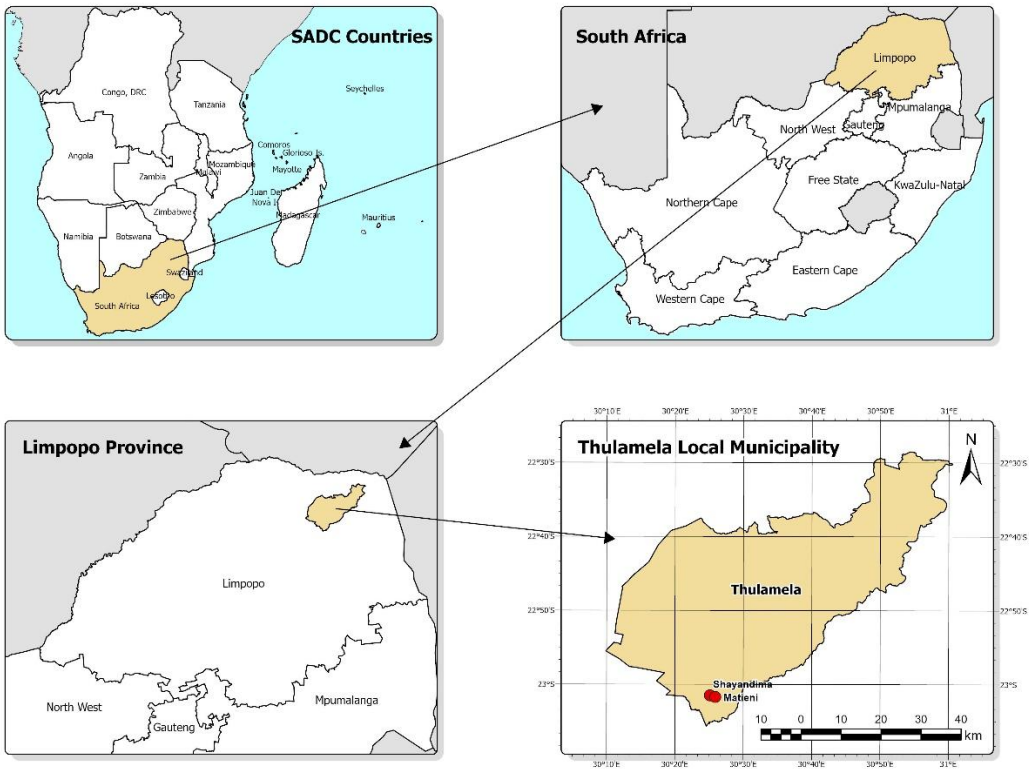

Figure 1. 1: Map of the Shayandima small-scale farmers, Thulamela Local Municipality in the Limpopo Province

1.4 Background of the study

Materechera and Scholes (2022) and Vhembe District Municipality (2014) have reported that 90% of rural communities in Vhembe District, depend on farming for their livelihoods and income. Similarly, the study by Thovhogi et al. (2022) in Thulamela Local Municipality depicted the ordeal faced by small-scale farmers because of the presence of pests. Some of the ordeals are that pests cause farmers to spend more money on buying more production inputs; and pests affect the quality and quantity of the yield produced which results in unmarketable produce leading to lower farm income (Thovhogi et al., 2022). This study has been motivated by the lack of data relating to the impact of fall armyworm on small-scale farmers in Thulamela Local Municipality.

The one interesting recent call to action that is most relevant to this study is the universal call to action to end poverty, protect the planet, and improve the lives and prospects of everyone, everywhere (Sustainable Development Goals (SDGs). The SDGs fit into this study because undeclared disasters or rather crises, including fall armyworm outbreaks

across the globe are stressful, cause enormous loss, threaten food security, affect livelihoods, and have an effect on mental health (Kassie et al., 2020; FAO, 2020; Price, 2021). The determination to achieve SDGs, particularly on zero hunger and no poverty can only be fulfilled if agriculture and food systems become sustainable, so that food supplies are stable, and all people have access to adequate nutrition and health (FAO, 2017).

The currently running international framework applied to this study is the Sendai Framework. The Sendai Framework on Disaster Risk Reduction (2015-2030 SFDRR) whose main purpose among others is to reduce disaster risk and loss of lives, livelihoods, and health, socio-economic, cultural, and environmental assets of persons, communities, etc., (UNISDR, 2015) fits well to the concepts of this study.

1.4.1 Background of fall armyworm species

The armyworm has been reported to attack food security important crops such as maize, sorghum, millet, legumes, rice, and sugarcane, including a whole range of crops (Tambo et al., 2021). According to the World Health Organisation's reports, these are the food security crops of most African countries (WHO, 2022). The fall armyworm's preference for maize which is a staple food for African families makes this fall armyworm a formidable hazard (Matova et al., 2020; Prasanna et al., 2018). Studies across the globe have revealed that more than 300 million African small-scale farming families are dependent on maize (Santpoort, 2020).

In South Africa, fall armyworm poses a serious economic risk to maize farmers, causing enormous yield losses (DALRRD, 2022). Fall armyworms attack maize from seedling emergence to ear development stage (Suby et al., 2020). The study by Thovhogi et al. (2022) carried out in Thulamela Local Municipality, highlights challenge small scale-farmers are facing due to pests. Farmers have indicated that pests such as fall armyworms are putting a lot of strain and eroding the gains by reducing the quantity and quality of the produce. This study will be the least to investigate the statistical overview of the impact of fall armyworm on small-scale farmers in Thulamela Local Municipality. The study will improve and contribute to the knowledge gaps and obtain baseline information in the research fraternity. It is due to these challenges encountered by small-scale farmers from the Shayandima rural communities in Limpopo province motivated this study intends to assess the impact of fall armyworm on food security, livelihood, and mental readiness of communities in Thulamela municipality.

This study differs from agriculture in that it applies the Disaster Management Act, which contemplates a coordinated strategy for preventing and responding to disasters, to lessen disaster losses and help affected communities recover speedily, along with other provisions of the Act (DMA, 2002). Furthermore, legislative policy framework on Disaster Risk Management practices suitable for enactment in all spheres of the South African government are put in place. The policy framework is put in place to effectively manage and respond to provincial agricultural-related disasters such as the outbreak of fall armyworm (NDMF, 2005). This is to strengthen disaster preparedness for effective response; assist small-scale farmers with emergency relief and promote implementation of disaster risk reduction measures (DRDAR, 2018).

1.4.2 Fall armyworm distribution

Native to the Americans (North and South America), the fall armyworm was officially reported in West Africa in January 2016 (FAO, 2020). When and where the fall armyworm first arrived on the African continent is unknown (Schlum et al., 2021). The arrival of the fall armyworm and its ability to spread very fast in new areas in Africa has caused panic (FAO, 2020). Fall armyworm has been proven to be the most highly damaging and devastating quarantine pest, to impacts agricultural production and food security across the African continent (Day et al., 2017; Kumela et al., 2019; Mlambo et al., 2024).

Maize is a staple food in the Southern African regions, including South Africa, and faces major threats due to outbreaks of pests and diseases that affect agricultural produce (DAFF, 2020). Fall armyworms have been reported to cause a significant yield loss of up to 53% of the annual production of maize in an average of three years (FAO, 2018).

The general lack of knowledge on management resulted in many African governments procuring and distributing non-validated insecticides for its control (Otim et al., 2021). These actions might have dire consequences for the health of the people if not well and adequately managed (Otim et al., 2021). For example, some African countries are using chemicals that pollute water resources, as a result, threatens the health of humans and the lives of other organisms in the water and the animals that drink water from these resources as well as destroying the natural balance of the ecosystem for short-term gain (Banson et al., 2016b). According to Banson et al. (2016b), approximately 10,000 people die each year in developing countries from pesticide poisoning, and about 400,000 suffer acutely as pesticides travel through the food chain. These fatalities caused by the armyworm have the

potential to cause mental health issues for the survivors. Moreover, the threat of maize by this worm can cause livelihood disruption and food insecurities for the affected.

1.5 Research problem

In South Africa, fall armyworm is a quarantine pest. It is regarded as a serious economic risk to the South African farmers in the list of the European Mediterranean Plant Protection Organization (EPPO). In South Africa, fall armyworms have been reported to be present in all nine provinces; however, the level of infestation varies per province, district, or area (DALRRD, 2022). Wind-assisted natural dispersal is another potential natural pathway for the introduction of this pest (Cock et al., 2017). This poses a serious problem as South Africa has lately been characterized by strong winds due to the effects of climate change.Furthermore, the invasions of this worm can also increase health expenditure arising from exposure to insecticides and affect the performance of businesses along the maize value chain (Chapman et al., 2017; Early et al., 2018). Unless effective control strategies are implemented, the pest will continue to cause massive destruction to maize and affect the livelihoods of millions of people especially in South Africa (Rwomushana et al., 2018). Implementing such control strategies requires updates on the current impact of fall armyworm on the economy, food security, and health (Rwomushana et al., 2018).

Fall armyworm has been reported in Limpopo Province, Thulamela Municipality (DALRRD, 2022). Although there is no statistical data in terms of the impact of fall armyworm, it was estimated that approximately 3,500 farmers in Limpopo Province have been affected by fall armyworm on 40 000 ha (Price, 2021), this is a serious problem for the agriculture-based province of South Africa. It is believed about 77% of farmers planted maize on <1ha of land, have recorded approximately 25-100% crop loss mainly due to this pest (Price, 2021). The impact of fall armyworms has resulted in stress, which is also one of the mental health measures because many farmers have decided to give up farming entirely due to the hardships posed by this worm (Price, 2021). Therefore, against this backdrop, that this study investigated how the fall armyworm impacts the livelihoods, food security, and mental health issues of the Shayandima communities at Thulamela Local Municipality in the Limpopo Province, South Africa.

1.6 Research questions

The main question that this study answered is how the fall armyworm impacts the livelihoods, food security, and mental health of the Shayandima communities, at Thulamela Local Municipality in the Limpopo Province, South Africa?

The following research sub-questions emanating from the above main question answered by this study are:

1. How does the fall armyworm outbreak impact on the livelihoods of the Shayandima communities?
2. What is the impact of the fall armyworm outbreak on the food security of the Shayandima communities?
3. What is the mental health impact of the fall armyworm on the Shayandima communities?

1.7 Objectives of the study

This study assessed the impact of fall armyworm on the livelihoods, food security, and mental health of the Shayandima communities at Thulamela Local Municipality in the Limpopo Province, South Africa.

Sub-objectives

1. To gauge fall armyworm's impact on the livelihoods of the Shayandima communities;
2. To determine fall armyworm's impact on the food security of the Shayandima communities; and
3. To assess the effects of the fall armyworm on the mental health of the communities of Shayandima.

This study used various inferential and descriptive statistical analyses that were performed to determine the relationships between variables to answer the objectives of this study. The community of Shayandima responded that indeed the outbreak of fall armyworm had impacted them and had furthermore triggered some financial burden. However, it has not yet been estimated how much losses were accounted for in South Africa which may have an impact on food security in South Africa. Even though the literature scan shows enough research studies on mental health relating to farm workers' exposure to pesticides and/or chemicals, there is a lack of information on how farmers and farm owners are affected by fall armyworms, including how the total crop maize loss affects them mentally.

1.8 The significance of the study

The study focused on livelihoods, food security, and mental health. These are the concepts rarely investigated in combination in most Disaster Management studies. Disaster mental

and public health is now gaining traction around the world owing to the COVID-19 pandemic, whereby most studies assessed the mental health impacts of the pandemic (Lindert et al., 2021; Raphela, 2022; Sharp et al., 2020; Williams et al., 2021). In addition, from the disaster perspective, preparedness is depicted as a tool to ensure effective coordination and enhancement of capacities to prevent, protect against, respond to, recover from, and mitigate the effects of natural and man-made hazards, this term encompasses food security, livelihoods and mental health of individuals in overall (Lindell et al., 2006).

The study contributes to the literature on the effect of fall armyworm on mental health, as a literature scan has shown that this area of research is neglected in Disaster Management studies as far as the effect of pests is concerned. In addition, the study gives perspective on the food security in the Vhembe District Municipality which is predominantly rural (Rusere et al., 2019). It is estimated that 89% of the population is categorised as rural and therefore plays a crucial role in the economic development of rural areas in Limpopo province (DAFF, 2013). Indeed, the mental health of poor communities is in most cases an afterthought for policymakers when it comes to decision-making.

The study supports the idea that most disasters will have mental health consequences. South Africa like any other developing country, will experience challenges such as instances where following the aftermath of a disaster has provided limited services such as counseling to the communities who are affected by disasters (Roudini, Khankeh, and Witruk, 2017). Inadequate capacity of mental health professionals and lack of knowledge and information regarding disaster mental health professionals such as psychologists are a neglected area of study. Therefore, this study seeks to contribute positively to multidisciplinary writings concerning this topic because of the negligible research area on human response and psychological aspects of natural disasters. It must be a known fact that the community affected by the disaster no matter the magnitude might need psychologists' assistance to avoid negative consequences such as Post Traumatic Stress Disorder (PTSD). Indeed, COVID-19 pandemic has shown how disasters or pandemics can affect mental health (Raphela, 2022).

1.9 Theoretical framework underpinning the study.

There are numerous theories, policies, frameworks, and legislation that are relevant to this study based on the objectives and the concepts that will be addressed comprehensively in Chapter 2 of this study.

Climate change is altering the face of disaster risk through increases in societal vulnerabilities, for example, from stress on water availability, agriculture, i.e., a suitable environment for pests and diseases, and ecosystems (CHF, 2014). This will result in increasing vulnerability as climate trends will damage livelihoods, increase poverty, and affect food security (CHF, 2014). There are environmental risks and health hazards when managing pests in terms of applying large quantities of chemical insecticides (Ekenwosu et al., 2021), that is where the risk reduction component of the Sendai Framework fits in.

Strategies and actions to reduce disaster risks must be implemented to limit vulnerability and exposure to hazards with an effort to address poverty and inequality and through risk-informed humanitarian responses to disasters and other crises such as fall armyworm (CHF, 2014). By increasing the resilience of vulnerable communities to extreme events such as the outbreak of fall armyworm, countries are obliged to meet commitments under the Sendai Framework for Disaster Risk Reduction (Seddon et al., 2016).

1.10 Research design

Research design encompasses a set of decisions regarding what topic is to be studied, among what population, with what research methods, and for what purpose (Sileyew, 2019). Therefore, it starts with an initial interest, idea, or theoretical expectation and proceeds through a series of interrelated steps that narrow the focus of the study so that concepts, methods, and procedures are well-defined (Babbie, 2020). The research design is planning and provides the overall structure for the procedures the researcher follows, the data the researcher collects, and the data analyses the researcher conducts (Leedy and Ormrod, 2001). Research designs can be categorised as ways to collect or analyse data and help readers understand what the author did in the research (Thomas and Zubkov, 2020). The purpose of research design is to systematically explain how research questions are addressed in a quantitative study (Thomas and Zubkov, 2020). On the other hand, Saunders, Lewis, and Thornhill (2009) describe research design as a general plan of how the researcher carried a plan about answering the research questions, this involved stating clear objectives derived from the research questions, specifying the sources from which the researcher intended to collect data, the proposal on how to collect and analyse data, this including discussion on ethical issues and the constraints the researcher inevitably encountered (e.g. access of data, time, location and money). This study followed the following key components in design, namely quantitative research design, qualitative research design, and mixed research design, as a combination of the two approaches. The quantitative research approach is generally associated with positivism, especially when used with predetermined and highly structured data collection techniques; and quantitative

research designs may also be undertaken within the realist and pragmatist philosophies (Walsh, 2015).

1.10.1 Research approach

To assess the impact of fall armyworm on the livelihoods, food security, and mental health of the study community, the researcher decides the type of data to collect to find answers to research questions by using any research methods/approaches to achieve the objective of the study, and methods range from informal to strictly scientific (Bernard, 2017). When the researcher is undertaking the research study, this implies that the following processes are being applied:

- Is being taken under the framework of a set of philosophies.
- Uses procedures, methods, and techniques that have been tested for their validity and reliability.
- Is designed to be unbiased and objective (Wisdom et al., 2012).

The approach is based on the rationale that qualitative techniques are better for certain situations than other quantitative techniques. Indeed, social research uses quantitative methods, also known as structured, qualitative, or unstructured approaches, as well as the mixed method approach (Coleman, 2022).

The study aimed to find out how fall armyworm impacts the livelihoods, food security, and mental health of the Shayandima communities. Therefore, many research experts (Creswell and Clark, 2011; Tashakkori and Teddlie, 1998; Teddlie and Tashakkori, 2009) have advocated using mixed methods in social research. According to Tashakkori and Teddlie (1998), research in social and behavioral sciences currently uses multiple methods, therefore, such studies that use two or more methods, to enhance the accuracy of the findings, are said to be using mixed/multiple methods approach which is the approach that this study adopted together with the postpositivist world view. These worldviews will be critically discussed in Chapter 4 of this study.

1.10.2 Philosophical view

Philosophy is a disciplined, orderly, logical study of the universe, i.e., of everything all reality, whose purpose is to investigate the truth of extreme plans about existence, life, reality, good, and so forth (Nayak and Singh, 2021). Furthermore, worldview means “a basic set of beliefs that guide action”, additionally seen as a general philosophical orientation about the

world and the nature of research that a researcher brings to a study which leads to embracing a strong qualitative, quantitative, or mixed methods approach in their research (Creswell and Creswell, 2017). It is imperative that in planning a study, researchers need to think through the philosophical worldview assumptions that they bring to the study, the research design that is related to a particular worldview, and the specific methods or procedures of research that translate the approach into practice, philosophical worldview assumptions such as ontological (nature of reality or being) and epistemological (what constitutes acceptable knowledge) are considered (Saunders, 2009). Cleland (2022) argued that research requires a philosophical viewpoint such as constructivism or interpretivism, positivism or post-positivism, pragmatism, or realism viewpoint. This study, therefore, adopted a postpositivist worldview because of the mixed methods research approach adopted and the above-mentioned worldviews and their relevance will be critically addressed in Chapter 4 of this study.

1.10.3 Research methodology

The methodology depends on the paradigm that guides the research activity, beliefs about the nature of reality and humanity (ontology), the theory of knowledge that informs the research (epistemology), and how that knowledge is gained (methodology) (Saunders, 2009). In simple terms, research methodology is defined as the philosophy underpinning research (Gupta, 2022).

Based on the above definitions of research methodology this study adopted a case study method and used a semi-structured questionnaire to collect primary data and secondary data was collected from published sources. The details of these methods and the choices of these methods are discussed in chapter 4 of this study.

1.10.4 Population sampling

The population for a study is that group (usually of people) about whom the researcher wants to draw, and another meaning is the theoretically specified aggregation of the elements in a study (Babbie, 2020). It is believed that a sample size of at least 100 must be used to make any statistical inferences and a reasonable inference from the data (Bullen and Brack, 2014). The target population is understood to be a group of people who satisfy the requirements for the research project and the group might be homogeneous or heterogeneous (Robinson, 2014). Sampling is an important component of quantitative research design that has been given less attention in methodological textbooks and journals than its centrality to the process warrants (Mason et al., 2021). The study sampled 100

respondents from the Shayandima community and used a semi-structured questionnaire to collect data from this community, and used purposive sampling, the details of the sampling technique, data tool, and procedures are extensively discussed in Chapter 4 of this study.

1.11 Data analysis

Analysis of data means studying the tabulated material to determine inherent facts or meanings, breaking down existing complex factors into simpler parts, and putting the parts together in new arrangements for interpretation (Thomas and Zubkov, 2020).The data for this study was captured, cleaned, and coded in Microsoft Excel and statistically analysed using Statistical Package for Social Scientists (SPSS). The data was analysed descriptively and inferentially (Sarka, 2021). Qualitative data was analysed using thematic analysis. Comprehensive analysis and statistical tests applied for this study are explicitly discussed in Chapter 4 of the study.

1.12 Data validity and reliability

Validity refers to the ability of an instrument to measure what it is supposed or intends, purports, or claims to measure, that an account accurately represents ‘those features that it is intended to describe, explain or theorise’ (Coleman, 2022). In addition, validity is an important key to effective research (Winter, 2000).

The triangulation technique includes multiple methods of data collection and analysis, and therefore, defined to be “a validity procedure where researchers search for convergence among multiple and different sources of information to form themes or categories in a study” (Creswell and Miller, 2000). Triangulation is typically a strategy (test) for improving the validity and reliability of research or evaluation of findings (Kaman and Othman, 2016).

Reliability is the ability of separate researchers to come to similar conclusions using the same experimental design or respondents in a study to consistently produce the same measurement (Cohen, Manion, and Morrison, 2002). Therefore, reliability is essentially an umbrella term for dependability, consistency, and replicability over time, over instruments, and groups of respondents (Cohen, Manion, and Morrison, 2002). For example, for research to be reliable it must demonstrate that if it were to be carried out on a similar group of respondents in a similar context, then similar results would be found. The study ensured validity and reliability by using Cronbach Alpha and by piloting the data collection tool. The details of how the validity and reliability of the study were ensured and described explicitly in chapter 4 of this study.

1.13 Limitation and delimitation of the study

Limitations are constraints that are largely beyond the control of the researcher but could affect the study outcome (Terrell, 2022). It often flows from methodology and study design choices in which each different option in methodology and design has limitations (Miles, 2017). Delimitation of the study refers to the scope of the research, aims, and research questions (Miles, 2017). This entails the choices made by the researcher which should be mentioned in the study like the objectives and the questions, variables of interest, theoretical perspectives that were adopted, the paradigm, the theoretical framework, and the population the researcher is not studying (and why not) (Barrot, 2017). Furthermore, it describes where and when the study is conducted and who the subjects are or the population included, and it also deals with the extent of the study to be made. In short, scope means all those things that will be covered in your research project. It is the problem that you seek to resolve that will fit within certain parameters (Barrot, 2017).

1.13.1 Limitation

Limitations of any study concern potential weaknesses that are usually out of the researcher's control, and are closely associated with the chosen research design, statistical model constraints, funding constraints, time, equipment, data, and respondents, a common limitation is the willingness of the individuals to respond at all, to respond in a timely fashion, and to respond accurately (Miles, 2017).) Therefore, the limitation is an 'imposed' restriction that is essentially out of the researcher's control (Theofanidis and Fountouki, 2018). For example, when exploring respondents' responses to a survey, the researcher may be limited to accessing only a small geographical area which would not provide an overall scope of responses.

This study was limited by the difficulty of synchronising the availability of the researchers and the farmers and by the issue of anonymity. Chapter Four of this study explains how these limitations were overcome.

1.13.2 Delimitation

Delimitations are the factors that prevent researchers from claiming that the findings are always true for all people and places (Miles, 2017). For example, in the case of quantitative study, these are the factors that limit generalization, and for qualitative study, these factors limit the relevancy of the study to other populations or individuals (Miles, 2017). It can be argued that delimitations are in the researcher's control and researchers decide to set the

boundaries or limits of their work so that the study's aims and objectives do not become impossible to achieve (Theofanidis and Fountouki, 2018). Thus, delimitations are mainly concerned with the study's theoretical background, objectives, research questions, variables under study, and study sample.

The study was delimited by the choice of types of farmers, and insufficient time and resources to cover a huge research population and sample size which are discussed in chapter 4.

1.14 Ethical considerations

The protection of human subjects through the application of appropriate ethical principles is important in all research studies. In a qualitative study, ethical considerations have a particular resonance due to the in-depth nature of the study process (Arifin, 2018).

The researcher obtained ethical clearance as required by the University of Free State's General Human Research ethics. The researcher made sure that respondents participated based on written informed consent in line with the University's ethics policy. The respondents were informed of their privacy rights and that their responses and identities would be kept confidential (Leedy and Ormrod, 2001; Babbie and Mouton, 2001). More ethical considerations that were considered as per the Popia-approved University of the Free State written informed consent form and information leaflet under protocol number UFS-HSD2023/151 are critically discussed in Chapter 4 of this study.

1.15 Chapter Summary

This study determines the impact of fall armyworms at Shayandima communities in the Thulamela Local Municipality. The study gauged the impact of the fall armyworm on the livelihoods, and food security and assessed the effects of the fall armyworm on the mental health of the Shayandima communities. The chapter outlined the background of the study and detailed a description of the study area (Thulamela Local Municipality) by showing the location using maps. In addition, the study highlights the problem statement and depicts the research question emanating from the problem and the objectives of the study. In addition, the importance of the study was also depicted. The theoretical framework underpinning the study was also highlighted and the research design was presented. The study provides a roadmap of how data was collected, analysed, and interpreted. The reliability and validity of this study are also detailed to indicate how the credibility of the research data was measured. Consequently, limitations and delimitations of the study were indicated to

demonstrate the shortcomings that could have affected the aim of the study. To conclude, ethical considerations for the study are briefly touched on, however, these considerations are critically discussed in chapter 4 of this study.

1.16 Study outline

Chapter 1: Introduction and Background to the study.

This chapter introduces the topic of the study, gives the background of the study, and describes the study area, the research problem, and the research question, along with the research objectives and the significance of this study. The methodology of the research and finally the limitations and delimitations are addressed.

Chapter 2: Theoretical Framework Underpinning the Study.

The chapter explains the theoretical and legislation frameworks administering the topic of the study, and its relevancy to the study.

Chapter 3: A literature review of the concepts to be studied.

This chapter gives an overview of the literature related to the study and links the literature to the research objectives.

Chapter 4: Methodology of the research pursued.

The chapter critically describes in detail the methodology the research adopted.

Chapter 5: Present the Data analysis and interpretation of the data.

The chapter presents the results, the data analysis as well as the interpretation of the data linking the data to the study aim and objectives.

Chapter 6: Conclusions and Recommendations

This chapter wraps up the research document by presenting conclusions and recommendations resulting from the research study, answering the research questions, and attempting to solve the research problem.

CHAPTER 2: THEORETICAL FRAMEWORK AND LEGISLATIVE REVIEW

2.1 Introduction

This chapter examines the legislative review conceptual frameworks for disaster management, additionally applying policies that govern disaster management internationally and nationally, as well as policies that focus on food security, livelihoods, and mental effects of communities following disasters. Theoretical and conceptual frameworks and international and national legislations are discussed to investigate the impacts of fall armyworm on the livelihoods, food security, and mental health issues of the communities at Shayandima, in Thulamela Local Municipality of the Limpopo Province, to add to the scanty literature on food security, livelihoods and the mental health in South Africa and the entire globe.

The chapter further provides background information by outlining the disaster risk reduction theoretical frameworks, the Sendai framework for disaster risk reduction, the 2030 Agenda for SDGs, and the legislative framework relating to disaster management and mental health regulations in South Africa. On the other hand, the chapter establishes the link between food security and the armyworm, its impact on mental health, and consequences on the policies and the frameworks. The determination to achieve SDGs, particularly on zero hunger and no poverty can only be fulfilled if agriculture and food systems become sustainable, so that food supplies are stable, and all people have access to adequate nutrition and health (FAO, 2017).

Disasters are stressful, including fall armyworm outbreaks across the globe; they cause enormous losses, threaten food security, affect livelihoods, and have an effect on mental health (Kassie et al., 2020; FAO, 2020; Price, 2021). Food security, livelihoods, and mental effects of disasters are frequently unnoticed because attention is focused more on immediate and basic physical needs and provision by the government (Barron, 2004; Zulch, Reser, and Creed, 2012). The spread of fall armyworm at a fast pace will subsequently have a significant economic impact on agriculture (Abro et al., 2021; Baltzegar et al., 2018; De Groote et al., 2020; FAO, 2017; Tanyi et al., 2020). Since food security is at the forefront of most decision-makers, the livelihoods and mental health issues affecting communities for such outbreaks are often neglected.

Maize is an important crop in international and sub-Saharan African (SSA) communities used by both communities as feed and staple crop. Therefore, the outbreak of fall armyworm threatens the production of maize and can lead to hunger in other continents (Abrahams et

al., 2017; ACAPS, 2017; Cock et al., 2017; Kansiime, Rwomushana and Mugambi, 2023; Kumela et al., 2019; Macauley and Ramadjita, 2015; Orke and Dehne, 2004; Smale et al., 2013; Tambo et al., 2021; VIB, 2017). If measures are not put in place to control fall armyworm, the trade of maize could negatively affect the global environment and lead to hunger. The 2030 Agenda for Sustainable Development Goals (SDGs) makes one interesting recent call to action that is most relevant for this study: the universal call to action to end poverty, protect the planet, and improve the lives and prospects of everyone, everywhere.

2.2 Theoretical Frameworks

This section discusses the Disaster Management Model and Pressure and Release (PAR) Model to address the objectives of this study.

- **Disaster Management Model**

According to UNISDR (2009), a systematic process of using administrative directives, organisations, and operational skills and capacities to implement strategies, policies, and improved coping capacities to lessen the adverse impacts of the hazards and possibilities of disaster is known as disaster management. Moreover, it is also regarded as integrated multi-sectoral and multidisciplinary administrative, organisational, and operational planning processes and capacities aimed at lessening the impacts of natural hazards and related environmental, technological, and biological disasters (DM, 2002). Disaster Management model comprises of six elements, namely strategic plan; hazard assessment, risk management; mitigation; preparedness, monitoring, and evaluation: The study applies this model because it addresses a range of administrative directives to provide a solution to the problem.

This study adopts the theory of eco-evolutionary for the prediction and management of plant diseases through utilising invasion ecology, therefore can improve the prediction the success of new and emerging pests such as fall armyworm as well as pathogens in new environments (Singh et.al., 2023). Certain studies on plant communities have demonstrated that invasion success is linked to high dispersal ability, growth rate, etc (Blumenthal, 2006). Current approaches to monitor, manage, and mitigate pest and disease risks are constrained by a focus on single-pest/pathogen, single-crop, and single-pest/disease theories (Jeger et al., 2021).

In terms of modeling future disease outbreaks, there is emerging agreement in many parts of the globe that climate change will increase pest and disease risk impacts (Chaloner et al., 2021; Deutsch et al., 2018). For example, changes in planting dates due to cooler seasons will reduce the global risk of late blighting of potatoes by the end of this century (Sparks et al., 2014). Small-scale farmers in Thulamela are growing their produce in all seasons, this model should be tested extensively for fall armyworm. There is a literature review that supports fall armyworms. Farmers in Thulamela have reported that early planting is cooler temperatures reduces the impact of fall armyworm; however, further studies are necessary to attest to this assumption. The study by Matova et al. (2020) reported that early plant mitigates the impact of fall armyworm, hence the theory can be further explorable to attest its relevance in the study area. On the other hand, climate change-mediated early anthesis in wheat will cause an increase. The study by Du Plessis and van den Berg (2020) reported that climatic condition provides a suitable condition for fall armyworm for farmers in the Limpopo Province. Abiotic factors can vary over space and time, such as with seasons (e.g., temperature, Thierry et al., 2019).

Using invasion theoretical frameworks to predict better successful invasion by new pests/pathogens might help, while also having the potential to support the development of pests/disease management approaches, for example by providing tools to identify biological controls of pathogens (Mäkikangas et al., 2016). Several studies have made recommendations to combine different control methods to tackle fall armyworm infestations because agricultural technologies and practices generate higher gains when adopted in combination rather than in isolation (Day et al., 2017; Tambo et al., 2020; Teklewold et al., 2013; Tambo and Mockshell, 2018).

In this scenario, structural are genetically modified crops, application of chemical and botanical pesticides, agronomic practices (such as early planting, intercropping, and crop rotation), and integrated pest management (IPM) (Abrahams et al., 2017; Tambo et al., 2020). Monitoring, warning, and evacuation are non-structural methods for hazard mitigation that can reduce the number of losses (de la Poterie et al., 2018). Therefore, disaster risk management can be accomplished through raising public awareness of threats and coming up with solutions to address them (Dalu et al., 2018).

Moreover, the South African Weather Services (SAWS) has been playing a vital role in offering weather warnings in terms of South African Weather Services Act (No 8 of 2001). For effective preparedness measures, the SAWS has installed early warning systems in some regions of the nation and even in other neighbouring countries to warn local communities of approaching meteorological hazards. Through monthly joint operation

meetings, the SAWS and the National Disaster Management Center continued to keep a close eye on impending threats that might occur across the country (Munyai et al., 2019). Since the interception of fall armyworm in 2016, the first affected farmers suffered huge losses because of unpreparedness (Matova et al., 2020).

- **Pressure and Release (PAR) Model**

The PAR concept is based on the premise that a disaster is the result of the interaction between natural hazards and the activities that cause vulnerability. According to Wisner et al. (2014), the range of economic, social, cultural, institutional, political, and psychological requirements that impact the lives and the environments where people live leads to vulnerability, and therefore, is the human dimension of destruction.

The applicability of the Pressure and Release (PAR) progression of vulnerability model gives a picture of the relationship between risk, vulnerability, and hazards.

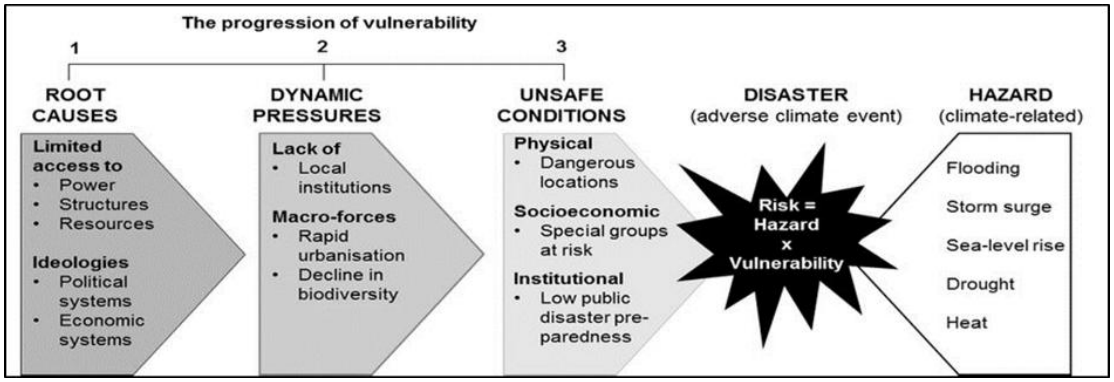

Figure 2. 1: The Pressure and Release (PAR) model. Adapted from Wisner et al. (2014).

The main causes of unsafe conditions are dynamic pressures, such as poverty, hunger, unemployment, and a vulnerable local economy, which are a few examples of how dynamic pressure from fundamental causes can translate into unsafe circumstances (Fatemi et al., 2017). For example, with the fall armyworm affecting parts of the world, there could be devastating consequences for the food security of the affected vulnerable in South Africa, particularly Shayandima communities relying on maize as their staple food.

People characteristically become vulnerable due to limited means of support, which reduces their resilience in the event of catastrophe, accordingly, the importance of the implementation of the disaster risk reduction strategies is crucial in order mitigation and prevention measures (Aksha et al., 2019).

Several studies have made recommendations to combine different control methods to tackle fall armyworm infestations because agricultural technologies and practices generate higher gains when adopted in combination rather than in isolation (Day et al., 2017; Tambo et al., 2020; Teklewold et al., 2013; Tambo and Mockshell, 2018). PAR describes the relationship between the root causes, dynamic pressures, and unsafe conditions; and how these factors impact fall armyworm about food security, livelihoods, and mental health of Shayandima communities. It shows the root causes, pressures, and unsafe conditions that lead to the vulnerability of the environment and the people. Fall armyworm has been identified as the hazards associated with risk and vulnerability of the community, so the model explains all the dynamics associated with the worm including the causes and effects:

Root causes

This is a deep-rooted set of factors within a society that together forms and maintains vulnerability (Van Niekerk, 2005). The Shayandima communities are faced with unemployment, poverty, lack of resources, food security, and limited access to economic systems. Most of the community members solely depend on government interventions because the community is a poor resource. For example, the continuous persistence of the pest may cause food security and poverty problems in the long run by reducing marketed surplus and income (Kassie et al., 2020).

Dynamic pressures

In this phase, there is a translating process that channels the effects of a negative cause into unsafe conditions. This process may be due to a lack of basic services or provision, or it may result from a series of macro-forces (Van Niekerk, 2005). Shortage or lack of local institutions means that there are no possibilities of institutionalising fall armyworm prevention and mitigation in the area. Training facilities are highly desirable in this area to educate, transfer skills and knowledge, and train community members about fall armyworm. The lack of adequate support from the government around the Shayandima community could trigger mental health problems because of the impact of rising costs of crop production (Campos et al., 2017). It has been reported that some farmers in Limpopo resorted to replanting maize because of the impact of fall armyworm devastation and therefore had financial repercussions (Price, 2021).

Unsafe conditions

An unsafe condition is a vulnerable context where people and property are exposed to the risk of disaster. The Shayandima community comprises farms situated next to one another, therefore the impact of fall armyworm on one farm poses a threat to another farm.

Research to date indicates that farmers, farm workers, and their respective families face an array of stressors related to the physical environment, structure of farming families, and the economic difficulties and uncertainties associated with farming which may be detrimental to their mental health (Fraser et al., 2005).

2.3 International and National Frameworks

This section examines the International and national frameworks that are responsible for disaster risk reduction in the case of an outbreak of fall armyworm to minimise the impact on livelihoods, food security, and mental health issues of Shayandima communities including mitigation measures that are required for the control on the worm, such as the Sendai Framework, the SDGs, and the South African Disaster Management Framework.

2.3.1 International Frameworks in Disaster Management

This section discusses two international Disaster Risk Reduction frameworks to address this study's objectives.

2.3.1.1 The Sustainable Development Goals (SDG's)

The 2030 Agenda for Sustainable Development was adopted by the United Nations (UN) General Assembly in 2015 as a mutual agreement that comprised 17 SDGs for peace and prosperity (UN, 2015). According to Bello et al. (2021), for a better understanding of the 2030 Agenda for Sustainable Development, integrating disaster risk reduction into sustainable development plans is paramount. By so doing, the global community will be immensely drawing attention to addressing the relations between poverty and disasters (Bello et al., 2021). Eliminating hunger and poverty has remained on the global development agenda for a long time and several initiatives have been taken to address these issues (Chand et al., 2022). The SDGs provide a very valuable benchmark; therefore, disaster risk reduction approaches consider addressing hunger, poverty, water supply, food security, nutrition, access to healthcare, climate change, and inclusive development (Bello et al., 2021; Chand et al., 2022). To achieve sustainable development goals, Bello et al. (2021)

indicate that a combined endeavor is required to improve a community's resilience and possibly reduce vulnerabilities.

Globally, the Food and Agricultural Organization (FAO) report indicated that approximately 815 million people are undernourished, and the trend is even increasing compared to previous years (FAO, 2023; Mohammed, Wassie, and Teferi, 2021). According to the United Nations (2015) report, there are still 836 million people in the world living in extreme poverty (less than USD1.25/day). It should further be noted that nutritional studies have shown a correlation between poverty and mental well-being (Grosso et al., 2020). At least 85% of the poor people live in rural areas, most of them depending partly or completely on agriculture for livelihood. It is estimated that 500 million small-scale farms in the developing world are supporting almost 2 billion people who are reported to lack regular access to sufficient, safe, and nutritious food (FAO, 2003; FAO, 2016).

Sustainable development goals strive to end hunger, and malnutrition and achieve food security (Jaba and Sharma, 2016). However, the mammoth task seems to be more difficult to accomplish because of the impact of climate change on agriculture and food security, creating a daunting challenge of ending hunger and malnutrition (Jaba and Sharma, 2016). Therefore, action is urgently needed to build resilience in agricultural production systems (Chand, Joshi, and Khadka, 2022). Food security can be defined as ‘‘*when all people, always, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life*’’ (FAO, 2003).

The following SDGs fit into this study, namely SDG1 and SDG2, which strive to end extreme poverty and hunger to ensure food security and nutrition within sustainable food systems. Furthermore, nutritional studies have shown a correlation between poverty and mental well-being (Grosso et al., 2020). Therefore, the report depicts a worrisome picture because of this worm infestation, which can potentially affect global food availability and food security, undermining most Sustainable Development Goals around the globe (WHO, 2018). Unless better management strategies for lessening the effects of the fall armyworm are implemented, global communities are faced with the threat of food security. To achieve sustainable development goals, Bello et al. (2021) suggest that a concerted effort must be made to strengthen a community's resilience and, in turn, reduce vulnerabilities. As enshrined in the 2030 Agenda for Sustainable Development, disaster preparedness entails reducing exposure and vulnerabilities.

Sadiq et al. (2013) reported maize production was profitable despite the outbreak of fall armyworm on small-scale maize production in Niger State; Cross River State and Nasarawa State in 2018. The results indicated that farmers implemented better management strategies for cushioning the effects of the fall armyworm. Therefore, South Africa should consider integrating disaster mitigation strategies into the development plans of the cities to mitigate the impact of fall armyworm (Bello et al., 2021).

Another relevant SDG is Goal No. 3 which enjoins us to ensure healthy lifestyles and promote well-being for all ages. Therefore, mental health problems can negatively impact an individual's emotional, social, and intellectual abilities (WHO, 2014; 2022). For example, some farmers end up selling their livestock and other belongings to generate income and this has affected their livelihood, and consequently, can cause mental health problems related to stress (Zulch, Reser, and Creed, 2012). Additionally, the study in Limpopo Province revealed that farmers resorted to replanting maize after being damaged by fall armyworm; this had financial repercussions (Price, 2021). Fall armyworm's impact undermined the purpose of SDG3 in poorly resourced SSA countries (Zhongming et al., 2021). However, the literature scan on the effect of fall armyworm on mental health has shown that this area of research is neglected.

In conclusion, António Guterres, Secretary-General of the United Nations, highlighted that "*we must rise higher to rescue the SDGs and stay true to our promise of a world of peace, dignity, and prosperity on a healthy planet"* (UN, 2022). Therefore, South Africa can rise above the challenges of the impact of fall armyworm, and build more resilient and better management strategies to reduce the impact on food security.

2.3.1.2 The Sendai Framework for Disaster Risk Reduction (SFDRR)

The Sendai Framework for Disaster Risk Reduction (SFDRR) was adopted by the Member States of the United Nations, further deliberating on four top priorities which specify seven global targets to evaluate the world's improvement in mitigating disasters (UNISDR, 2015).

It has emerged that developing recovery strategies to provide psychosocial support and mental health services be prioritised for people who require such needs (UNISDR, 2015). Since food security is at the forefront of most decision-makers, the livelihoods and mental health issues of Shayandima communities are of paramount concern because of the outbreaks of fall armyworm, and therefore, the ideologies and priorities for action from the SFDRR are crucial.

The Sendai Framework on Disaster Risk Reduction (2015-2030 SFDRR) whose main purpose amongst others is to reduce disaster risk and losses in lives, livelihoods, and health, socio-economic, cultural, and environmental assets of persons, communities amongst others, (UNISDR, 2015; Zhou et al., 2014) fits well to the concepts of this study.

Strategies and actions to reduce disaster risks must be implemented to limit vulnerability and exposure to hazards with an effort to address poverty and inequality and through risk-informed humanitarian responses to disasters and other crises such as fall armyworm (UNISDR, 2015). By increasing the resilience of vulnerable communities to extreme events such as outbreaks of fall armyworm, countries are obliged to meet commitments under the Sendai Framework for Disaster Risk Reduction (Seddon et al., 2016). Therefore, taking into consideration four priorities, the study will apply the Sendai framework for disaster risk reduction by focusing on the following priorities:

Priority 1 of the SFDRR focuses on understanding disaster risk which indicates that for policies and systems to be put in place, it is of utmost importance for the Thulamela communities to know and understand the risk fall armyworm poses to them in terms of vulnerability, capacity exposure as well as other contributing factors. The reason is to render assistance in determining and analysing the risk involved regarding livelihoods, food security, and mental health effects, and to further establish the extent the communities know about fall armyworm, the impact of fall armyworm, how to control fall armyworm, their readiness for future occurrence of this worm. Do the communities seek mental assistance or not, do they have such information or not, the analysis of information is crucial in decision-making with the view to put in place the practices and policies for fall armyworm preparedness in Thulamela municipality. The fall armyworm outbreak has revealed that disaster risk is on the upsurge, signifying that contemporary normative frameworks at national and international levels are insufficient, hence making priorities for action crucial to this study.

Priority 2 of the SFDRR highlights strengthening disaster risk governance to manage disaster risk, fall armyworm is transboundary, therefore has no boundaries, native to the Americas, and can spread very fast in new areas and now in Africa finally arrives at the shore of South Africa, and has been reported in all nine provinces including Limpopo Province, Thulamela area (FAO, 2020; Goergen et al., 2016; DALRRD, 2022; Price, 2021; Chand et al., 2022). This priority stresses strengthening the legislative framework both at the local, provincial, and national levels to deal with fall armyworm risk reduction effectively and efficiently (i.e., prevention, preparedness response, and recovery plan). For example, in the agricultural perspective, when the fall armyworm strikes, a 24-48 hrs plan of early

warning and disaster risk management policy is implemented, to assist the affected farmers (DRDAR, 2018). The focal point of this study is on the preparedness of management of fall armyworms in Shayandima communities. It requires the implementation of mechanisms and institutions that promote the active collaboration and involvement of relevant stakeholders' participation. To control the further spread of fall armyworms across the globe, stakeholders are cohesively working towards preventing further introduction, spread, and establishment of fall armyworm, on the other hand, reducing the adverse impact of the outbreak.

Priority 3 investing in disaster risk reduction for resilience through structural and non-structural measures, which will improve the economic, social, health, and cultural resilience of the community as well as the environment (UN, 2015). As this study aims to investigate the preparedness level to reduce the disaster risks as well as to understand what the underlying factors are as well as the impacts of fall armyworm in South Africa, therefore, putting the necessary approaches and strategies together can reduce the risk and vulnerability concerning disasters such as outbreak of fall armyworm in South Africa, particularly Shayandima communities.

With investments in disaster risk reduction initiatives, Bello et al. (2021) share that private and public investments in structural and non-structural mitigation measures safeguard the socioeconomic effects of communities. This is because a literature scan revealed the impact of pests and diseases including fall armyworm on food security, livelihoods, and mental effects across the globe (Vurro, Bonciani, and Vannacci, 2010). Moreover, mental health problems can negatively impact an individual's emotional, social, and intellectual abilities (WHO, 2014; 2022). Several studies across the globe have cautioned the increased use of chemicals in food production to reduce the impact of pests and diseases including fall armyworm is a key reason for many diseases and health hazards in humans (Chand, 2022).

There is a mounting fear about the impact on the mental health of agricultural workers in the field of occupational health (Cancino et al., 2023). This is because of the increased application of chemicals to an outbreak of fall armyworm and/or any other plant pests and diseases, and the health risks associated with depression, therefore, considering this aspect, it is crucial to implement more stringent measures to monitor the mental health of agricultural workers regularly exposed to pesticides and to enhance surveillance of companies that apply these chemicals.

Priority 4 focuses on enhancing disaster preparedness for effective response and to "*Build Back Better*" in recovery, rehabilitation, and reconstruction. In the context of this study,

'Building Back Better' following the aftermath of the outbreak of fall armyworm, the SFDRR highlights the importance of ensuring effective disaster preparedness for efficient response (UN, 2015). Therefore, building back better might entail institutions that will be better assembled and prepared to provide people with better services regarding livelihoods, food security, and mental health issues should an outbreak of fall armyworm occur. Ensure to put in place policies that involve risk-based decisions that enable understanding of multiple threats and risks and therefore act on the knowledge (UNDP, 2015). In South Africa, fall armyworm is currently regulated in terms of the Control Measures Relating to Fall armyworm (Act No. 36 of 1983) (DALRRD, 2022). The study will contribute to the knowledge gap and further assist in contributing to the literature on the effect of fall armyworm on mental health, as a literature scan has shown that this area of research is neglected in Disaster Management studies as far as the effect of pests is concerned. The study supports the idea that most disasters will have mental health consequences. South Africa, like any other developing country, experiences challenges such as instances where services following the aftermath of the outbreak have provided limited services such as counseling to the communities affected by the disaster (Roudini, Khankeh, and Witruk, 2017).

The impact of fall armyworms has resulted in stress, which is also one of the mental health measures because many farmers have decided to give up farming entirely due to hardship (Price, 2021). Therefore, this is to ensure that services are continuously rendered to the needy people without disruption, i.e., livelihoods, food security, and mental health issues in the Shayandima communities due to the outbreak of fall armyworm. Creating guidelines as a response is vital, and the goal of the guide is to ensure that people who require mental health services encounter no service disruptions due to the pandemic (McDaid, 2021). This includes maintaining high-quality care for those with mental health needs and maintaining routine screenings for common mental conditions in primary care settings (Kilbourne et al., 2018). The policies should incorporate issues of mental health to assist small scale-farmers with funding after the loss of crops from armyworms, it should also include risk reduction strategies to outright prevent the distraction caused by these pests.

The above priorities are relevant to this study as advocates for Disaster Risk Reduction, with priorities 3 and 4 being the most relevant and applicable.

2.3.2 National Frameworks in Disaster Management

South Africa has a wide-ranging set of disaster management legislations and regulations that have been passed to reduce the likelihood of disastrous events (IFRCRCS, 2012). This study examined only relevant pieces of legislation to address research questions essential

to managing risk associated with the outbreak of fall armyworms if there is a link between food insecurity and mental health issues.

- **The Constitution of the Republic of South Africa (Act 108 of 1996)**

The Constitution of the Republic of South Africa (Act 108 of 1996) is the highest law in the country. Therefore, the South African government is legally responsible for ensuring citizens' food security. Three organs of state are the national, provincial, and local governments established under Chapters 3, 6, and 7 of the 1996 Constitution of the Republic of South Africa. Their role should be to exercise their authority to perform their duties to enable effective and efficient coordination of their executive decisions and policies for effective service delivery (Thornhill, 2011).

According to Section 27(2) of the Constitution of the Republic of South Africa, “everyone has the right to have access to sufficient food and water” (RSA, Constitution), 1996). ‘The state must take reasonable legislative and other measures, within its available resources, to achieve the progressive realisation of each of these rights” (RSA, Constitution), 1996). According to FAO (2015) millions of people across the globe are facing a threat of hunger due to food security. The right to food is a human right recognised under national and international law, which protects the right of human beings to access food either by producing their food or by buying food (SAHRC, 2024). The right to food requires that food be always available, accessible, and adequate for everyone without discrimination (SAHRC, 2024). Currently, there are about 11 million people in South Africa who are food insecure (who do not know where their next meal is coming from). Additionally, there are 12 million poor food insecure people, of which approximately 70% live in rural areas, and more than 60 percent of chronically hungry people are women (SAHRC, 2024).

Section 27(1)(a)(b) of the Constitution of the Republic of South Africa provides that, “everyone has the right to have access to health care services and sufficient food and water. This enjoins organisations and individuals working in disaster relief efforts to ensure that all people affected by fall armyworm's impact have access to sufficient food. Furthermore, people's health, well-being, and ability to provide for themselves and their families must be prioritised during pandemics.

Mental health is “a state of well-being in which an individual realizes his or her abilities, can cope with the normal stresses of life, can work productively, and can make a contribution to his or her community” (WHO, 2014). All spheres of government are obligated to “protect the well-being of the people of the Republic" and local government must “ensure food security

and wellbeing" is adhered to as mandated by the highest law of the country (Ibid), p.8). According to Zamisa and Mutereko (2019), Section 151(2) of the Constitution of the Republic of South Africa (Act 106 of 1996) empowers municipalities in South Africa to pass disaster management-related by-laws. The Municipality must provide oversight in collaboration with other relevant stakeholders to prevent and mitigate fall armyworm's impact. Several policies and strategies are being put in place to manage pest infestation and minimise the impact of pests on food security and mental health.

Disaster Management Act 2002 (Act No. 57 of 2002)

The Disaster Management Act 2002 (Act No. 57 of 2002) was enacted on January 15, 2003. The Act's main purpose is to create systems and conduct planning that are more proactive in reducing the risk of disaster which communities might be exposed. The Act contemplates a coordinated strategy for preventing and responding to disasters, lessening disaster losses, and helping affected communities recover speedily, along with other provisions of the Act. Each state's national, provincial, and municipal organ must conduct a disaster risk assessment for its functional areas and identify and map risks in areas, communities, households, and ecosystems that are exposed or vulnerable to physical and human-induced threats.

The DMA mandates each municipality to establish a disaster management centre which specialises in disaster situations threatening the municipal area. Therefore, the Act allows the local municipalities to establish disaster management centres in partnership with a district municipality because of capacity constraints. The disaster management centres which were established are mandated to inform the National Disaster Management Centre (NDMC) of disasters threatening to occur. Disaster Management Act (DMA) provides an array of disaster risk management policies and legislation. In essence, the DMA regulates all disaster situations in South Africa by providing disaster risk management mandates that focus on disaster prevention, reduction, disaster preparedness, and post-disaster recovery (Van der Berg, 2015).

Municipal disaster management centre recognises the critical requirement for consistency in the strategy used by such a wide variety of role players and partners. It includes determining how vulnerable communities and households are to potential disasters and keeping track of the likelihood and level of alertness to disasters. The spreading of fall armyworm speedily had negative effects on food security and livelihoods of millions of people including resource-poor farmers in South Africa (FAO, 2018).

Various studies have found that mental health issues are neglected in South Africa particularly in disaster situations (Burger and Mchenga, 2021; Thela et al., 2022). Municipalities around the country should create and implement a policy to manage and coordinate local disaster risk reduction (DRR) and ensure that mental health issues are taken care of during and after a crisis. The Disaster Management Act is integral to preparing before, during, and after a disaster. Issues such as anxiety, stress, and post-traumatic stress disorders exacerbated by disasters should be looked at critically and included in the Disaster Management Guidelines.

- **The Mental Health Care Act, Act No.17 of 2002**

Mental Health Care Act of 2002 was signed on October 28, 2002, but it did not become effective until December 15, 2004. The ten fundamental principles of mental healthcare law established by the World Health Organization (WHO) serve as the basis for the 2002 Mental Health Care Act was enacted and one of the goals is to establish a legislative framework to monitor and control mental health services (Walker and Osei, 2017).

In South Africa, there are policies in place to support people with mental health problems, but they are not helping those who need it the most (Madonsela, 2022). For example, farm communities that were affected when fall armyworm destroyed their entire farms, resorted to replanting crops, and had financial repercussions, therefore can have financial stress to poorly resourced farmers (Price, 2021). In terms of Section 4 of the Mental Health Care Act of 2002, provisions that (1) promote and enhances the mental health of the population, and (c) advocate for the rights and interests of those who seek mental health care. However, the provision of the Act probably has not been adhered to in South Africa, presumable, because the affected communities were never made aware of the Act (Sodi et al., 2021). Section 4 of the Mental Health Act of 2002 places its primary emphasis on the policies and procedures that are put into place by individual states.

- **South African National Disaster Management Framework (NDMF) of 2005**

The National Disaster Management Framework (NDMF) promulgated the Disaster Management (DM) Act of 2002, which was enacted to draw attention to international Disaster Risk Management practices (Kunguma, 2020). Therefore, the NDMF aims to provide an inclusive legislative policy on Disaster Risk Management practices suitable for enactment in all spheres of the South African government. The main function of NDMF is

predominantly reducing the severity and magnitude of disasters in disaster-prone communities (Van Niekerk, 2014).

The NDMF facilitates the engagement of relevant stakeholders i.e., traditional leaders; non-government organisations, etc. in Disaster Risk Management (Kunguma, 2020). Taking into consideration capacity-building, the NDMF incorporates indigenous knowledge in Disaster Management training and education, as well as in disaster risk reduction initiatives (Munsaka and Dube, 2018). The outbreak of fall armyworm in South Africa caught people by surprise, and unprepared when it was reported in 2017, the worm has been reported to be capable of attacking quite a number of food security crops with such a devastating effect and therefore listed on the EPPO A2 as a quarantine pest as well as priority pests on the European Commission (Day et al., 2017; Ram, 2019; EU, 2019), therefore, has made the provisions by the NDMF to be challenging in the sense that has affected capacity-building as required.

The NDMF has four key performance areas (KPAs) and three enablers supporting the KPAs, therefore the KPAs steps are as follows:
• KPA 1 supports all measures directed at integrating the institutional capacity for disaster disk management. Such measures enable the effective implementation: of disaster management legislation and policies. Van Riet (2009) shares that KPA 1 is engrossed in establishing communication systems, such as an early warning system that warns communities of imminent threats.

• KPA 2 deals with establishing a systematic approach to community-based disaster risk assessments (Van Riet, 2009).

• KPA 3 KPA 3 encourages stakeholder participation in disaster risk reduction plans and is entrenched in achieving effective response and recovery in the aftermath of disasters. Therefore, concerning the outbreak of fall armyworm, the question is whether there were existing disaster risk management plans in South African municipalities focused on the outbreak of pests such as fall armyworm.

KPA 4 deals with the activities of rapid response to disasters and the recovery phase.

The above KPAs are entangled with the three enablers in the framework namely: 1) enabler 1: information management and communication which is very critical and therefore supposed to be maintained throughout the management of disasters; 2) enabler 2: education, training, public awareness, and research should be prioritised for effective and

efficient disaster risk reduction; and 3) enabler 3: funding arrangements for disaster risk management should be prioritised across all the phases of disaster management. KPAs 3 and 4 are the most relevant to this study. The findings of the research study will provide insight into how farmers have implemented better management strategies for cushioning the impact of fall armyworm. These strategies are very important to promote resilience within the community at Shayandima.

KPA 4 put emphasises on the readiness to respond to the outbreak of fall armyworm; furthermore, to gauges how the response was provided in relation to the impact of the worm. However, timeously and effectively response is based on better management practices in terms of fall armyworm.

Subsequently, having said the above, the NDMF framework outlines generic guidelines for disaster risk management (Kunguma, 2020). Remarkably, Van Niekerk (2014) has reported inconsistencies between what is outlined in the legislation and the realities within the local government. Various authors have reported that the implementation of NDMF guidelines is facing a significant hindrance because of insufficient funds for the disaster risk management function (Van der Berg, 2015; Van Niekerk and Wentink, 2017). Therefore, affecting operational functions at both provincial and municipal levels.

In conclusion, this study strives to promote a culture of disaster risk reduction to improve the capability of the disaster risk management function. Therefore, the researcher is of the view that outlining relevant sections in the NDMF and all the quoted legislative frameworks and policies is fundamental within the context of the study as it is of paramount importance in addressing the research problem.

CHAPTER 3: LITERATURE REVIEW

3.1 Introduction

Literature review involves contextualising the research problem by synthesising existing knowledge, forming conclusions, and identifying gaps in the literature (Snyder, 2019). The chapter describes the socio-economic and mental health impact of fall armyworm on the small-scale farmers at Thulamela Local Municipality in the Limpopo Province, South Africa. The chapter also covers global, sub-Saharan Africa, South Africa, and the study area of Thulamela Municipality.

The fall armyworm, *Spodoptera frugiperda* is a polyphagous moth, an invasive pest, native to tropical and subtropical regions of America (Pogue, 2002; Suby et al., 2020; Wang et al., 2023) and of economic importance in Africa (Kansiime, Rwomushana, and Mugambi, 2023). Its presence has been confirmed in regions globally, including Europe, Asia, Africa, and South Africa causing substantial economic and ecological damage (Westbrook et al., 2016). While the fall armyworm has not been declared a disaster yet, its invasive character affects the ecosystem, and disaster risk reduction talks now are focusing on ecosystem-based Disaster Risk Reduction (IUCN, 2017) and this worm could be a threat where it occurs. Due to its significant agricultural and ecosystem risks, the pest is listed as a quarantine pest (EPPO A2) by the European and Mediterranean Plant Protection Organization (EPPO) and the European Commission (EFSA PLH Panel et al., 2017; 2018a; EFSA et al., 2020).

The fall armyworm's preference for maize (*Zea mays* L.) is a serious problem. Studies across the globe revealed that more than 300 million African small-scale farming families depend on maize as a staple food (Matova et al., 2020; Santpoort, R., 2020; Tambo et al., 2021). The pest has been reported to attack 353 plant species belonging to 76 plant families (Montezano et al., 2018). Apart from corn maize, fall armyworm is causing serious damage to rice, sorghum, sugarcane, potato, onion, millet, soybean, tomato, cabbage, beet, groundnut, potato, and cotton (Day et al., 2017; Ram, 2019). Attacking these food security crops makes the worm a formidable pest and the impacts of this pest on communities especially rural communities need to be reported case by case.

The fall armyworm was first reported in Africa in 2016 and currently spread to various countries such as Morocco, Tunisia, Egypt, Zambia, Ethiopia, Kenya, Zimbabwe including South Africa (Bannor et al., 2022; DALRRD, 2022; Tambo et al., 2021). Indeed, the rapid spread of the pests poses a serious threat to food security, nutrition, and livelihoods

(Prasanna et al., 2018; Matova et al., 2020) but the mental health issues and threats that come with this worm have not been extensively studied.

In South Africa, fall armyworm were reported in 2017 in the Limpopo and Northwest Provinces, Department of Agriculture, Land Reform and Rural Development (DALRRD, 2022). Currently, fall armyworm has been confirmed in all nine Provinces of South Africa, including Limpopo Province, particularly the farming communities at Shayandima in the Thulamela Local Municipality under Vhembe District Municipality, where this study is undertaken.

3.1.1 Fall armyworm migration and the impact of climatic conditions

The wide spread of the fall armyworm globally is influenced by several factors, including its high reproductive capacity, high migration ability as well as the change in climate patterns (Gullino et al., 2021). For instance, adult fall armyworms have a strong flying ability of 100 km/night (Pogue, 2002) and could cross the Gulf of Mexico by migration (Wang et al., 2023). In the UK, the lepidopteran moths and butterflies have been reported each year to have increased in migration rate and this has been linked to increased temperatures in southwest Europe (Sparks et al., 2007). According to Gitz et al. (2016) increasing temperatures have been reported to have played a major role in facilitating pest range expansion, especially at higher latitudes and altitudes, and some warm areas in Europe, such as Spain, Italy and Greece, may provide suitable climatic conditions for establishment of fall armyworm (Gullino et al., 2021).

Current researchers have demonstrated extensively how climatic conditions (i.e., temperatures, precipitation levels, seasonal wind currents induced by climate change) play a crucial role in the existence and spread of fall armyworms (Di Falco et al., 2012; Wang et al., 2023). South and Southeast Asia and Australia are highly suitable for fall armyworm, given the climate conditions that would allow fall armyworm to invade (Sartiami et al., 2020); suitable environment for the establishment of fall armyworm to continue all year round such as the availability of host plants, irrigated and off-season in sub-Saharan Africa (SSA) (Prasanna et al., 2018).

The study has shown that climatic factors such as temperature, rainfall, and humidity directly impact the lifecycle of fall armyworm, affecting its distribution and abundance (Nurzannah et al., 2020). For instance, in regions like Senegal and South Africa, where temperatures are within the optimal range for fall armyworm development, the pest tends to proliferate more rapidly (Du Plessis et al., 2020; Tendeng et al., 2019).

However, fall armyworm does not diapause, and has the capability for multigenerational seasonal migration (with the potential to cause damage) in areas that may be unsuitable for the year-round persistence of the pest (Maino et al., 2021; Niassy et al., 2021; Zhou et al., 2021). The fall armyworm has been reported to adapt, reproduce, and survive in hot conditions and therefore, the climatic condition of Thulamela Local Municipality in Shayandima communities which fall within Thohoyandou town in the Limpopo Province of South Africa provides a suitable advantage for this pest to develop, survive and establish (Du Plessis et al., 2020).

3.1.2 Global impact of fall armyworm on agriculture and trade

The total economic loss due to fall armyworm is estimated to be US$ 200 million across the world, which is equivalent to 0.08% of the global gross domestic product (Abro et al., 2021). Fall armyworm insects poses potential threats to agriculture in the European, Asian, and African continents (EFSA PLH Panel et al., 2018a; EFSA et al., 2020). Maize is a high-value crop in Africa used as a staple food (Matova et al., 2020; Tambo et al., 2021), however, in other countries such as the United States, maize is used as animal feed (Orke and Dehne, 2004). The greatest risk of introducing fall armyworms may lead to technical barriers to trade (Secretariat, IPPC, 2021). The spread of fall armyworm at a fast pace will subsequently have a significant economic impact on agriculture (Abro et al., 2021; De Groote et al., 2020; Tanyi et al., 2020).

The fall armyworm is known to be a seriously damaging agricultural pest, causing total losses of an estimated $39 to $297 million annually (Sparks 1986). As a result of the risk of introduction, establishment, and devastating effect on Europe, fall armyworm is therefore listed on the EPPO A2 as a quarantine pest as well as a priority pest on the European Commission (EU, 2019).

In Africa, a significant economic loss of approximately $9.4 billion annually was estimated in 33 countries due to fall armyworm damage (Eschen et al., 2021). Also, Matova et al. (2020) reported that the pest is likely to affect maize trade, including seed, grain, and green maize in Africa (ACAPS, 2017). Reports suggest that grain consignments contaminated with fall armyworms, coming from Africa, were prevented from entering Europe (Goergen et al., 2016). This has resulted in strict and thorough checking at entry points (ACAPS, 2017).

In Ethiopia, the total economic loss due to fall armyworm was estimated at $200 million or 0.08% of GDP (Abro et al., 2021). In Zimbabwe, a social economic survey showed

significantly lower maize income and total household income per capita for fall armyworm-affected households than those not affected, with a mean difference of $59.19 and $258.84 per year, respectively (Tambo et al., 2021) and finally a national loss of approximately $177 million and $159 million was recorded in Ghana and Zambia respectively due to fall armyworm (Rwomushana et al., 2019). In South Africa, the pest has been confirmed in the production areas of maize which contributes the major component of approximately 57% of yield production for yellow maize (DALRRD, 2022).

3.2. The impact of fall armyworm on maize worldwide

Maize is used worldwide for feed, hence, the international trade of maize has reached 72 million tons (12% of production) in 1998 (Orke and Dehne, 2004). In Asia, maize is the third most important cereal after rice and wheat (Prasanna et al., 2021). Therefore, maize area is approximately one-third of the global maize area of 197 million ha of which five countries namely China, India, Indonesia, the Philippines, and Pakistan account for 90% of the area under maize cultivation on the continent (Prasanna et al., 2021). During the 2019 harvest season, China has harvested maize area and recorded 41.28 million ha, followed by India as the second largest maize-growing, with an estimated maize area of 9.03 million ha, Indonesia with 5.64 million ha; and the least is Pakistan with 5.12 tons/ha respectively (BPS 2021; Prasanna et al., 2021). With the fall armyworm affecting these parts of the world, there could be devastating consequences for the food security of the affected vulnerable communities relying on maize as their staple food.

The impact of fall armyworm has also been noted in the United States where it led to yield losses ranging from 25 to 100%, depending on the severity of infestations (Arias et al., 2011; Womack et al., 2018). The fall armyworm was reported to cause an annual average yield loss of $60 m between 1975 and 1983 in the United States (Ellis, 2005). Furthermore, an estimated annual loss of US $400 million has been reported on maize crops in Brazil because of fall armyworm (Figueiredo et al., 2005; Kumela et al., 2019; IITA, 2016). It was estimated that Brazil spends about US$600 on fall armyworm outbreaks (Wild, 2017). Additionally, in Central America, Hruska and Gould (1997) revealed that fall armyworms have resulted in maize loss between 15% and 73% in Nicaragua, which is a loss that could have fed some proportion of the country's population. In addition, approximately up to 73% yield loss in maize has been observed due to fall armyworm in Latin America (Hruska and Gould,1997).

In Asian countries, the fall armyworm is posing a serious challenge to the livelihoods of hundreds of millions of farming communities in the Asian region (Prasanna et al., 2021).

The current distribution of fall armyworms has a serious negative impact on the livelihoods of Asian people (CABI, 2017). Approximately 44–100% of field infestation in the regions of Karnataka in India has been reported (Navik et al., 2021). The largest number of food-insecure persons are found in South Asia, which has roughly 300 million undernourished (Porter et al., 2014). Another survey shows an estimate of over 70% maize loss due to fall armyworm infestation in Nepal (Bhusal and Bhattarai, 2019).

Maize is the most important crop in SSA, covering 36 million hectares, which accounts for over 30% of SSA people's caloric intake, therefore, the outbreak of fall armyworm threatens the production of maize (ACAPS, 2017; Kansiime, Rwomushana, and Mugambi, 2023; Tambo et al., 2021). Rwomushana et al. (2018) extrapolated that the pest has the potential to cause an annual reduction in maize production in Zimbabwe of about 264,000 tonnes, translating into a revenue loss of US$ 83 million. The study in Namibia shows that the country could lose 57% of total maize production annually due to fall armyworm infestation (FAO, 2018). In 2017, Kassie et al. (2020) estimated that 7% of the 2.74 million tonnes of maize production loss because of fall armyworm was reported in Ethiopia estimated by Day et al. (2017). Similarly, estimated losses were 13% of the 1.67 million tonnes of maize loss in 2018 estimated by Rwomushana et al. (2018). If measures are not put in place to control fall armyworm, the trade of maize could be affected negatively on the global environment.

3.2.1 The impact of fall armyworm on livelihoods in Africa- sub-Saharan Africa

Fall armyworms have been confirmed and established in São Tomé and Príncipe, Benin, Nigeria, and Togo in 2016 (Nagoshi et al., 2018; Nagoshi and Meagher, 2018; Prasanna et al., 2018). Since the interception of fall armyworm in 2016, the first affected farmers suffered huge losses because of unpreparedness (Matova et al., 2020). Subsequently, in 2018, fall armyworm invaded 44 African countries causing a massive decline in crop yield (Cock et al., 2017).

Fall armyworms in Africa are causing significant damage to maize crops, in so doing threatening the livelihood of numerous farmers who rely on maize production for income (Goergen et al., 2016). Approximately 300 million farming families depend on maize for livelihoods (Cock et al., 2017; Kansiime, Rwomushana, and Mugambi, 2023; Tambo et al., 2021). Therefore, the outbreak of the fall armyworm in Africa has led to yield losses and impact negatively on the livelihoods of small-scale farmers and their income (Kansiime, Rwomushana, and Mugambi, 2023; Rwomushana et al., 2018).

The impact of fall armyworm at the household level may not affect the amount of maize consumed, but rather the amount sold because farmers mostly sell off the excess harvest after catering to household food demands (Otim et al., 2021). This may affect the income earned and result in cash shortages, leading to failure to afford necessities (Kassie et al., 2020). Sadiq et al. (2013) also reported the profitability and production efficiency of small-scale maize production and that the net farm income in Niger State; Cross River State and Nasarawa State were severely affected in 2018. The results indicated that maize production was profitable despite the outbreak of fall armyworm, presumably because farmers implemented better management strategies to cushion the effects of the fall armyworm. Similarly, a study by Abiodun et al. (2020) in Ekiti State reported yield loss of millions which was not quantified in value consequently leading to reduced household income and poverty.

It was further assumed that this loss might have been due to poor management practices by farmers leading to maize farms being abandoned (Abiodun et al., 2020) in contrast to a study by Sadiq et al. (2013). Similarly, Tambo et al. (2021) revealed that in Zimbabwe, fall armyworm negatively impacted household food shortage and decreased per capita income. Indeed, a survey carried out by the Centre for Agriculture and Biosciences International (CABI) indicated that an estimate of approximately 40% of the national mean losses of maize crops due to fall armyworms with a range of (25-50%) in Zambia showcasing the negative impact of this worm to vulnerable communities.

3.2.2 The impact of fall armyworm on livelihoods in South Africa

In South Africa, small-scale farming is an important aspect of livelihood and therefore, agriculture is the mainstay of livelihood especially in Limpopo Province which accounts for approximately 8 million hectares of land used for agriculture (Uhunamure et al., 2021). Approximately 4.4% of Limpopo households practice farming and/or agriculture for income (De Cock et al., 2013; StatsSA, 2017). Moreover, approximately 77% of farmers who planted maize on <1ha of land have recorded an estimated 25-100% crop loss mainly due to this pest (Price, 2021).

Most of the South African maize crop was produced in the Free State (41,5%), Mpumalanga (23,4%), and the Northwest (16,7%) (DALRRD, 2022). The estimated area where South African commercial producers planted maize during the 2022 season was 2,623 million ha (DALRRD, 2022). This was 4,8% or 132 400 million ha less than the 2,755 million ha planted in the previous season (DALRRD, 2022). Of this area, 1,224 million ha (46,7%) were in the Free State, 544 000 ha (20,7%) in the Northwest, and 515,000 ha

(19,6%) in Mpumalanga (DALRRD, 2022). However, the plantings of maize in the Free State decreased by an estimated 7,8%, from 1,328 million ha in 2021 to 1,224 million ha in 2022, and in the Northwest by 6,2%, from 580 000 ha to 544 000 ha. Planting in Mpumalanga decreased by an estimated 1,9%, from 525 000 ha in 2021 to 515 000 ha in 2022 (DALRRD, 2022). Apart from other environmental factors, it can only be speculated that fall armyworm might have played a role in the yield loss, considering that the host of the pest is maize. Although there was an increase in yield maize production, there is no record that quantifies the impact of fall armyworm in value across the studied provinces.

3.3 Fall armyworm and food security worldwide

According to the Secretariat, IPPC (2021), fall armyworms are regarded as the most destructive pests for maize which is a staple food for most communities across the world maize. Therefore, the infestation of this worm has the potential to affect global food availability and food security undermining most Sustainable Development Goals around the globe (Secretariat, IPPC, 2021). Indeed, maize is a cheap source of carbohydrates for the marginalised and is keeping, the most marginalised communities across the world's food secure (Secretariat, IPPC, 2021). When fall armyworm infest, it causes significant food losses for millions of people including farmers (De Groote et al., 2020; Kansiime, Rwomushana, and Mugambi, 2023). Globally, it has been quite a challenging exercise to observe about 300 million people faced with the threat of food insecurity due to yield loss of approximately 45% of maize production which accounts for an estimated annual loss of up to U$D 2400-4800 million (Mitchell, 1979).

The outbreaks of plant pests such as fall armyworm cause annual yield losses of approximately US$220 billion (Chakraborty and Panda, 2019; Rohr et al., 2019; Ristaino et al., 2021). Therefore, the rate of increasing threatens food security for the vulnerable in many areas of the world because a stable, nutritious food supply is required to boost millions of people out of poverty and improve health outcomes (Chakraborty and Panda, 2019; Rohr et al., 2019; Ristaino et al., 2021). Global yield losses due to crop pests (such as fall armyworm) and diseases on food crops are large, with mean losses ranging from 21.5% (10.1 to 28.1%) in wheat, 30.3% (24.6 to 40.9%) in rice, 22.6% (19.5 to 41.4%) in maize, 17.2% (8.1 to 21%) in potato, and 21.4% (11 to 32.4%) in soybean (Ristaino et al., 2021).

In Europe, Spain, and Italy have the highest risk of invasion by this worm, with 39.08% and 32.20% of effective arrival points respectively, followed by Turkey, France, Greece, and Portugal with 8.89%, 6.82%, 5.77%, and 5.08% of effective arrival respectively (Wang et

al., 2023). While food insecurity due to this worm is not yet profound, mitigation measures are needed for the control of the worm. Other authors identified risks in areas of Central Europe or further north, up to Ireland (Liu et al., 2020; Ramasamy et al., 2022) and Southern Norway (Tepa-Yotto et al., 2021), although with low habitat suitability indices for this worm. Therefore, there is not yet a link between food security and the armyworm in these European countries.

In the United States of America, the literature scan on the impact of fall armyworm on food security is scanty. This is because researchers have not extensively studied the impact of fall armyworms on food security on a broader scale, leaving a knowledge gap in scientific knowledge. Moreover, lack of sufficient studies on fall armyworms can be attributed to the colder weather in most parts of America that are not suitable for the armyworm. The only recent study which distinctively reported on fall armyworm in America, only reported estimated losses of up to 250-630 million US dollars per year was published in 2018 (Bateman et al., 2018).

According to Wightman (2018), the impact of fall armyworm may be catastrophic and lead to famine in the South Asia region. This is because the impact of fall armyworms on both the current and future food security has not been quantified accurately at this point because of the continued spread, and the implications extend beyond the cash value of the crops that are destroyed in some Asian countries (Wightman, 2018). China is the second largest maize producer in the world, and maize is grown in all the provinces (Li et al., 2020). Fall armyworm has been spreading speedily in South Asian regions, despite scientists raising serious concerns for the past two years and this is a concern to food safety (FAO, 2018). In Sri Lanka, 40000 hectares of 20% maize are infested with fall armyworms with an economic loss of 1- 3 billion in Asia since infestation and U$D 2400-4000 million per year loss (Secretariat, IPPC, 2021).

Various authors have depicted the outbreak of fall armyworm in Asian countries namely China, India, Indonesia, Japan, Nepal, and Yemen (Bhusal and Bhattarai, 2019; Tambo et al., 2019). Fall armyworms in India had become the dominant pest species in maize crops and records revealed that more than 90% of maize plants were infested (Navik et al., 2021). On the other hand, economic losses for fall armyworm have not yet been estimated in Indonesia even though is it well known that it has the potential to cause maize yield losses of approximately 8.3 to 20.6 million tonnes annually valued at between US$2.5 to US$6.2 billion (CABI, 2017). However, the link to food insecurity has not yet been reported.

3.3.1 The impact of fall armyworm on food security in Africa- SSA.

The projection that fall armyworms would give rise to an annual crop yield loss of between 4.3 to 17.7 million tons of maize in Africa is alarming (Rwomushana et al., 2018). This forecast is indeed a challenge and calls for immediate action. This is because more than 300 million farming families depend on maize for food security in Africa (Cock et al., 2017; Kumela et al., 2019; VIB, 2017). It is recorded that fall armyworm has the potential to cause an annual yield loss of maize between 8.3 and 20.6 million tons in 12 African countries to the tune of US$6.1bn (Day et al., 2017). According to the surveys carried out across the African region, it revealed that 22%-67% of damage occurred in Ghana and Zambia, causing the loss of approximately millions of dollars (Day et al., 2017). For example, Ethiopia has recorded an estimated yield loss of 0.18 million tonnes due to fall armyworm (Kassie et al., 2020). A survey by different researchers shows an estimated maize yield losses of between 11% and 67% on the farm level in some SSA countries due to fall armyworm (De Groote et al., 2020; Kassie et al., 2020; Overton et al., 2021).

Tambo et al. (2021), revealed that in Zimbabwe fall armyworm positively impacted household food shortage and decreased per capita income. In 2019, farmers reported infestation levels of approximately 11.57% (Zimbabwe), 32% (Ethiopia), and 47.3% (Kenya) respectively, and predicted a general trend of increasing infestation in future seasons (Baudron et al., 2019; Kumela et al., 2019). In conclusion, the continuous persistence of the pest may cause food insecurity and poverty in the long run by reducing marketed surplus and income (Kassie et al., 2020).

3.3.2 The impact of fall armyworm on food security in South Africa

South Africa is one of the countries that has been reported as the largest maize producer in the Southern African Development Community (SADC)(DALRRD, 2022). However, less has been reported on the economic losses related to fall armyworms. Therefore, it has not yet been estimated how much losses were accounted which may have an impact on food security in South Africa. Most studies have focused more on the estimation of the effects of fall armyworms instead of quantifying the impact of the pest on food security. This was seen in a study conducted in Limpopo Province on small-scale farmers which revealed an estimate of approximately 3 500 farmers who were affected by fall armyworm on 40 000ha (Price, 2021). Therefore, more studies are needed to explore the impact of the fall armyworm on food security in South Africa case by case.

3.4. The mental health impact of the fall armyworm

According to the World Health Organization (WHO), mental health is "*a state of well-being in which an individual realizes his or her abilities, can cope with the normal stresses of life, can work productively, and can contribute to his or her community*" (WHO, 2014). Mental health problems can negatively impact an individual's emotional, social, and intellectual abilities (WHO, 2014; 2022). Depression is one of the most widespread measures of mental health disorders globally, affecting a large portion of the population (WHO, 2014). According to CDC (2005) report, mental health problems are interrelated and can result from social, natural, cultural, and environmental activities (CDC, 2005). For instance, there is a mounting fear in the field of occupational health about the impact on the mental health of agricultural workers biomarkers of depression (Cancino et al., 2023). The study by Cancino et al. (2023) indicates an association between pesticide exposure and the development of depression. Research studies show that post-traumatic stress disorder (PTSD), depression, and depressive disorder contribute to the way people behave or respond in life due to sudden shocks such as fall armyworm infestation (Fergusson et al., 2014; Stringo et.al., 2008).

3.4.1 The mental health effects of fall armyworm worldwide

Interestingly, there are enough research studies on mental health relating to farm workers' exposure to pesticides and/or chemicals. For example, Fraser et al. (2005) in the United Kingdom, Europe, and Australia have provided an overview of the literature examining mental health issues experienced by farming populations as the highest rates of suicide of any industry. There is also growing evidence that those involved in farming are at higher risk of developing mental health problems (Daghagh, Wheeler, and Zuo, 2019). However, there is a lack of information on how farmers and farm owners are affected by fall armyworms, including how the total crop maize loss affects them mentally.

Additionally, in southeastern Spain, intensive and highly productive agriculture under plastic also poses a risk to human health, as evidenced by reports on acute pesticide poisoning and its effects on mental health (Ruirui, 2024). Research to date indicates that farmers, farm workers, and their respective families face an array of stressors related to the physical environment, structure of farming families, and the economic difficulties and uncertainties associated with farming which may be detrimental to their mental health (Fraser et al., 2005). However, the literature scan specifically on the link between pests' infestation and mental health is scanty. Worldwide, there is increasingly a call for additional research studies on the mental preparedness for disasters including fall armyworm to

improve the knowledge gaps and obtain baseline information in this regard. The outbreak of pests and diseases such as *Tuta absoluta* including fall armyworms could trigger mental health problems because of the impact of rising costs of crop production (Campos et al., 2017). People spend more to access measures responsible for pest management, and the potential loss of trading partners through restrictions on export to non-infested countries, these factors can trigger mental health issues relating to financial burdens and loss (Campos et al., 2017).

In India, for example, an estimate shows that about US$110 billion is lost each year in low and middle-income countries due to loss of productivity because of fall armyworm which has affected the mental health of the community as it nearly resulted in famine (Satapathy, 2001). Presumably, this might be because of shocks from the agricultural sector which are triggered by a system of multiscale stressors (Chuku and Okoye, 2009). These include outbreaks of pests (fall armyworm), climate change, natural disasters, volatility of commodity prices, policy shocks, and the effects of globalisation (Chuku and Okoye, 2009). Another one of the few studies in Asia, however, revealed evidence of pesticide exposure posing a risk to farmers' mental health, particularly long-term and high-intensity exposure in Thailand (Ong-Artborirak, 2022). One other report indicates that fall armyworm infestation left farmers in great distress (Bannor et al., 2022).

Studies have neglected research on mental readiness for disaster that could be caused by pest infestation around poor communities in South Africa. The impact of fall armyworms is devastating because replanting maize has financial repercussions (Price, 2021). Some farmers end up selling their livestock and other belongings to generate income and this has affected their livelihood and, consequently, can cause mental health problems related to stress (Zulch, Reser, and Creed, 2012). Those farmers who lost everything seek employment on other farms or search for work in cities (Barron, 2004).

3.5 Mitigation of fall armyworm

To date, fall armyworm has been detected in more than 70 countries and none of the countries has been able to eradicate this pest and significant pest populations have been established in these affected countries (FAO, 2020). Around the globe, policies and strategies are being put in place to manage pest infestation, for instance, Europe has classified the fall armyworm high risks areas and periods of invasion for early deployment of pest management measurements (Wang et al., 2023). The control methods used in the United States include genetically modified crops, application of chemical and botanical

pesticides, agronomic practices (such as early planting, intercropping, and crop rotation), and integrated pest management (IPM) (Tambo et al., 2020).

Several studies have made recommendations to combine different control methods to tackle fall armyworm infestations because agricultural technologies and practices generate higher gains when adopted in combination rather than in isolation (Day et al., 2017; Tambo et al., 2020; Teklewold et al., 2013; Tambo and Mockshell, 2018). The small-scale farmers in SSA regions such as Zambia, Ethiopia, and Kenya for example, have been adapting to the pest by increasing crop surveillance and developing low-cost solutions such as placing soil or ash in maize whorls, handpicking larvae, crushing egg masses, and young larvae, placing different soil types and wood ash be effective in reducing the number of larvae and damage to maize (Kumela et al., 2019; Tambo et al., 2020).

Moreover, cultural practices such as regular weeding, early planting, and crop rotation were more predominant among farmers in Ghana (Tambo et al., 2020). Farmers have implemented cultural practices to manage fall armyworm infestation and ensure timely planting (Tambo et al., 2020). Breeders are developing cultivars that can offer native resistance to the pest, while chemical companies, entomologists, and other researchers are developing insecticides, bio-controls, and cultural methods, respectively, to minimize crop damage that can result after infestation (Wightman, 2018). In South Africa, fall armyworm is regulated under of the Agricultural Pests Act No. 36. of 1983. For Control Measures relating to fall armyworm (DALRRD, 2022). Farmers are required to carry out scouting for egg packs, leaf damage, and caterpillars, as well as trapping (DALRRD, 2022). Effective control of the fall armyworm can be realised through integrated pest management practices (DALRRD, 2022).

3.6 Conclusion

There is quite extensive research data globally that quantified the impact of fall armyworms on farmers. However, there is a limited literature review on the impact of fall armyworm on the mental health of small-scale farmers globally including South Africa. Indeed, studies that link food security with this worm are also scanty around the world. Therefore, this study chapter has put into perspective what gaps are supposed to be filled in the study of this formidable pest that is affecting farming communities across the world. The research findings of the study will hopefully address the gap of understanding and knowledge accumulation about mental health issues concerning the impact of fall armyworm in the farming sector, particularly on small-scale farmers in the Thulamela Municipality in Limpopo Province. It is imperative that effective fall armyworm management strategies are in place

and be implemented to guard against the pest's potential negative effects on food security and livelihoods of millions of people including resource-poor farmers in South Africa.

CHAPTER 4: STUDY METHODOLOGY

4.1 Introduction

This Chapter presents a description of the research process. It provides information concerning the method that was used in undertaking this research as well as a justification for the use of this method. The Chapter also describes the various stages of the research, which include the selection of respondents, the data collection process, and the process of data analysis.

The chapter, therefore, presents the methodology employed to gather and analyse data on the assessment of the impact of fall armyworm on the livelihoods, food security, and mental health of the study communities. Moreover, this chapter covers a wide range of research methodology approaches and techniques, such as (i) triangulation technique to gather both qualitative and quantitative data (ii) philosophical worldviews or paradigms to understand the research and how findings were interpreted, (iii) the research design, (iv) the research methodologies, (v) the analysis method, and (vi) the process of data validity, data reliability, limitations and delimitations, ethical considerations.

4.1.1 Research design

Research design is a plan or framework for conducting an investigatory study, and thus involves the ways for collecting and analysing data (Singh, 2023). Therefore, the research design should be carefully planned as it influences the quality and validity of the research outcomes (Sharma et al., 2023). According to Babbie (2013), research design is a set of decisions regarding the topic to be studied, among what population, research methods, and for what purpose. When designing a research project, the researcher considers the following assessment: the researcher's interests, abilities, and available resources (Babbie, 2013). Another definition of research design is a plan or strategy prepared for organizing the research to be practicable (McCombes and Bhandari, 2021). The research design also allows the research questions to be answered based on evidence and a general strategy to integrate the different components of the study coherently and logically (Kirshenblatt-Gimblet, 2006). The design also ensures that the researcher effectively addresses the research problem, constituting the blueprint for data collection, measurement, and analysis (Cohen, Manion, and Morrison, 2002).

4.1.2 Research Approaches

Research approaches are plans and procedures for research that span the steps from broad assumptions to detailed data collection and analysis methods. Additionally, the overall decision involves which approach to be used for research (Creswell and Creswell, 2017). Informing this decision should be the philosophical assumptions the researcher brings to the study; procedures of inquiry (called research designs); and specific research methods of data collection, analysis, and interpretation, hence the selection of a research approach is based on the nature of the research problem or issue being addressed, the researchers' personal experiences, and the audiences for the study (Creswell and Creswell, 2017). Nevertheless, three research approaches will be discussed below.

- *Qualitative Approach*

The qualitative research approach includes collecting and analysing non-numerical data, such as words, images, and observations (Sharma et al., 2023). Furthermore, qualitative research explores and understands the meaning individuals or groups ascribe to a social or human problem (Choy, 2014). This approach seeks to explain a current situation and describe the situation for that targeted group, therefore, since only a current situation is observed, all qualitative research is done in the field (Babbie, 2013). The strength of this qualitative field research lies in the depth of understanding it permits; flexibility is another advantage of field research; field research can be relatively inexpensive; and field research typically can be undertaken by one researcher with a notebook and a pencil (Babbie, 2020).

The weakness of the qualitative research approach is that the results in data are not objectively verifiable; time-consuming during the interviewing process and require a labour-intensive analysis process such as categorization, recording, and require skilled interviewers to successfully carry out the primary data collection activities (Choy, 2014). The approach has misunderstood that qualitative studies always provide indisputable evidence is widespread (Dawadi et al., 2021). The inability of researchers to draw firm conclusions from the results even when adequate information is available to make sound decisions is concerning. Therefore, this approach has shortcomings to not fit alone into this study as it cannot adequately answer the research question (Sharma et al., 2023).

- *Quantitative Approach*

Quantitative research designs involve the collection and analysis of numerical data (Sharma et al., 2023). Additionally, quantitative research is an approach for testing objective theories

by examining the relationship among variables which can be measured on instruments, so that numbered data can be analysed using statistical procedures (Creswell and Creswell, 2017). Quantitative research seeks to validate a theory by conducting an experiment and analysing the results numerically (Babbie, 2020). The advantage of the quantitative research approach is that it can be administered and evaluated quickly and within the short time frame for the survey (Choy, 2014). Furthermore, the data collection follows rigorously, using the appropriate methods and analysed critically, in its reliability (Choy, 2014).

The quantitative approach has shortcomings because in most cases, especially in the laboratory setups there is an absence of the respondents' perceptions and beliefs (Queirós et al., 2017). The lack of resources for large-scale research; improper representation of the target population might hinder the researcher from achieving its desired aims and objectives; and failure to provide an in-depth description of the experience of the disaster upon the affected population are other weaknesses of this approach (Chetty, 2016). In addition, the use of close-ended questionnaires provides the respondents with opportunities that might not apply to them. Therefore, this approach has shortcomings that do not fit alone into this study because it cannot adequately answer the research question (Sharma et al., 2023).

- *Mixed method approach*

Mixed methods research is an approach that uses the strength of both quantitative and qualitative in collecting data, integrating the two forms of data, and using distinct designs that may involve philosophical assumptions and theoretical frameworks (Sharma et al., 2023). The core assumption of this form of inquiry is that the integration of qualitative and quantitative data yields additional insight beyond the information provided by either the quantitative or qualitative data alone (Queirós et al., 2017). This study therefore applied a mixed method approach because their combined strength enhances the depth and accuracy of the findings; enables the researcher to tackle a broader and complex range of research questions; and provides insights and methods that might be omitted when only a single method is adopted to produce more complete knowledge necessary to inform theory and practice (Doyle et al., 2009). This approach is termed hybrid research or methodological triangulation in the sense that it allows researchers to triangulate their findings, providing a more comprehensive understanding of the research problem (Sharma et al., 2023). Mixed methods research may be the right choice when the research process indicates that quantitative or qualitative data alone cannot adequately answer the research question

(Wasti et al., 2022). A mixed-methods design can integrate and synergise multiple data sources which can assist in studying complex problems (Poth and Munce, 2020).

The advantages of the mixed method approach are integrating both post-positivist and interpretivist philosophical frameworks; providing a logical foundation, methodological flexibility, and a deep understanding of small cases (Fetters, 2016; Maxwell, 2016). The use of mixed methods enables researchers to answer research questions with sufficient depth and breadth (Enosh, Tzafrir, and Stolovy, 2014) and helps generalise findings and implications of the researched issues to the whole population. Therefore, this study applied a mixed method approach because this approach uses both the strength of quantitative and qualitative in collecting data, integrating the two forms of data (Sharma et al., 2023). To achieve the objectives of the study which is to gauge the impact of fall armyworm on the livelihoods of the Shayandima communities; to determine the impact of fall armyworm on the food security of the Shayandima communities; and to assess the effects of the fall armyworm on the mental health of the communities of Shayandima, hence, the mixed methods research is relevant to the study.

4.1.3 Philosophical view

Philosophical worldviews or paradigms are the intrinsic beliefs a researcher applies to the study (Nayak and Singh, 2021). According to Saunders, Kitzinger, and Kitzinger (2015), Burrell and Morgan's four paradigms for organisational analysis are revealed and act as a helpful tool for mapping different research philosophies and understanding their relationships to different research paradigms, i.e., the labels 'paradigms' and 'philosophies' (and often others like 'approaches' and 'schools of thought') are used interchangeably to describe assumptions researchers make in their work (Žukauskas et al., 2018). The assumptions about the reality researchers encounter in their research (ontological assumptions), about human knowledge (epistemological assumptions), and about the extent and ways your values influence your research process (axiological assumptions). These assumptions inevitably shape how researchers understand their research questions, the methods used, and how findings are interpreted (Crotty, 1998). These paradigms include positivism, constructivism, pragmatism post positivism, and critical theory (Nayak and Singh, 2021). Therefore, this study adopted the post-positivist worldview because of the mixed-method approach.

• *Positivism*

Positivism is a philosophical worldview that underpins a scientific approach which is mainly used for experiments and the testing of hypotheses (Nayak and Singh, 2021). The researcher has an objective position, and the results are numerical/statistical, making it best suited to quantitative research (Leedy and Omrod, 2023). Positivists believe that there exists only one true reality which is apprehendable, identifiable, and measurable (Ponterotto, 2005). This study requires qualitative and quantitative data; thus, positivism is not adopted in the study (Leedy and Omrod, 2023).

• *Critical theory*

The outline of methodological posture embraced in research refers to critical theory (Saunders, Kitzinger, and Kitzinger, 2015). Critical theory is prescriptive and normative, entailing a view of what behaviour in a social democracy should entail; therefore, critical theory intends to realise a society that is based on equality and democracy for all its members to change them (Morrison, 1995a). Furthermore, critical theory seeks to emancipate the disempowered, to redress inequality, and to promote individual freedoms within a democratic society (Cohen, Manion, and Morrison, 2002). In doing so, it focuses not only on individuals and groups, but also on society and its institutions and social arrangements, and it uses both evaluative and descriptive concepts (Hammersley, 2012) such as exploitation, empowerment, class division, emancipation, justice, interests to bring about specific political aims: equality, social justice, democracy, freedom from oppression and exploitation, and the transformation of society to an emancipated democracy within which people are empowered to take control over their own lives and life choices.

• *Constructivism*

Constructivism worldview is frequently combined with interpretivism (Mertens, 2023). It deals with the thoughts and perceptions of people and is used in the social science field of study (Kaushik and Walsh, 2019). Interpretivism emphasises that humans are different from physical phenomena because they create meanings, and the purpose of interpretivism research is to create new, richer understandings and interpretations of social worlds and contexts (Saunders, Lewis, and Thornhill, 2009). In general, interpretivists emphasise the importance of language, culture, and history (Crotty, 1998) in the shaping of our interpretations and experiences of organisational and social worlds. According to this discipline, there are biases involved in the study, and the researchers believe that individuals seek an understanding of the world in which they live and work; therefore,

develop varied and multiple subjective meanings of their experiences (Creswell and Creswell, 2017). For example, the data collected from Shayandima farming communities including mental health is crucial because the response of the respondents provides a benchmark to have an in-depth understanding of the situation regarding the impact of fall armyworm with the view to provide potential solutions for the community in the future. Qualitative researchers tend to use open-ended questions so that the respondents can share their views (Creswell and Poth, 2016). The qualitative nature of the constructivism philosophy renders it unsuitable for this research, however, it cannot be used alone as the data collection tool also has a lot of closed-ended questions. This therefore makes this worldview unsuitable to completely address the study objectives holistically.

• *Pragmatism*

The pragmatism worldview encompasses events, circumstances, actions, and responses because of human actions and beliefs, in addition, has a high degree of variability and includes qualitative and quantitative studies (Kaushik and Walsh, 2019). Pragmatic worldview is a framework that applies a mixed methods approach, i.e., the collection of both quantitative and qualitative data sequentially in the design (Creswell and Creswell, 2017). The integration of both qualitative and quantitative research approaches provides the most appropriate mechanism for the research to be conducted and subsequently holds true to the concept that there are multiple methods and angles used to achieve an understanding of a research problem (Kaushik and Walsh, 2019). For a pragmatist, research starts with a problem, and aims to contribute practical solutions that inform future practice (Elkjaer and Simpson, 2011).

Pragmatists recognise that there are many ways of interpreting the world and undertaking research, that no single point of view can ever give the entire picture, and that there may be multiple realities; however, pragmatists use methods that enable credible, well-founded, reliable, and relevant data to be collected that advance the research (Rumens and Kelemen, 2016). In light of the above, looking into the objective of the study which is to assess the impact of fall armyworm livelihoods, food security, and mental health issues of the Shayandima communities, applying a pragmatic framework is appropriate; however, a shortfall which can be fulfilled by post-positivism worldview.

• *Post-positivism*

Post-positivist worldview represents the thinking after positivism, challenging the traditional notion of the absolute truth of knowledge and recognising that we cannot be positive about

our claims of knowledge when studying the behaviour and actions of humans (Phillips and Burbules, 2000). The knowledge that develops through a post-positivist lens is based on careful observation and measurement of the objective reality that exists “out there” in the world and therefore involves experimental design, and pretest and posttest measures of attitudes (Creswell and Creswell, 2017).

The mixed-method research approach adopted for this study revolves around the post-positivist worldview, which states that individuals actively construct knowledge based on their experiences and social interactions (Kaushik and Walsh, 2019). A study influenced by post-positivists acknowledges the limitations of positivism while still valuing empirical evidence and the scientific method (Lim, 2023). In mixed methods research, post-positivism can provide a foundation for integrating qualitative and quantitative approaches by emphasising the importance of multiple perspectives, acknowledging the influence of context, and recognising the role of the researcher in shaping knowledge (Kaushik and Walsh, 2019). In a mixed-method study guided by post-positivism, the investigator can use quantitative methods to collect numerical data while also employing qualitative methods to gather rich contextual information and insights from participant's experiences (Lim, 2023). Therefore, this study adopted a post-positivism worldview.

4.1.4 Research methodology

The science of finding out procedures for scientific investigation is called research methodology (Babbie, 2013). Furthermore, research methodology involves the systematic procedures by which the researcher starts from general activities such as (identifying problems, reviewing the literature, formulating hypotheses, procedure for testing hypotheses, measurement, data collection, analysis of data, interpreting results, and drawing conclusions (Nayak and Singh, 2021).

The study collected primary data using a semi-structured questionnaire and observations, whereas secondary data was obtained from various sources such as published data sources (Kothari, 2004). The semi-structured questionnaire used involves the use of a set of predetermined questions and highly standardised techniques of recording (Kothari, 2004). This type of questionnaire does not allow for deviation and opens room for follow-up questions. Therefore, follow-up open-ended questions were also part of the questionnaire used for this study. The other method that this study employed is the case study method which is an intensive description and analysis of a single individual; widely used in systematic field research techniques in sociology (Shaughnessy, Zechmeister, and

Zechmeister, 2000). This study is field research and hence a case study was adopted as another study method.

4.1.5 Population Sampling

A research study is never able to study all the members of the population that interests the study, nor make observations of those targeted groups of people, however, the researcher selects a sample from among the data that might be collected and studied (Babbie, 2013). Moreover, a population is the set of all cases of interest and the subset of the population drawn from the sampling frame is called the sample (Shaughnessy, Zechmeister, and Zechmeister, 2000).

The sampled population comprised of the small-scale farmers and farm workers of Shayandima communities, agricultural extension officers, and disaster management practitioners who form part of the study community. When the researcher selects a sample based on knowledge of a population, its elements, and the purpose of the study, it is called purposive sampling (Babbie, 2020). Purposive sampling was used for this study as the community was identified with the assistance of agricultural extension officers and disaster management practitioners in Thulamela Local Municipality. This type of sampling aims for diversity within the selected samples. Using purposive sampling, the researcher focussed on communities relevant to the research objectives. The sample size formula of Yamane (1973) was used to determine the sample size of 100 respondents.

- *Data Collection, tool, and procedure*

This study applied triangulation techniques to gather both qualitative and quantitative data. Triangulation involves using more than one source of data and method of collection to confirm the validity/credibility/authenticity of research data, as well as to analyze and interpret it, and interpretation (Saunders, Kitzinger and Kitzinger, 2015). Therefore, the researcher is necessitated to use a multi-method quantitative study, a multi-method qualitative study, or a mixed-methods study. The purpose is to use two or more independent sources of data and methods of collection within one study to ensure the data established in their research is quality (Saunders et al., 2015). The data collection tool was a semi-structured questionnaire developed by the researcher with the supervisor's assistance.

This study collected primary data through a semi-structured questionnaire survey approved by the University of the Free State Human Ethics Committee (UFS-HSD2023/1519) and

direct observation. Primary data was obtained through a semi-structured self-administered questionnaire.

The study collected data from Shayandima small-scale farmers from 7 to 19 November and December 2023. A qualifying criterion to participate was that individuals had to be 18 years and older. The respondents who could complete the questionnaire were allowed to complete it by themselves with the assistance of the researcher; on the same note, further assistance was provided for those who were unable to complete it. Therefore, following the approval of ethics, the meeting was arranged with the assistance of extension officers and successfully held with the small-scale farmers in November 2023. The purpose of the meeting was to introduce myself and the research study to the farmers. It was on the same meeting when the study objectives were properly explained in their language, and further mentioned that the participation is voluntary, and therefore consent was sought and granted. The researcher was fortunate on the first day, questionnaires were distributed to the farmers who heed the call and come to the meeting.

Farmers who completed questionnaires were useful to inform other farmers that researcher will be visiting their farms and home respectively. Each time the questionnaire is distributed, farmers are asked if they have already completed the questionnaire or not, this was to avoid duplication of data collected. Considering that data will be collected from different plots, the researcher use the opportunity to ask the farmers to indicate time which is convenient to them. It was fulfilling that different plot were assign to dates based on their availability. Each plot has a leader who is also a farmer who is used as a vehicle to rely important information relating to fall armyworm. Every Monday of the week farmers hold meeting to deliberate on issues affecting their crops. In the study, 100 respondents were randomly selected from Shayandima communities. The farmers owned plots ranging between 1ha and 10ha. There is a total of approximately 106 plots grouped into four blocks which are situated spatially. The researcher has identified the blocks namely blocks 1, 2, 3, and 4. In block 1 (n=25) questionnaires were collected, block 2 (n=35), block 3 (n=13) questionnaires, and block 4 (n=33) questionnaires.

The questions were designed in a clear and simple way to ensure our local communities understand the questions in it. The quantitative structured questionnaire comprised five sections with a total of 55 questions constructed. The questionnaires were administered in English language for convenience and simplicity but where indispensable, interpreters were used in local dialects. Section A consisted of demographic and personal information. Section B pertains to questions relating to the impact of fall armyworms on livelihoods. Section C includes questions on the impact of fall armyworms on food security. Section D

consists of questions on the evaluation of the impact of fall armyworms on mental health. Section E consists of questions on mitigation. The semi-structured questionnaire consists of questions with varying scales, open-ended and closed-ended questions.

Observation is a type of data collection tool used in the qualitative study where data is collected by observing the behaviour of the respondents in a natural set-up (Bouchrika, 2020). This study used the observation method as one of the tools for collecting primary data. The first day of arrival on the study area, the observation found that the demographics ranges from 18 - 65 years and above. However, most farmers were observed to be elderly people. The study also found that majority women are farming as compared to men and young people. Furthermore, there is limited knowledge because of education. Upon arrival at the study area, the researcher discovers that there were few small-scale farmers in their farms. This was quite alarming but when the researcher continues to engage other farmers in the area, it was reported that they have already left their farms. The reason provided was that elderly people prefer to start tilling the land early hours from 4:am till 8;00am when the temperature is cool. The challenges facing small scale elderly people is the reluctant of farming under high temperatures due to medical conditions.

When the sunrise, elderly people prefer to go home and prepare their meals and take medication. When the researcher was busy completing questionnaires, one mobile clinic/ambulance arrive at one of the plot areas. The purpose was to distribute medicine to the elderly farmers. When farmers are not on-site, researchers are compelled to follow them to their homes with the permission and accompanied by the extension officers. Another challenge which was observed when completing questionnaires was that interacting with elderly farmers is time consuming. To complete one questionnaire can take up to more than 30 minutes which was an estimated time, the reason is that they prefer to sit under the tree shade due to different reasons. Even the questionnaire was too long, and when answering questions posed to them, they proceed to elaborate and answer what was not asked. Accessing the plots was quite challenging due to the slope area and type of soil, which is slippery on rainy season, more often we arrange with the farmer to meet with us at a location agreed upon for completing of questionnaires.

Most importantly, the impact of fall armyworm on maize crop and other produce were observe in the farms. The researcher observed different stage of maize, other were at an early stage, other late stage. We further observed that farming is throughout all seasons because the source of water is borehole. The researcher observes the mental health of the farmers as a result of the fall armyworm, during the engagement, we observe using criteria

as outline in the questionnaire to measure the mental state, i.e. if they are happy, nervous, anxious and etc.

The information is sought by way of the researcher's direct observation without asking from the respondents when the method serves a formulated research purpose, is systematically planned, and recorded, and is subjected to checks and controls on validity and reliability (Kothari, 2004). The main advantage of this method is that subjective bias is eliminated if the observation is done accurately; secondly, the information obtained relates to what is currently happening; it is not complicated by either past behaviour or future intentions or attitudes; and thirdly, there is respondents' willingness to respond and as such is relatively less demanding of active cooperation on the part of respondents as happens to be the case in the interview or the questionnaire method (Kothari, 2004).

4.1.6 Data analysis

Data analysis is the process of systematically applying statistical and/or logical techniques to describe and illustrate, condense, recap, and evaluate data, therefore, data analysis converts data into information and knowledge and explores the relationship between variables (Sharma, 2018). According to Sharma (2018) various analytic procedures "provide a way of drawing inductive inferences from data and distinguishing the signal (the phenomenon of interest) from the noise (statistical fluctuations) present in the data." The process of analysis involves organizing, accounting for, and explaining the data (Cohen, Manion, and Morrison, 2002).

This study analysed the data collected descriptively and inferentially by applying a series of chi-squared tests of independence, and several multinomial logistics regression tests. Chi square (x^2) is a frequently used test of significance in social science. It's based on the null hypothesis: the assumption that there is no relationship between two variables in the total population (Babbie, 2013). Regression analysis is a method of data analysis in which the relationships among variables are represented in the form of an equation, called a regression equation (Babbie, 2013). The study used Statistical Package for Social Scientists (SPSS) version 29 to analyse quantitative and qualitative data. For qualitative analysis, the P value was set at ≤ 0.05.

Knowledge accomplished through academic studies, and a university degree can distinguish a person's level of thinking and awareness (Eraut, 2000). Therefore, this study firstly applied three Chi-squared tests of independence to assess this knowledge as follows: the question on whether the respondents knew fall armyworm was cross-tabulated with the

questions of 1) how the respondents heard about fall armyworm; 2) when did the participant hear about fall armyworm; 3) what the respondents did when they heard about the fall armyworm separately. Insignificant differences were not found for correlations 2 and 3. Nevertheless, this study decided to analyse the question of hearing about the fall armyworm and the respondents' actions upon hearing about the fall armyworm separately using descriptive statistics as these are two important questions for this knowledge section.

Secondly, the study assessed the impact of fall armyworm on the livelihoods of Shayandima communities by applying the Chi-square test and regression analysis to establish the relationship between dependent. Thirdly, to assess the financial impact of fall armyworm on the study community the study applied a regression analysis, Chi-square test of independence, and also applied descriptive statistics on a question estimated income loss due to fall armyworm. Fourthly, the study further assessed the impact of fall armyworms on the food security of Shayandima communities by running an ordinal regression and two Chi-square tests on independence.

The study further assessed the mental health issues that might have been caused or exacerbated by fall armyworm by using the most critical priority measure of mental health which is Post Traumatic Stress Disorder (PTSD; Koenen et al., 2017; Watson, 2019). The study probed six PTSD questions adapted from the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) and the Post Traumatic Stress Disorder Checklist (PCL-5). The scale is available from the National Centre for PTSD at www.ptsd.va.gov in the Lickert Scale format.

To analyse the Likert scale questions with six predictors and one outcome variable, this study used multiple linear regression as the outcome variable was set as continuous. The data conform to linearity, the study therefore log-transformed the variable to conform to the assumption of linear regression before analysis. In addition, the study analysed the question of respondents' feelings about fall armyworms descriptively to close this section. Lastly, the study gauged the fall armyworms mitigation measures by applying another logistics regression and descriptive statistics.

4.2 Data validity and reliability

Validity refers to whether the measuring instrument measures the behaviour or quality it is intended to measure and is a measure of how well the measuring instrument performs its function (Anastasi, 1997). Therefore, validity means that the researcher is measuring what is intended to be measured (Babbie, 2013). Reliability is a matter of whether a particular

technique, applied repeatedly to the same object, yields the same result each time, subsequently, that quality of measurement methods that suggests that the same data would have been collected each time in repeated observations of the same phenomenon (Babbie, 2013).

Reliability and validity are concepts used in research to gauge the credibility of the research data (Creswell and Miller, 2000; Cohen, Manion, and Morrison, 2002). The reliability test assesses the consistency of the measure, while validity assesses the accuracy of the measure (Anastasi, 1997). The Cronbach Alpha was used to test the validity of the questionnaire, and the Alpha value was 75%, proving the questions' validity. Therefore, no questions from the questionnaires were deleted during the analysis. The questionnaire was constructed to measure what is intended to be measured and to produce similar results if they were applied to measure the same aspects at different times (Shaughnessy, Zechmeister, and Zechmeister, 2000). The questionnaire was also piloted first with a few sampled populations of the study community before it was fully administered to ensure validity and reliability.

4.3 Limitation and delimitation of the study

The limitations of the study are those characteristics of design or methodology that impacted or influenced the interpretation of the findings from the research, and because of this, they relate to the validity and reliability of the study (Price and Murnan, 2004).

The delimitations of a study are the factors and variables not to be included in the investigation; they specify the boundaries set by the researcher on what the study will not cover, distinguishing them from limitations, which are potential weaknesses in the study not controlled by the researcher (Santana, 2024). Additionally, they are foundational elements that guide the research process, and choices made to narrow the scope of a study, focusing on specific aspects while excluding others (Santana, 2024).

4.3.1 Limitation

Limitations are possible difficulties in the study and are out of the researcher’s restriction (Simon, 2013). The researcher gives details on how the study dealt with the limitations and delimitations encountered during data collection that ensured that the outcome of the study was not affected (Simon, 2013). There are limitations in almost every research study, for example, using a sample of convenience, as opposed to a sample collected randomly, then

the results of the study cannot be generally applied to a larger population. This study adopted purposive sampling.

According to Daniel (2018), a researcher might encounter challenges such as the unwillingness of small-scale farmers and farm workers to participate in the study. To ensure the respondents' participation, the researcher assured the respondents that the information they were voluntarily providing is going to be used for academic purposes, therefore the respondents should feel free to participate. Time and resources (photocopy and petrol) were constraints for this study as people were not always available when the researcher was available. A questionnaire of 15 pages for 100 participants is quite expensive. Petrol to reach to farmers especially when plots are spatially located. The researcher resorted to scheduling appointments in the individual farms to circumvent the time constraints. Requesting the farm leader to group them in one area at a specific time agreed upon. Visiting certain group to their homes especially elderly people was another option to mitigate time constraints.

4.3.2 Delimitation

The delimitations are the attributes that restrict the scope and outline of the study (Simon, 2013). The delimitations are in the control of the researcher (Simon, 2013). There are delimiting factors which include the choice of objectives, the research questions, variables of interest, theoretical perspectives that the researcher has adopted, and the population selected for investigation (Simon, 2013).

This study focused on small-scale farmers even though Shayandima community is comprised also of large-scale commercial farmers who might have been impacted by the fall armyworm. The delimitation is because most commercial farmers in South Africa have some form of formal resilience in terms of insurance. Therefore, to capture the food security and health impact resilience has been ignored for this study hence the use of subsistence (small scale) farmers only for this study. The research population and the sample size which the researcher was obliged to control due to insufficient time and resources to cover a huge research population and sample size.

4.4 Ethical considerations

What is considered ethical and unethical in research is ultimately a matter of what a community of people agrees is right and wrong (Babbie, 2013). The right to privacy is a very important ethical concern for research in this area, therefore, the right to privacy is easily

maintained by researchers (Babbie, 2013). In survey research, self-administered questionnaires can be anonymous, and interviews can be kept confidential. Additionally, in case and observational studies, the identity of the person or group studied can be disguised in any publication (Babbie, 2013).

This study has received ethical clearance certificate approval from the University of the Free State Human Ethics Committee (UFS-HSD2023/1519). The study aims to assess the impact of fall armyworm on the livelihoods, food security, and mental health of the Shayandima communities. Participation in this study was voluntarily and there was no penalty or loss of benefit for non-participation. The researcher obtains permission to gain access to the study sites and to study respondents. This was done by requesting a meeting and specifying the date and time, and the purpose of the study research to the respondents (Creswell and Creswell, 2017).

The study was on voluntary participation from Shayandima communities, and informed consent was obtained prior to data collection, and the respondents were made aware during the meeting that the time frame estimated (30 minutes) to complete the questionnaire might be prolonged thereby affecting their daily activities. Therefore, the inconvenience of loss of work was noted and recorded by this study. This was because the study involved questionnaires, and the respondents answered the questions from the questionnaire which took approximately 30 minutes for each participant, and interpreting English to the local language contributed. However, the respondents were comfortable participating because the researcher made them aware that the questionnaire was quite long. The researcher made it clear to the respondents that they were allowed to withdraw their participation from the study at any given point should they wish to or should the pursuit of the study have noticeable distressing impacts on them. Respondents were not forced or deceived in any way to participate in the study because deceiving people is unethical (Babbie, 2013). The potential benefit for the respondents is that through the research study processes, they were able to raise various concerns affecting the Shayandima farming communities regarding fall armyworm and its negative impact.

Through ethical approval, there are requirements that the researcher must protect the information (personal details, name of the farm, address of the farm, GPS coordinates, contact numbers, and identity documents), essentially the researcher agreed on the ethical application to collect personal information of the respondents as reasonably possible. The information obtained from the respondents is kept confidential. Therefore, the researcher promised the respondents to keep their personal information confidential and that only the researcher and study leader have access to the data. Hard copies of respondents' answers

are to be stored by the researcher for a period of five years in a locked cupboard at home for future research or academic purposes, and electronic information is to be stored on a password-protected computer. Future use of the stored data is to be subject to further Research Ethics Review and approval if applicable. The respondents are not reimbursed for participating in this study. This study does not foresee any possible risk to the respondents except the loss of work or study time.

4.5. Chapter Summary

This section outlined the study methodology carried out in the study whose main purpose was to assess the impact of fall armyworm on the livelihoods, food security, and mental health of the Shayandima communities in the Thulamela Local Municipality of the Limpopo Province, South Africa. This study applied triangulation techniques to gather both qualitative and quantitative data to provide a more comprehensive understanding of the research problem. Various paradigms for analysis are revealed as helpful tools for mapping different research philosophies and how researchers understand their research questions, the methods used, and how findings were interpreted. The primary data was collected using a semi-structured questionnaire and other methods including observations and case studies. In the study, 100 respondents were randomly selected from Shayandima communities. This chapter detailed how data was analysed, further explained the concepts used in research to gauge the credibility of the research data such as validity and reliability and outlined limitations and delimitations they encountered during data collection.

CHAPTER 5: STUDY FINDINGS AND DISCUSSIONS

5.1 Introduction

This Chapter presents the findings derived from the data that was collected through a semi-structured questionnaire survey and direct observation. The study randomly selected 100 respondents from Shayandima farming communities in the Thulamela Local Municipality of the Limpopo Province, South Africa. The study was carried out based on voluntary participation from Shayandima communities and written informed consent was obtained before data collection.

5.2 Demographic characteristic

The majority of the respondents were females (53%) while the males accounted for the remaining 47 %. This could be because households in rural areas of the Limpopo Province are headed by women as males move to cities in search of better opportunities (Price, 2021). The findings are consistent with the Global Household Survey (GHS) of Statistics South Africa (StatsSA, 2023), which found that 42.3% of households were headed by females, with the highest prevalence in Limpopo rural areas. The findings also agree with those of De Groote et al. (2020), who found that women are more involved in farming than men across the Limpopo Province.

The marital status revealed that the majority of the respondents involved in farming were married at 51%, and the majority of respondents were self-employed at 55%. The study findings indicated that agricultural farming at Shayandima area is mainly carried out by the elderly population whereby the majority age bracket of 25% above the age of 65 years. The youngest age group (17-25 years) accounted for only 3% of the total farmers who participated in the study.

The results further showed the majority of the farmers in the region, that is 41% have attained the secondary level of education. It was also worth noting that 20% of the farmers had no level of education. Education in farmers' level of knowledge has been reported to contribute to the effective control of agricultural pests (Caniço, Mexia, and Santos, 2021). Additionally, education is crucial to the improvement of agricultural productivity because it improves the farmer's knowledge. Table 5.1 below shows the distribution of the respondent's demographic characteristics in addition to the majority narrated above.

Table 5. 1: Demographic characteristics of respondents. Source: Survey data, 2023

Variables	Categories	n=100
Gender group	Female	53
	Male	47
Age group	18-25	3
	26-35	17
	36-45	14
	46-55	22
	56-65	19
	Above 65	25
Education level	No schooling	20
	Abet education	6
	Primary education	14
	Secondary education	41
	Tertiary education	19
Marital Status	Divorced	3
	Cohabiting	1
	Married	51
	Single	27
	Widowed	18
Ethnic group	Asian	0
	Black	100
	Coloured	0
	Indian	0
	White	0
	Other	0
Employment status	Permanently employed	4
	Temporarily employed	2
	Self- employed	55
	Unemployed	31
	Retired	7
	Other	1

5.3. Knowledge of fall armyworm

The study findings showed that most of the farmers had heard about fall armyworm with the majority (60%) having heard it from other farmers, approximately 20% heard from extension

officers while the remaining 20% got the information from research institutions and other sources (Fig. 5.1).

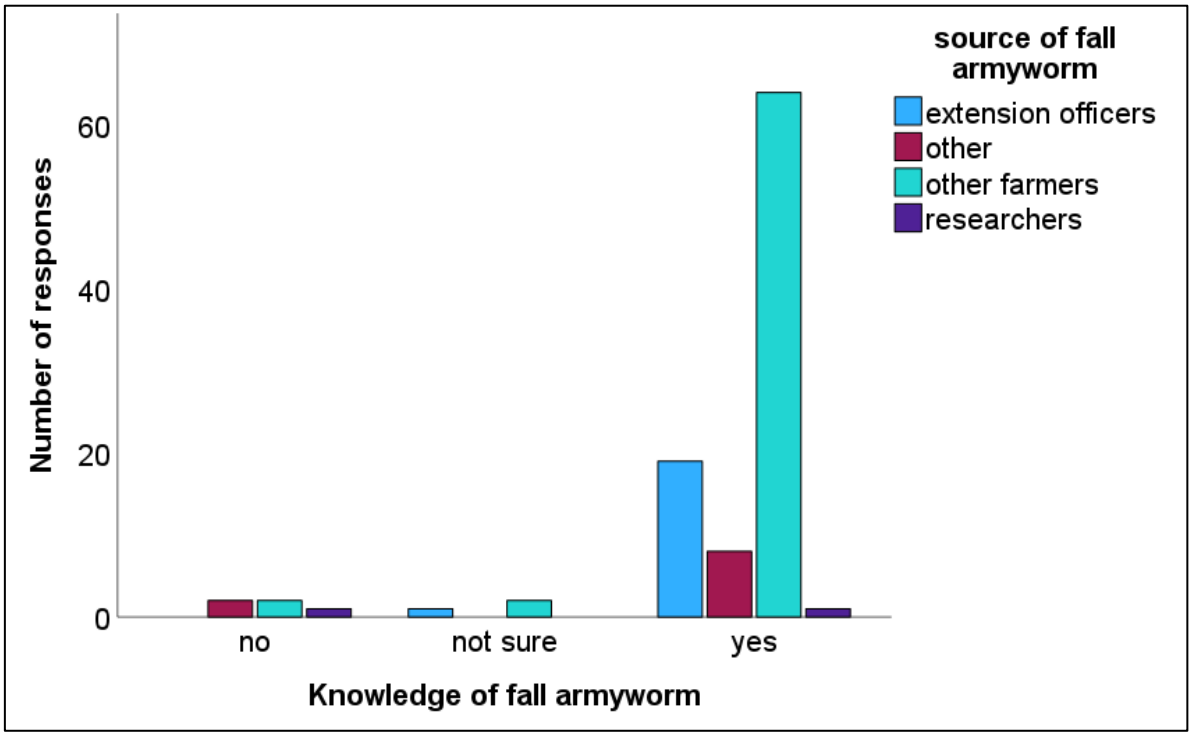

Figure 5. 1: Number of respondents' reports on knowledge and sources of fall armyworm. Source: Survey data, 2023

Farmers' knowledge about fall armyworms has been poorly documented following the outbreak across the globe (Houngbo et al., 2020). Therefore, our study results indicate highest knowledge of this worm, and sources from other farmers could indicate the seriousness of this pest in the study area. This is not surprising because recent studies about the knowledge of this worm are scanty to support the study findings. Only one recent study by Wang et al. (2023) focused precisely on fall armyworm migration risk in Europe. However, in Africa, several studies similarly agree with the result findings and have documented the majority of farmers' knowledge about fall armyworms (De Groote et al., 2020; Kumela et al., 2019). The relevant study by Nethononda et al. (2023) carried out in Thulamela Municipality provided better understanding of the knowledge of fall armyworm on small scale farmers. This shows the seriousness of this worm in South Africa and the enhanced knowledge about it amongst the farmers.

The second Chi-square test shows an insignificant value on the question which says; does the respondents know the fall armyworm was cross-tabulated with the question of when they heard about the fall armyworm (X^2= 8,116; df=8; P=0,422). This implies that the knowledge is there irrespective of when the knowledge was gained. Another Chi-square test also showed an insignificant value when the question of the participant's knowledge of fall armyworm was cross-tabulated with the question of what the respondents did after hearing about the fall armyworm (X^2= 11,812; df=6; P=0,066). The last Chi-square test on knowledge about the fall armyworm also showed an insignificant value when the question about the knowledge of fall armyworm was cross-tabulated with the question of what the respondents did upon hearing about the fall armyworm (X^2= 11,807; df=12; P=0,461).

The insignificant differences found for time farmers heard about the worm and the actions they took after hearing about the fall armyworm are irrelevant for this study as the majority (n=38) of the farmers reported they heard about the fall armyworm between 2016/2017, as this is the exact years that the worm was widely reported and possibly made its entry in South Africa (Day et al., 2017; Fig. 5.2). Furthermore, the majority of respondents (n=67) reported that after hearing about fall armyworms, they informed other farmers (Fig.5.3).

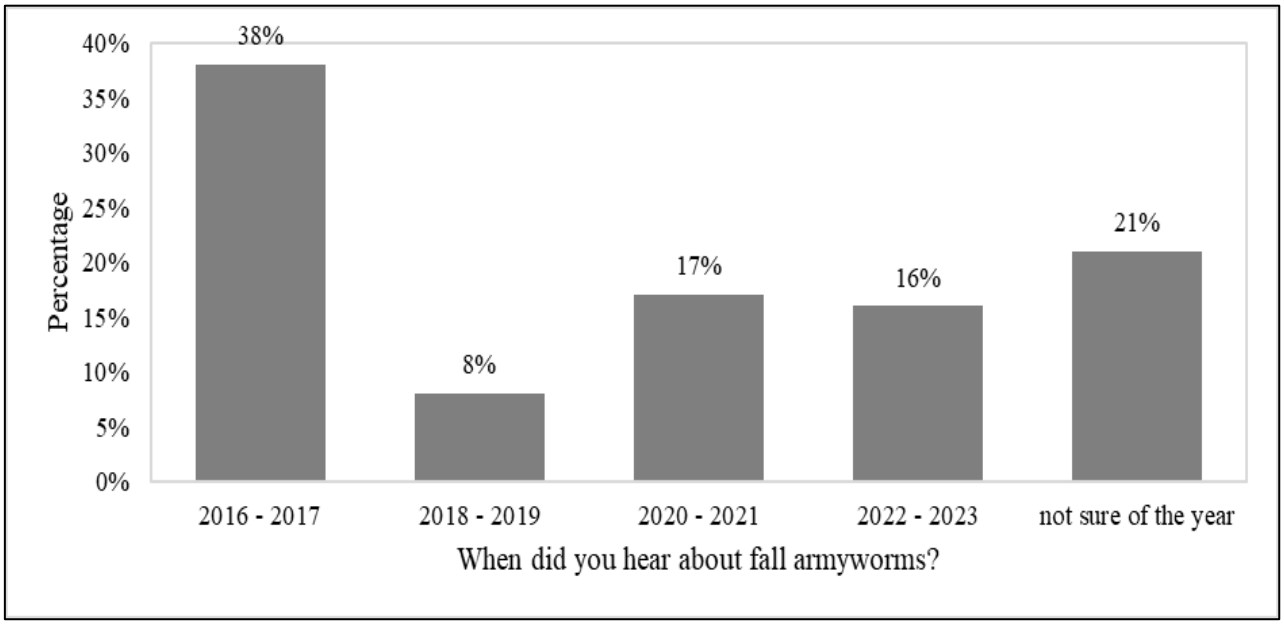

Figure 5. 2: The year respondents heard about fall armyworm. Source: Survey data, 2023

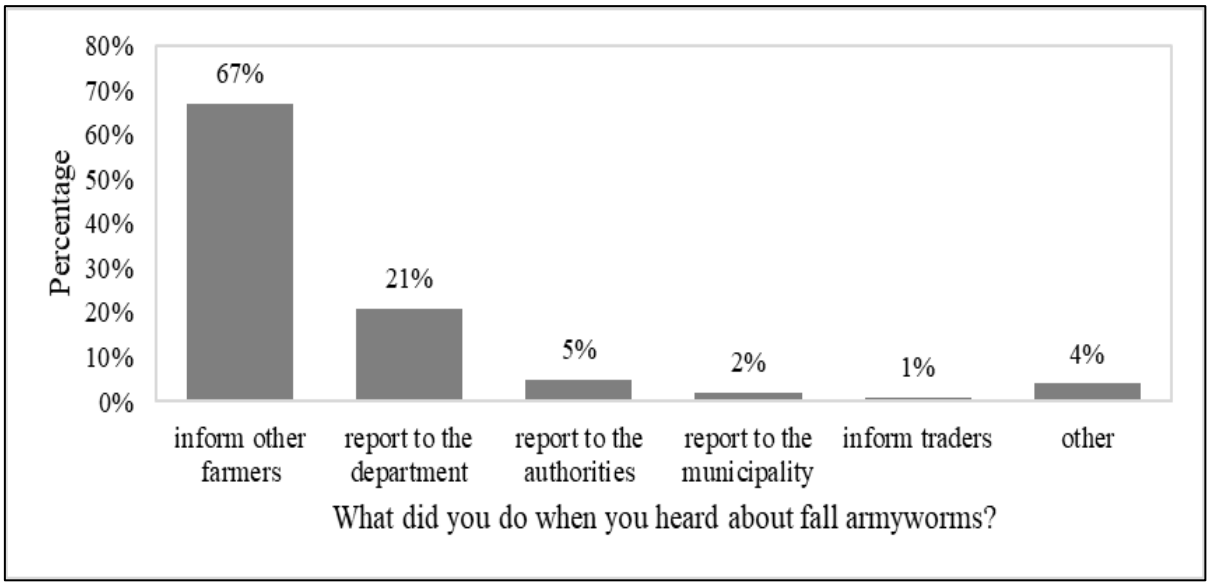

Figure 5. 3: The reaction of the respondents after hearing about fall armyworm. Source: Survey data, 2023

The results of this study agree with the findings of several studies which reported that as of August 2017, the fall armyworm had been confirmed to be present in 28 countries in Africa which was 16 more countries on top of the 12 reported in April 2017 (Day et al., 2017; De Groote et al., 2020; FAO, 2020; Otim et al., 2021). Similar studies reported an initial invasion of fall armyworm in West Africa in 2016 (De Groote et al., 2020; FAO, 2019; Goergen et al., 2016; Njuguna et al., 2021; Otim et al., 2021). Therefore, this study's findings in terms of majority are consistent with other African studies on the infestation period of fall worm armyworm across Africa (Bannor et al., 2021; Kassie et al., 2020).

The literature scan during the write-up of this study did not reveal any results of actions taken by farmers after hearing about the fall armyworm. Therefore, there is no study to use to compare the study findings for the actions farmers took after hearing about the fall armyworm. Therefore, this study finding is expected to help fill the gap in the literature on the actions taken by farmers after hearing about fall armyworms.

5.4 Financial impact of fall armyworm on livelihoods

The study further assessed the financial impact of fall armyworms on the livelihoods of Shayandima communities. The ordinal regression results showed a statistically insignificant difference when the question of how much the respondents generate from selling their crops (dependent variable) was regressed with the other three Likert scale questions (X^2= 25.767; df=30; P=0.687; R^2= 76%. The results of the Chi-square test showed significant value when

the question of how much farmers generate from selling their crops was cross-tabulated with the question of whether the presence of fall armyworms affects the farmers' livelihoods (X^2= 73,916; df=9; P<0,001). In addition, the majority of the respondents (n=83) responded little when asked how much money they are generating from selling their produce. Furthermore, most respondents (n=97) responded yes when asked if the presence of fall armyworm affects their livelihoods. Farmers have reported that they lost income has contributed to poverty. They are not affording the basic needs; this include reducing nutritious meal as a result of cash shortages (Table 5.3).

The results of the study revealed that fall armyworm is present in all maize farming areas as reported by the respondents. It is crucial to indicate that developing countries depend entirely on agriculture as the main source of livelihood and small-scale farmers are the drivers of the agricultural sector (Chand, Joshi, Khadka., 2022). Therefore, yield losses in this study were assessed based on the number of bags of maize produced by farmers before and after the outbreak of fall armyworm. Several studies conducted across Africa and globally found that fall armyworm may have negative consequences (Day et al., 2017; De Groote et al., 2020; Fernandes et al., 2019; Tambo et al., 2020).

The results are similar to the study by Bannor et al. (2021) who found that fall armyworm affected their livelihoods as it reduced their crop yields and increased maize production costs. In addition, maize is a staple food in the area, and the occurrence of fall armyworms in their farms threatens maize production and the livelihood of the farmers in the study area (Bannor et al., 2021). This is because the respondents further indicated that the outbreak of fall armyworm caused the local market to increase the prices of their produce.

The study further asked the respondents about the estimated costs of crop loss due to fall armyworm infestation in their farms and the majority of the respondents, 29%, reported an estimated loss of R0-R500 (Table 5.3). This might seem insignificant by world standards; however, in the context of South African subsistence farming families, this translates to a lot of income loss. Indeed, studies done in the same context in rural South Africa found similar amounts of income loss for small-scale farmers (Raphela and Pillay, 2021). Indeed, Raphela and Pillay (2021) calculated a potential income loss of R427.00 per annum for all crop types combined in the rural subsistence farmers in KwaZulu Natal, South Africa.

Table 5. 2: The respondents estimated the cost of crop losses due to fall armyworm. Source: Survey data, 2023

Estimated cost of crop losses due to fall armyworm	No	%
R0-R500	29	29%
R500- R1000	16	16%
R1001- R2000	13	13%
R2001- R3000	11	11%
R3001- R4000	17	17%
R4001- R5000	3	3%
above R5000	11	11%
Total		100%

The outbreaks of plant pests such as fall armyworm on crops cause annual yield losses of approximately US$220 billion (Chakraborty and Newton, 2011; Rohr et al., 2019; Ristaino et al., 2021). The total economic loss due to fall armyworm is estimated to be US$ 200 million, which is equivalent to 0.08% of the global gross domestic product (Abro et al., 2021). The recent study which distinctively reported on fall armyworm in America, reported an estimated loss of up to 250-630 million US dollars per year was published in 2018 (Bateman et al., 2018). This is a knowledge gap and calls for immediate attention for researchers to close and address this scientific lack of current literature review.

In Asian countries, Sri Lanka for example, approximately 40000 hectares of 20% maize are infested with fall armyworms with an economic loss of 1- 3 billion in Asia since infestation and U$D 2400-4000 million per year loss (Secretariat, IPPC, 2021). In Africa, a significant economic loss of approximately $9.4 billion annually was estimated in 33 countries due to fall armyworm damage (Eschen et al., 2021). In South Africa, there is no record of a study that quantified the impact of fall armyworm in value across all provinces.

5.4.1 The impact of fall armyworm on livelihoods

The ordinal regression results showed a statistically insignificant difference when the question of whether fall armyworm has impacted the respondents and their family in any way (dependent variable) was regressed with other Likert scale questions in the table below (X^2= 33.605; df=35; P=0.535; R^2=53%; Table 5.2). This implies that how the fall armyworm impacted the farmers' families had nothing to do with how the farmers rated the impact caused by fall armyworm on their farm; whether the farmers sold their crops after harvesting, whether the farmers encountered challenges on their farm when selling or exporting their

crops; whether the communities receive support from the government due to the presence of fall armyworms which are damaging their crops and how much previous knowledge have farmers gained that can assist them in the coming growing season to make sure that impact is reduced (Table 5.2).

Table 5. 3: Output of regression analysis for the Likert scale questions to gauge the impact of fall armyworm on the livelihoods of the respondents. Source: Survey data, 2023

Parameters	**Estimates**	**Std errors**	**Wald**	**P-values**
How would you rate the impact caused by fall armyworm in your farm	-0,808	0,368	4,816	0,078
Do you sell your crops after harvesting	15,242	0,000		
Do you encounter challenges on your farm when selling/exporting your crops	15,721	5174,268	0,000	0,998
Do the communities receive support from the government due to the presence of fall armyworms which are damaging their crops	-0,463	1,095	0,179	0,673
Through previous experience in mitigating the impact of fall armyworms, how much knowledge have you gained that can assist you in the coming growing season to make sure that impact is reduced	-0,873	1,241	0,495	0,482

To further assess the impacts of fall armyworm on farmers' livelihoods, the study ran a series of Chi-Square tests of independence. Firstly, the Chi-square test when the question of has the fall armyworm impacted the respondents and their family in any way was cross-tabulated with the question of how the respondents would rate the impact or damage caused by the fall armyworms in their farm showed a significant value (X^2= 35,480; df=8; P<0,001). According to the findings of this study, 95% of the respondents have reported that fall armyworm has impacted them and their family (Fig.5.4a). Therefore, the findings of this study is consistent with the study conducted by Kassie et al. (2020) who reported that fall armyworm may affect the income.

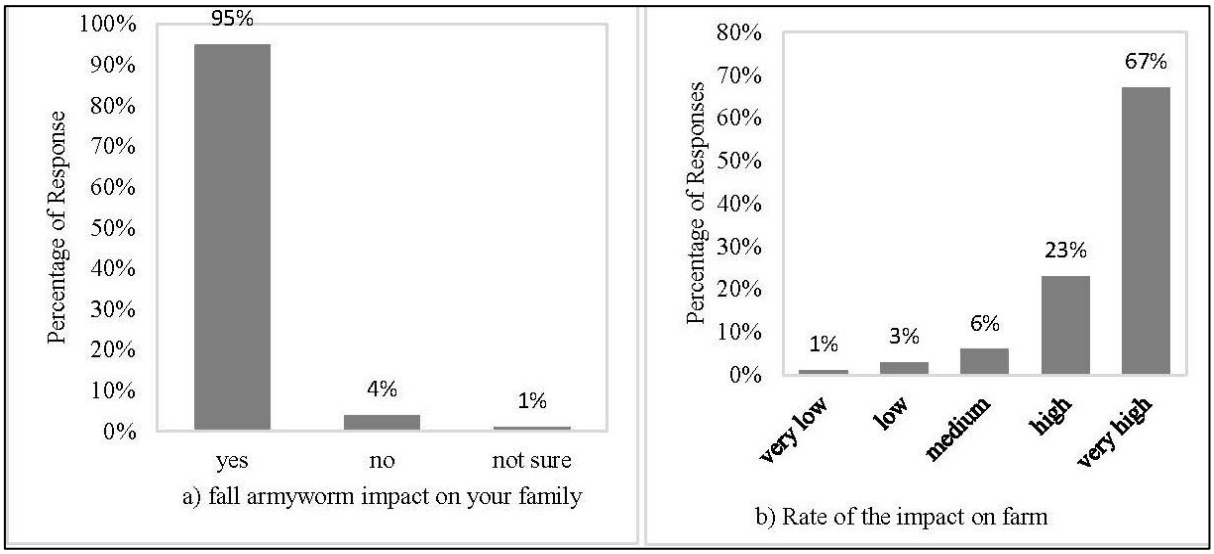

Figure 5. 4: Impact and rates of impact on respondents and their farms. Source: Survey data, 2023

The majority of respondents n=93 responded yes to selling their crops after harvesting, and separately from those farmers, 95% reported that they sell their crops to local traders. Furthermore, the majority (n=93) of the respondents responded yes, when asked if they encounter challenges on their farm when selling their crops. Farmers are complaining that local traders ask them to cut prizes when buying from them, but they sell at a higher price. If farmers do not heed to the local traders, they threatened to leave their and buy to others. This result into a loss as they are struggled to make end meets. Moreover, the majority (n=73) of the respondents responded yes to receiving support from the government of South Africa to control fall armyworms. When the respondents were asked about the knowledge, they have gained through previous experience to assist in the reduction of the impact of fall armyworm.

Secondly, the Chi-square test on the communities receiving support from the government of South Africa due to the presence of fall armyworm which is damaging their crops cross-tabulated with the question of previous experience in mitigating the impact of fall armyworm, how much knowledge have they gained that can assist them in the coming growing season to make sure the impact is reduced showed insignificant value (X^2= 2,813; df=3; P=0,421).

The third Chi-square test also showed insignificant value when the question of whether farmers receive support from the government of South Africa due to the presence of fall armyworm which is damaging their crops was cross-tabulated with the question of, how much knowledge farmers have gained through previous experience in mitigating the impact of fall armyworm that can assist them in the coming growing season to make sure the impact

is reduced. However, the fourth Chi-square test showed significant value when farmers were asked whether they sell their crops after harvesting was cross-tabulated with the question of whether the farmers encounter challenges in their farm when selling their crops (X^2= 8,344; df=1; P=0,004).

The finding reveals that (67%) of the respondents reported that the impact due to fall armyworm infestation in their farms was very high (Fig.5.4b). Most of the farmers sell their produce to local traders for their livelihood and income. Therefore, the impact may had a dire consequence on their livelihoods and their family as it affects income flow. Fall armyworm infestation may affect the income earned and result in cash shortages, leading to failure to afford necessities (Kassie et al., 2020). This result is consistent with the findings by Otim et al. (2021) who reported that farmers mostly sell off the excess harvest after catering to household food demands. According to the findings of this study, 95% of the respondents have reported that fall armyworm has impacted their family (Fig.5.4a). Therefore, the findings were confirmed by a study that reported that fall armyworm infestation may affect the income earned and result in cash shortages, leading to failure to afford necessities (Kassie et al., 2020).

Several studies have reported that even though the United States used maize as animal feed, the impact of fall armyworm led to yield losses ranging from 25 to 100% depending on the severity of infestations (Arias et al., 2011; Orke and Dehne, 2004; Womack et al., 2018). Furthermore, in Nicaragua, Hruska and Gould (1997) demonstrated a positive relationship between yield losses and levels of fall armyworm infestation.

Additionally, literature reveals that the infestation of fall armyworm has a serious negative impact on the livelihoods of hundreds of millions of farming communities across Asian people whereby approximately 44–100% yield losses in the regions of Karnataka in India have been reported (Navik et al., 2021; CABI, 2017). Moreover, more than 300 million African small-scale farming families depend on maize as a staple food (Cock et al., 2017; Matova et al., 2020; Prasanna et al., 2021; Tambo et al., 2021). Therefore, the relevance of this study in South Africa is crucial particularly in Thulamela Local Municipality, Limpopo Province to safeguard against Shayandima farming communities and curbing the spread of fall armyworm.

It is against this backdrop to highlight that out of 8 million hectares of land used for agriculture, approximately 4.4% of Limpopo households practice farming and/or agriculture for income (De Cock et al., 2013; Uhunamure et al., 2021; StatsSA, 2017). This is because the results reveal that the impact due to fall armyworm infestation was very high and has

reduced their yields which they sell to local traders for their livelihood and income. On the contrary, Sadiq et al. (2013) reported the profitability and production efficiency of small-scale maize production despite the outbreak of fall armyworm in Niger State; Cross River State, and Nasarawa State. The results indicated that maize production was profitable despite the outbreak of fall armyworm, presumably because farmers implemented better management strategies to cushion the effects of the fall armyworm.

5.5 The impact of fall armyworm on food security

The ordinal regression results showed a statistically significant relationship when the question of when the respondents grew their crop was regressed with five other questions (X^2= 155.412; df=43; P<0.001; R^2= 91% in the table below (Table 5.4). Furthermore, there was a statistically significant difference found on the question that says; do you think fall armyworms cause food insecurity (Table 5.4) of questions.

Table 5. 4: Output of regression analysis to assess when do respondents grow their crops. Source: Survey data, 2023

Parameters	**Estimates**	**Std errors**	**Wald**	**P-values**
What is the minimum temperature in the area	0,17	0,450	0,001	0,971
Do you think the temperature is worsening the spread of fall armyworm	-,864	0,513	2,837	0,092
Do you think fall armyworm reduces crop yield on your farm	0,296	0,727	0,166	0,684
In which season do you think crop yield is reduced the most in your farm	0,310	0,334	0,863	0,353
Do you think fall armyworms cause food insecurity	**1,723**	**0,719**	**5,751**	**0,016**

The study further investigated the relationship between the questions that seek to find out the season the respondents grow their crops and the type of crops they grow on the farm. The Chi-squared test revealed that there was an insignificant relationship between these two questions (X^2=126,452; df=144; P=0.851). Furthermore, most of the respondents (n=99) reported that they grow maize on their farms and also the majority of respondents (n=97) reported that they grow their crops in the summer months (Fig.5.5).

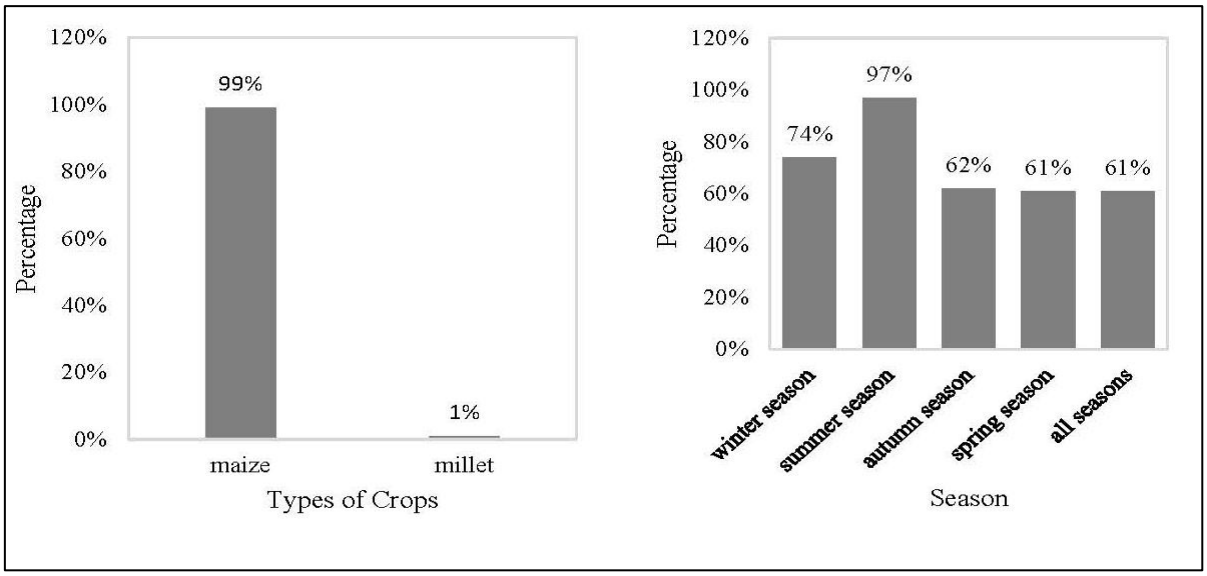

Figure 5. 5: Types of crops the respondents grow and the seasons they grow these crops. Source: Survey data, 2023

The study further asked the respondents about the temperature range in their area to establish the link between fall armyworm and temperature. Out of all the respondents, the majority (n=83) reported that temperature ranges between 27≤ T ≤ 45 degrees Celsius in their area (Fig.5.6).

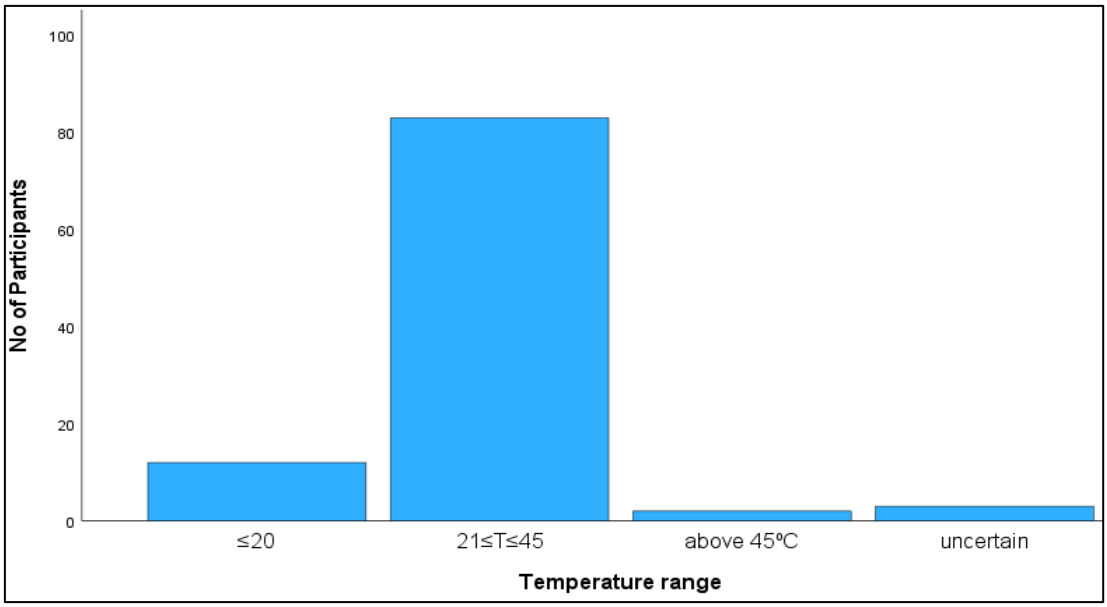

Figure 5. 6: Temperature ranges in the study area. Source: Survey data, 2023

The Chi-square tests were then performed to establish the relationship between the temperatures fall armyworms and crop yield-fall armyworms. The results show a significant value when the question of whether the respondents think fall armyworm reduces crop yield on their farm was cross-tabulated with the question of whether the respondents

think the temperature is worsening the spread of fall armyworm (X^2= 41,143; df=2; P<0,001). Additionally, 95% of the respondents reported that fall armyworms reduce crop yield. The finding is consistent with a study that has reported that globally, fall armyworm infestation can cause yield losses ranging from 8.3 million to 20.6 million tons of maize annually and with an estimate of approximately US$220 billion (Chakraborty and Newton, 2011; Day et al., 2017 Rohr et al., 2019; Ristaino et al., 2021). Additionally, plant pests such as fall armyworm were reported to have caused maize yield losses of between 11% and 67% by studies carried out in sub-Saharan Africa (SSA) (Baudron et al., 2019; Day et al., 2017; De Groote et al., 2020; Kassie et al., 2020; Kumela et al., 2019; Rwomushana et al., 2018; Overton et al., 2021).

The result of this study is similar to the findings of the study conducted in Europe, which reported that warmer areas as a result of higher temperatures may provide suitable climatic conditions for the establishment of fall armyworm (Gullino et al., 2021). Moreover, in regions like Senegal and South Africa, where temperatures are within the optimal range for fall the armyworm development, the pest tends to proliferate more rapidly (Du Plessis et al., 2020; Tendeng et al., 2019). However, no study has reported a correlation between high temperatures, decline in crop yields, and fall armyworm in Africa.

The study also applied descriptive statistics to assess crop yield reduction and seasonal variations. Approximately 76% of the respondents who reported that crop yield reduction is evident during the summer season also reported that fall armyworms cause food insecurity. Similarly, Bariw et al. (2020) reported that fall armyworm infestation threatens food security in Ghana. In Europe, the literature scan on the impact of fall armyworm on food security is scanty. This is because researchers have not extensively studied the impact of fall armyworms on food security on a broader scale, presumable due to the variation in terms of invasion of fall armyworms. For example, in Western Europe; Spain, and Italy have reported the highest risk of invasion by this worm, and in Northern Europe; Ireland, and Norway have been reported to experience low habitat suitability indices (Liu et al., 2020; Tepa-Yotto et al., 2021; Wang et al., 2023). This might be because of the predominantly cold weather in most parts of Europe that are not suitable for the armyworm; therefore, researchers divert their attention and neglect the focus.

In the United States of America, the literature scan on the impact of fall armyworm on food security is scanty. This is because researchers have not extensively studied the impact of fall armyworms on food security on a broader scale leaving a knowledge gap in the scientific knowledge. Again, it could also be because of the colder weather in most parts of America that are not suitable for the armyworm. The only recent study which distinctively reported

on fall armyworm in America, only reported estimated losses of up to 250-630 million US dollars per year was published in 2018 (Bateman et al., 2018).

In the Asian region, the impact of fall armyworms on both the current and future food security has not been quantified accurately at this point because of the ongoing spread, and the implications extend beyond the cash value of the crops that are destroyed in some Asian countries (Wightman, 2018). The projection that fall armyworms would give rise to an annual crop yield reduction that may impact negatively on food security range between 4.3 to 17.7 million tons of maize in Africa is worrying and indeed a challenge and calls for immediate action (Rwomushana et al., 2018). In South Africa, more studies are needed to explore the impact of the fall armyworm on food security case by case.

5.6 The effects of the fall armyworm on mental health

The multiple linear regression results showed a statistically significant relationship when the question of how the respondents feel when they are preparing for planting season, especially with the fear that fall armyworm will damage crops again was regressed with the other six questions on Table 5.5 below (X^2= 255.051; df=189; P<0.001; R^2= 86%. A significant difference was also recorded for the following question: do you avoid memories, thoughts, feelings, and external reminders of the fall armyworm (Table 5.5).

Table 5. 5: Output of regression analysis for Likert scale questions on PTSD assessment. Source: Survey data, 2023

Parameters	**Estimates**	**Std errors**	**Wald**	**P-values**
Do you have repeated, disturbing, and unwanted memories of the stressful memory	-0.37	0.136	0.073	0.787
Do you avoid memories, thoughts, feelings, and external reminders of the fall armyworm	**0.444**	**0.138**	**10.326**	**0.001**
Do you have trouble remembering important parts of the stressful experience of the fall armyworm?	-0.045	0.145	0.098	0.754
Do you have strong negative beliefs about yourself, other people, or the world because of the fall worm impact in your community	0.268	0.201	1.769	0.184
Do you blame yourself or someone else for the stressful experience due to fall armyworm	-0.043	0.265	0.027	0.870
Are you ready to start planting for the current season?	0.018	0.256	0.005	0.943

The majority of the respondents (n=66) responded that they feel nervous when they are preparing for planting season, especially about the fear that fall armyworm will damage crops again (Fig.5.7).

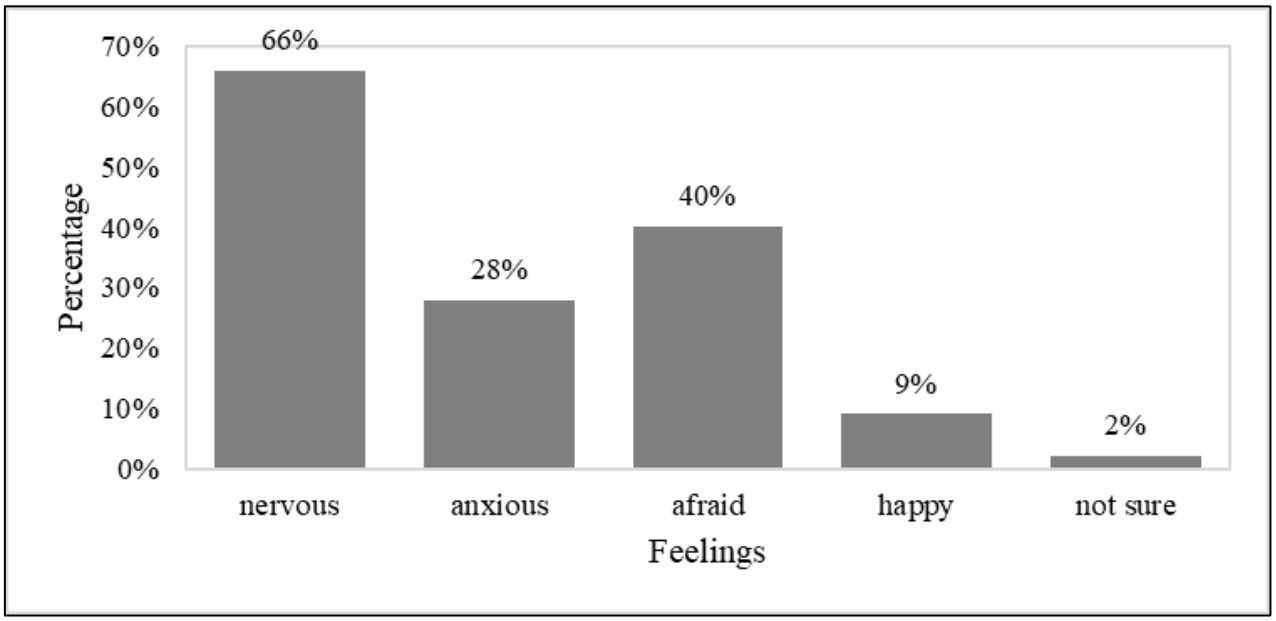

Figure 5. 7: Respondents feeling about fall armyworm. Source: Survey data, 2023

The findings of this study are not surprising because the impact triggers memories and feelings that the respondents encounter following the outbreak of fall armyworm. The respondents feel nervous and afraid when they are preparing for the planting season, especially with the fear that fall armyworms will damage crops. This is a reality, and a true reflection of what farmers are dealing with in their everyday lives because of the fall armyworm. People spend more to access measures responsible for pest management, and the potential loss of trading partners through, these factors can trigger mental health issues relating to financial burdens and loss (Campos et al., 2017). The impact of fall armyworms on people's mental health could be generated by the fact that replanting maize has financial repercussions, as Price (2021) reported. In this study, replanting was not the main focus and should be given further attention. Farmers have reported that several plots have been left abandoned because other farmers are struggling to cope with the loss of their crops due to fall armyworms and hence remain untested.

5.7 Mitigation of fall armyworm

All respondents reported that they use chemicals to control fall armyworms. The results of the logistics regression show a significant value when the question; does the government assist with providing chemicals to manage fall armyworm was regressed with nine other questions (X^2=52,688: df=56; 0.601; R^2= 0.187) in Table 5.6 below. In addition, there was

a statistically significant difference in the question besides chemicals, hence responses were sought on this question: do you know intercropping as a mitigation measure (Table 5.6).

Table 5. 6: Output summary of regression analysis for the Likert scale questions to assess the respondents on mitigation of fall armyworm. Statistical parameters are highlighted in Bold. Source: Survey data, 2023

Parameters	**Estimates**	**Std errors**	**Wald**	**P-values**
Does the government also assist with providing chemicals to manage fall armyworm=not sure	-3,506	1,875	3,497	0,061
Did you receive training on how to handle chemicals	-1,883	1,059	3,163	0,075
If the answer is yes, do you know how to use the chemicals	0,356	0,972	0,135	0,714
How effective are chemicals working in killing fall armyworms on your farm	0,503	0,606	0,688	0,407
Do you know the effect of chemicals on human health	-0,225	0,818	0,076	0,783
Besides chemicals, do you know intercropping as a mitigation measure	**15,065**	**0.900**	**280,19**	**<,0001**
Do you practice intercropping on your farm	-15,805	0,000	-	-
how much knowledge have you gained which can assist you in the coming growing season to make sure that impact is reduced	0,285	0,453	0,398	0,528
If you know a lot, from where did you get the information about fall armyworm	-0,410	0,466	0,773	0,379

Furthermore, the majority of the respondents, (n=75) reported that the government of South Africa also assists with providing chemicals to manage fall armyworms; they know how to use the chemicals (n=79); and the chemicals are a little bit effective in killing the fall armyworms (n=62) and that they know the effect of chemicals on their health (n=89). Moreover, most respondents, (n=86) reported that they know intercropping and they also practice it. However, the majority of the respondents (n=71) reported that they know a little about fall armyworms through previous experience in mitigating the impact of fall armyworms and a lot of respondents (n=75) reported the source of their fall armyworm information as extension officers (Table 5.7).

T**able 5. 7:** Output summary of responses to assess the respondents on mitigation of fall armyworm. Source: Survey data, 2023

Parameters	**Respondent's response**	**No**	**%**
Does the government also assist with providing chemicals to manage fall armyworm	No	16	16,0%
	not sure	9	9,0%
	Yes	75	75,0%
If the answer is yes, do you know how to use the chemicals	No	18	18,0%
	not really	3	3,0%
	Yes	79	79,0%
How effective are chemicals working in killing fall armyworms on your farm	Effective	34	34,0%
	little bit effective	62	62,0%
	not effective	4	4,0%
Do you know the effect of chemicals on human health	No	8	8,0%
	not really	3	3,0%
	Yes	89	89,0%
Besides chemicals, do you know intercropping	No	17	17,0%
	Yes	83	83,0%
Do you practice intercropping on your farm	No	14	14,0%
	Yes	86	86,0%
Through previous experience of mitigating impact of fall armyworms, how much knowledge have you gained which can assist you in the coming growing season to make sure that impact is reduced	I know a little about fall armyworm	71	71,0%
	I know a lot about fall armyworm	14	14,0%
	I know nothing about fall armyworm	6	6,0%
	Uncertain about fall armyworm	9	9,0%
If you know a lot, from where did you get the information about fall armyworm	Extension officers	75	75,0%
	Farmers	16	16,0%
	Other	5	5,0%
	Plant health clinics	4	4,0%
Total		100	**100,0%**

All respondents reported that they use chemicals to control fall armyworms. This is because chemicals were the option available to control fall armyworm invasion. This finding is consistent with other studies where affected small-scale farmers use chemicals to control fall armyworm (Goergen et al., 2016; Hruska, 2019; Kassie et al., 2020; Kumela et al., 2019; Matova et al., 2020).

The results show that the government of South Africa (DoA) is providing support to small-scale farmers; therefore, chemicals are supplied by the Limpopo Department of Agriculture and Rural Development (LDARD) free of charge to Shayandima farmers. This finding is consistent with a study in Latin America, that reported that registered pesticides are also recommended as a control measure for fall armyworms (Day et al., 2017). According to Fatoretto et al. (2017), it is a common practice to control fall armyworms using chemical insecticides in North and South America.

The majority of the respondents reported that they know intercropping and also, they reported that they are practicing intercropping in their farms as a mitigation measure to control the fall armyworm. Lastly, most of the respondents reported that they know how to use the chemicals which is consistent with the study in Zambia where farmers confirmed that pesticide application assists in controlling fall armyworm as an alternative measure (Kansiime et al., 2019).

The majority of the respondents reported that chemicals provided to control fall armyworm are less effective and are consistent with studies by Day et al. (2017) and Sisay et al. (2018) who both found that most government departments in Africa distributed chemical insecticides to farmers as an emergency response strategy to control fall armyworm invasion in 2016 instead of provision as a preparedness measure. The study by Goergen et al. (2016) found that pesticides are not effective for older larvae of fall armyworms. It has been revealed that fall armyworm is predominant during the vegetative stage and the pest is difficult to control as the maize plant matures: the caterpillars feed inside the leaf whorl outside the reach of chemicals (Bannor et al., 2022; DALRRD, 2022; Prasanna et al., 2018). Contrary to our study findings, Kumela et al. (2019) asserted that most farmers in Ethiopia believe that chemical sprays are effective, while most farmers in Kenya reported otherwise (Kumela et al., 2019).

5.8 Conclusion

In conclusion, the outbreaks of plant pests such as fall armyworm cause annual yield losses of approximately US$220 billion (Chakraborty and Newton, 2019; Rohr et al., 2019; Ristaino et al., 2021) worldwide. This finding shows the potential for Post Traumatic Stress Disorder (PTSD) among the farmers. Studies have neglected research on mental readiness for disaster that could be caused by pest infestation around poor communities in South Africa.

CHAPTER 6: GENERAL CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The invasive character of the fall armyworm affects the ecosystem, and disaster risk reduction talks focus on ecosystem-based disaster risk reduction (IUCN, 2017). Ecosystem-based disaster risk reduction (Eco-DRR) is a “no regrets” option that can provide multiple benefits during a disaster and ensure the accomplishment of numerous goals and responsibilities more cost-effectively (IUCN, 2017). In addition, it can concurrently contribute to risk reduction, sustainable development, gender equity, climate change adaptation, and food security (IUCN, 2017).

South Africa is a net exporter of agricultural products which was estimated to the value of US$12.8 billion in 2022, up by 4% from the 2023/24 financial year, this is according to Annual Performance Plan (APP, 2023/2024) (DALRRD; 2024). Therefore, the rapid spread of fall armyworm seriously threatens food security, nutrition, and livelihoods (Matova et al., 2020; Prasanna et al., 2018).

To avoid further catastrophe that makes the fall armyworm, a formidable pest and the impacts of this pest on food security crops especially in rural farming communities, this study makes the conclusions based on the findings in Chapter 5 as follows:

6.1.1 Demographic characteristic

The study findings show most of the respondents were females than men. This finds are consistant with De Groote et al. (2020) who found that women are more involved in farming than men across the Limpopo Province. The study by Price (2021) reveals that females are involved in farming due to men searching for work in cities. Our findings suggest that women play a critical role in the farming sector as seen evident by their presence on their farms. According to APP (2023-2024), the farming of agricultural land contributes to economic growth, improves livelihood, and mitigates household food insecurity (DALRRD, 2024). The government of South Africa in response to the African Union (AU) Declaration on Land, is continuing to review land policies and strengthening its institutions targeting women and youth. The government is aiming to provide equitable access to land and strengthen land tenure security for women and youth (DALRRD, 2024). The study findings by Badstue et al. (2020) found that governmental efforts to ensure gender equity in land distribution according to the provisions of the law were highly promising.

During the 2020/21 financial year, it was reported that out of 29 000 hectares (ha) acquired, 22 000 ha were through land redistribution and 7 000 ha through the Land Tenure Reform Programme, therefore, more than 7 500 ha were allocated to women and 12 000 ha to youth (DALRRD, 2024). This shows the wheel of the government is turning even though it is slowly (DALRRD, 2024).

The goal of the 2030 Agenda for Sustainable Development is progressively documented and undertaken across spheres of governance and therefore of utmost importance for achieving gender equality and empowering women (FAO, 2023). Moreover, harnessing the potential of women is a vital economic and social driver for more inclusive and sustainable development, additionally, empowering women in the farming sector enhances the well-being of women and their households, reducing hunger, boosting incomes, and strengthening resilience (FAO, 2023; Thobejane et al., 2023).

The government of South Africa must continue to empower women in rural farming by providing more resources, prioritise developing and implementing policies for women's empowerment, including improving women's access to resources and assets, which will support boosting incomes, food security, local economy and resilience for women, their families, and communities.

The study has exposed a need for the transfer of skills from older farmers to younger farmers. This is because the study found that Shayandima small-scale farmers are dominated by those 65 years and above compared with the younger age group. According to Balezentis et al. (2020), it is a challenge for older people to dominate farming activities as they will experience challenges in understanding and adopting new agricultural policies aimed at disaster risk reduction, which may have negative consequences for agricultural production.

When the government comes on board in support of the young age group and educated respondents, the support will ensure food security. Additionally, enhance the output of crops as the government implement new agricultural policies aimed at disaster risk reduction to deal with the impact of fall armyworm. Besides new technology, the capacity to deal with the sketch of the outbreak of fall armyworm might need young energetic people as compared to the elderly as reported by our study. Furthermore, when the nation invests in the younger generation, the country thrives, and the economy is believed to perform better because young people are innovative and capable of understanding and adopting new agricultural policies.

This study shows the highest level of education the respondents possess was secondary education, which depicts the importance of education for farmers' knowledge in improving agricultural productivity (Rajendran et al. 2016). The findings of the study show that most respondents were married people, and a possible explanation for this majority is assumed to be because of the responsibility that comes within this group such as taking care of extended family setup, therefore agriculture became the main source of income to support the family. According to Badstue et al. (2020), marital status influences the capacity of poor rural women to innovate in agriculture, this could suggest that married women might innovate effectively because they are in a collaborative relationship with their husbands and children. While it seems as if the government lags in terms of providing support to vulnerable and marginalised small-scale farmers in Shayandima, particularly women, married women must receive continuous support to improve agricultural production in the fight against the outbreak of fall armyworm.

Most respondents were self-employed according to the study findings. Therefore, a possible explanation for this finding might be based on the assumption that South Africa is grappling with a high rate of unemployment as the economy is grappling to create adequate jobs for its citizens, especially the vulnerable and marginalised people, therefore, an alternative is sought to support families. Besides contributing to improving livelihoods and mitigating food insecurity, the implementation of the Presidential Employment Stimulus (PES) has maintained self-employment (DALRRD, 2024). The government of South Africa through the National Rural Youth Services Corps (NARYSEC) remains an important vehicle for the empowerment of the rural youth through skills development and employment (DALRRD, 2024).

6.1.2 Knowledge of fall armyworm

Farming requires technical knowledge through the experience of involvement in farming (Ozowa, 1995). Additionally, knowledge is the best tool for disseminating technology, and this can only be achieved with more field agents and technicians (Ketcham, 2018). Knowledge of the presence, distribution, impact, and control of this pest is crucial in community-level disaster preparedness. Several literature studies have recorded that there was some confusion regarding the correct identification of pests such as fall armyworm with other caterpillars (Caniço, Mexia, and Santos, 2021; FAO and CABI, 2019; Kansiime et al., 2019; Sisay et al., 2018).

The findings of the study found that the majority of Shayandima farmers had the highest knowledge of fall armyworm and sources were from other farmers themselves compared to

extension officers. This could be attributed to the thin number of extension officers to reach all the farmers. However, the findings of the study are encouraging to have farmers take charge of the farming environment because upon hearing about fall armyworm, farmers inform other farmers.

6.1.3 The impact of fall armyworm on livelihood

Agriculture is the principal source of livelihood in most developing countries and is dominated by small-scale farmers (Chand et al., 2022). The fall armyworm invasion affected livelihoods as it reduced crop yield (Houngbo et al., 2020). The study also found that the majority of the respondents reported that fall armyworm has impacted them and their families and there was also a statistically significant difference for this question, with the majority of the respondents reporting yes to being affected by the fall armyworm.

The findings of the study revealed that the majority of Shayandima farmers' livelihoods and those of their families had been impacted because of fall armyworm invasion. The farmers have indicated that their livelihood had been impacted because the farming community is struggling to afford the necessities such as paying school fees for their children, failing to give their children pocket money to carry to school, increased dependency, and budget constraints concerning feeding their families daily becomes a reality.

Our study findings regarding the high impacts of fall armyworms on farms reported by the surveyed farmers could threaten maize production and the livelihood. This is because numerous farmers depend on maize production for income as most farmers grow maize as their main crop. The government will fail to achieve SDGs goal, particularly on zero hunger and no poverty targeting the 2030 Agenda for Sustainable Development. This is because the determination to achieve SDGs can only be fulfilled if agriculture and food systems become sustainable. This ensures stable food supplies for all people to access adequate nutrition and health.

The majority of respondents reported selling their crops after harvesting, irrespective of the impact of fall armyworm on local traders. Therefore, having reported encountering challenges apart from fall armyworm, local traders expect farmers to cut the selling price of their crops, this could imply low profitability as compared to what farmers expected. Besides that farmers had already spent extensively on managing the pests using chemicals and cutting the price of their crops became a burden to their livelihoods as they suffered low income.

Furthermore, most farmers from our study reported receiving support from the government of South Africa to control fall armyworms but despite the support received they continue experiencing losses. This could indicate a knowledge gap in Shayandima farming communities with respect to fall armyworm management which irreversibly affects their livelihoods. The failure to win the battle in fighting fall armyworm could mean there is limited knowledge from the extension officers which is supposed to be transferred to farmers. Nonetheless, the government should come up with effective avenues to ensure there is a knowledge bank with regard to rapid response in time of the outbreak of pests such as fall armyworm. The government is doing its best to support the farmers in managing the fall armyworm, however, there could be other factors that are contributing to the impact such as temperature variability as reported by Du Plessis et al., 2020; Nurzannah et al., 2020; Wang et al., 2023).

The majority of the respondents who know little about fall armyworms indicated that the impact of fall armyworm could have been lessened if the farmers in the study area were capacitated. When the extension officers play an oversight of information sharing about fall armyworm, this could reduced their crop losses. The literature review suggests the losses due to pests such as fall armyworm may be prevented, or reduced, by deploying effective tools and/or strategies, which depend entirely on farmers' knowledge and behaviour towards pest management (Kansiime et al. 2019).

Two chi-square tests used to assess the impact of fall armyworms on livelihoods showed insignificant values and also indicate that communities at Shayandima receive support from the government of South Africa due to the presence of fall armyworms which is damaging their crops. Additionally, farmers who receive support from the government of South Africa due to the presence of fall armyworm in the community which is damaging their crops did not have an influence on the knowledge farmers have gained that can assist them in the coming growing season. This was done to make sure that the impact of the fall armyworm is reduced, and the amount of knowledge farmers have gained through previous experience in mitigating the impact of fall armyworm can assist them in the coming growing season to make sure the impact is reduced respectively.

The study shows that although the government is providing support or not, there has been limited knowledge gained by farmers with respect to fall armyworm management which irreversibly affects livelihood. Therefore, there is a knowledge gap among extension officers who are providing training to farmers.

6.1.4 Contribution of climatic factors to the Impact of fall armyworm on food security

South Africa can rise above the challenges of the impact of fall armyworm, to build more resilient and better management strategies to reduce the impact on food security. The infestation of fall armyworm has the potential to affect global food availability and food security undermining most Sustainable Development Goals (SDG1 and SDG2) which strive to end extreme poverty and hunger around the globe (WHO, 2018). Unless better management strategies for lessening the effects of the fall armyworm are implemented, the global community is faced with the threat of food security. To achieve sustainable development goals, Bello et al. (2021) suggest that a concerted effort must be made in disaster preparedness to strengthen a community's resilience and, in turn, reduce vulnerabilities.

A statistical relationship was found between the question of when respondents grow their crops and the question that state that they think fall armyworms cause food insecurity. This was a very interesting concept that shows the relationship between the time the crops are grown in relation to food access, and food stability versus the period which fluctuates when the crops are not grown, access based on the unstableness of when the crops are not grown for some or other reason and utilisation. These are the four important pillars used to measure food security.

A statistical finding revealed that there was no relationship between the season when the respondents grow their crops and food security. Therefore, this is confirmed by the findings that the respondents depend on boreholes for irrigation instead of summer rain. This means that the respondents may grow their crops in any particular season. In conclusion, farmers may be marginalised in profit in all other seasons apart from summer where fall armyworm impact is more severe.

In addition, seasonal variation can have a huge impact on the food security of subsistence farmers (Raphela and Pillay, 2021). Most of the respondents who reported growing their crops in the summer season and further reporting their major crop to be maize could be at the plight of the fall armyworm. Studies have reported that fall armyworm to thrive in high temperatures and attack maize more than any other crop.

The majority of the Shayandima small-scale farmers reporting temperature ranges between $27 \leq T \leq 45$ degrees Celsius in their area indicate that temperature influences fall armyworm establishment. Indeed, increasing temperatures are believed to have played a crucial role

in the establishment of fall armyworms at Shayandima farming community and subsequently pose a serious threat to food security. The question about the influence of temperature on crop yield based on the respondent's perception implies that temperature may have an influence on invasive nature thereby reducing crop yield. This has been alluded to in other studies which reveal that temperature may have an irreversible agricultural system. The study's majority findings for the variables concluded that fall armyworm was reported to cause food insecurity with most farmers reporting that crop yield reduction.

6.1.5 Impact of fall armyworm on mental health

The influence of the question, do you avoid memories, thoughts, feelings, and external reminders of the fall armyworm on the question of how the respondents feel when they are preparing for planting season, especially with the fear that fall armyworm will damage crops again has a serious impact. The majority of the respondents reported that they feel nervous when they are preparing for planting season, especially about the fear that fall armyworm will damage crops again. Therefore, this might imply that there could be mental health issues within the farming community. Indeed, avoidance of memories, thoughts, and feelings of a traumatic event has been reported to be linked to Post Traumatic Stress Disorder (Haberstroh, 2020).

Additionally, studies conducted in the United States established the relationship between pesticide exposure and farmer's mental health issues (Daghagh Yazd, Wheeler, and Zuo, 2019). It has been found that Organophosphates can enter an individual's body through the skin or through inhalation (Mearns, Dunn, and Lees-Haley, 1994). Moreover, Koh et al. (2017) revealed that farmers with previous pesticide poisoning occurrences are found to be associated with depression. Knowledge of risk factors affecting farmers' mental issues is essential for reducing the burden of mental factors and outlining possible suggestions for prevention, as well as areas for future research.

The study findings show at most of the respondents (86%) have reported mixed feelings in response to how they feel when preparing for planting season, especially with the fear that fall armyworm will damage crops again. However, there is a lack of information on how farmers and farm owners are affected by fall armyworms mentally, including how the total crop maize loss affects them mentally. The scanty literature scans specifically on the link between pests' infestation and mental health. .

6.1.6 Mitigation of fall armyworm

The influence of the question of whether the government assists with providing chemicals to manage fall armyworm. On the question that states that besides chemicals, do the farmers know intercropping as a mitigation measure? In addition, the majority of the respondents reported that the government of South Africa also assists with providing chemicals to manage fall armyworms; they know how to use the chemicals; and the chemicals are less effective in killing the fall armyworms and they know the effect of chemicals on their health could indicate some level of available mitigation strategies within the farming community. Around the globe, policies and strategies are being put in place to manage a pest infestation, for instance, Europe has classified the fall armyworm high risks pest, and periods of invasion for early deployment of pest management measurements are monitored (Wang et al., 2023).

The control methods used in the United States include genetically modified crops, application of chemical and botanical pesticides, agronomic practices (such as early planting, intercropping, and crop rotation), and integrated pest management (IPM) (Tambo et al., 2020). Therefore, the combination of different control methods to tackle fall armyworm infestations could be the best option because agricultural technologies and practices generate higher gains when adopted in combination rather than in isolation (Day et al., 2017; Tambo et al., 2020). This is true because effective control of the fall armyworm can be realised through integrated pest management practices (DALRRD, 2022). The respondents reported the use of intercropping in controlling the worms in their farms. The results by Kassie et al. (2020) found that intercropping had little impact on controlling maize production losses due to fall armyworms in southern Ethiopia. Therefore, multiple mitigation strategies need to be adopted to mitigate the fall armyworm. However, in contrast, the study in Uganda showed that intercropping was more effective than monocropping in controlling fall armyworms (Hailu et al., 2018).

These chemicals seem to be less effective in controlling mature fall armyworms, as indicated by Goergen (2016), pesticides are not effective for older larvae. In Brazil, farmers also use repeated applications of insecticides, on average five sprays were required for the control of fall armyworm in maize Sisay et al. (2018). Massive use of pesticides on maize crops was applied by farmers in Kenya and Ethiopia to control the worm. Remarkably, Kumela et al. (2019) asserted that most farmers in Ethiopia believed that chemical sprays were effective, while most farmers in Kenya perceived otherwise.

In conclusion, descriptive statistical results were performed on demographics such as gender, age group, educational level, marital status, and employment status, and interesting results were observed. The study recorded 53% of women participating in farming than their male counterparts.

Perceptions from this study can be beneficial in efforts to eradicate the impact of this damaging pest on farmers' livelihoods. The study found that seasonal variation can have a huge impact on the food security of subsistence farmers. The study's majority findings concluded that fall armyworm was reported to cause food insecurity with most farmers reporting they have experienced crop yield reduction.

The chemical control measure was used as an available option to manage fall armyworm which the government supplied, however, the chemicals were not adequate. More importantly, the government should continue to provide support to small-scale Shayandima farming communities regarding fall armyworm management. The majority of farmers, that is 62% of the respondents have indicated that chemicals provided by the government to control fall armyworm are less. Besides chemicals, the majority of farmers (86%) have indicated other potential fall armyworm prevention measures including rotation and intercropping with non-host plants.

6.2 Study recommendations

This study makes recommendations based on the findings:

6.2.1. Demographic characteristic

This is because the local economy is managed by women. The study recommends that the government should double efforts and speed at ensuring that the provision of equitable access to land is executed and also strengthen the land tenure security for women and youth. Supporting the younger age group should be prioritised. When the old age group is being phased out from farming due to aging, young people should take over.

The recommendation might provide a sense of hope for young people, and this is nation building initiative. The government should continue to use the emerging NARYSEC for the empowerment of rural youth through skills development and employment (DALRRD, 2024).

6.2.2 Knowledge of fall armyworm

The farmer's knowledge is also important in bringing about sustainable agricultural innovations (Rajendran, 2020). The study recommends the need to foster education for all as the study findings indicated that the educated groups do better in production compared to their uneducated counterparts.

The study recommends that the government employ more extension officers to reach out to more farmers and offer refresher training by the relevant department to assist farmers properly. Furthermore, it should be recommended that the government allocate adequate resources to ensure that farmers are empowered to improve agricultural productivity. There are various mechanisms and platforms to impart knowledge about fall armyworm, for example, through imbizo initiative, workshops, training, and roadshow and other government programs. This is because the study findings have demonstrated that the respondents also included older farmers who through indigenous knowledge tackle the outbreak of pests including fall armyworm and identification of pests.

6.2.3 The impact of fall armyworm on livelihood

The study recommends that small-scale farmers should not depend on one main crop, but farmers should focus more on expanding the market to marginalise profit. Moreover, the study further recommends that the government should continue to assist the Shayandima farming communities whose livelihoods are affected and disrupted by the manner their produce is being sold after harvesting to local traders. The study recommended that a compensation scheme should be introduced to assist these

6.2.4 Contribution of climatic factors to the Impact of fall armyworm on food security

The majority of the respondents indicated that fall armyworms reduce crop yield. The study reported that crop yield reduction is evident during the summer season and that fall armyworms cause food insecurity. The study recommends that the Disaster Relief Fund be available regarding an outbreak of pest particularly the invasion of fall armyworm to compensate the affected small-scale farmers during the summer seasons.

6.2.5 Impact of fall armyworm on mental health

The study recommends that the government should provide counseling services for farmers who reported avoidance of memories, thoughts, and feelings of a traumatic event that could

related to the fall armyworm outbreak. The research findings have revealed that too little attention has been directed to community engagement and mental health.

There is a lack of information on how farmers and farm owners are affected by fall armyworms, including how the total crop maize loss affects them mentally. This study looked at the potential PTSD.

6.2.6 Mitigation of fall armyworm

The study recommends that farmers should implement better management strategies to reduce the impact of the fall armyworm. This is because it has been recorded that profitability and production efficiency of small-scale maize production was reported despite the outbreak of fall armyworm in Niger State.

This study further recommends that the government should continue to provide support to small-scale Shayandima farming communities regarding fall armyworm management. Our study reported that the chemicals provided by the government are not enough, therefore, it is recommended that adequate chemicals should be provided. Considering that more farmers require more chemicals, could the reason be that pests are resistant to chemicals, Additionally, the support should not be limited to chemicals but also provision of seeds, fertilisers, provision of credit, and any support relating to farming activities. Hailu et al. (2018), reported that intercropping was more effective in controlling fall armyworm in Uganda.

Finally, the study recommended that the government should distribute chemicals that are registered to Shayandima farming community, and seeds should also be provided by the government for the expansion of their market.

6.3 Recommendation for future studies

This study makes the recommendations for future studies based on the findings in Chapter 5 as follows:

6.3.1 Demographic characteristic

Based on the study's majority findings for all the variables, future studies should look at the reasons why the older generations are farmers as compared to the younger generation, The future study should recommend correlations between gender, level of education, marital status, employment status, and farming within the study community. This study

should probe the respondent to be able to find the reason if correlations are found across these demographic variables.

The study recommends that future studies should also probe whether women own farms or not, currently, the study has reported that Shayandima small-scale farmers own 1ha but the study did not investigate how many women own how much percentage of land for agricultural sustainability, this study is crucial as currently the government programs and initiatives are underway with the implementation of policies resulted in more than 7 500 ha allocated to women, this is recommended and is seen as a huge achievement from the government.

6.3.2 Knowledge of fall armyworm

The study findings recommend future studies to look at the importance of assigning expertise to impart relevant knowledge to assist farmers to curb the sketch of the outbreak of fall armyworm. Future studies are recommended to establish the relationship between the level of education and farmer's knowledge of fall armyworm. Furthermore, to avoid confusion in the correct identification of fall armyworm, future studies should recommend the importance of compulsory training of farmers in the study area and extension officers with the view to improve knowledge to efficiently, effectively, and correctly identify fall armyworm as a measure for community preparedness and response.

6.3.3 The impact of fall armyworm on livelihood

Therefore, based on these findings, future studies should extensively examine and identify additional areas of focus where their livelihoods were impacted with the view to quantify the impact prior to the outbreak of fall armyworm in their farms versus crop yield production. This study should explore the respondents to be able to find the reason if correlations are found across these variables. future studies to investigate any existing correlation between lack of knowledge of fall armyworm and the impact thereof.Furthermore, it is recommended that future studies should examine the role of government in the provision of chemicals, seeds, and other assistance to local farmers for expansion of the market versus the impact of fall armyworm on their livelihoods. Future studies should investigate the impact of using chemicals that are not registered to control fall armyworms in relation to farmers' livelihoods.

6.3.4 Contribution of climatic factors to the Impact of fall armyworm on food security

Therefore, future studies should investigate extensively various factors that contribute to the impact of fall armyworms which cause food insecurity. Furthermore, future studies should also look at economic analysis to establish what will be the losses on farmers who do not depend on the season if fall armyworm might be suppressed season. It has been speculated that pest resistance will become a problem if solution is not sought. Additionally, there should be future studies to be carried out that link fall armyworm to food security as there is no study that has reported.

6.3.5 Impact of fall armyworm on mental health

Worldwide, there is increasingly a call for additional research studies on the mental preparedness for disasters including fall armyworm to improve the knowledge gaps and obtain baseline information in this regard. Studies have neglected research on mental readiness for disaster that could be caused by pest infestation around poor communities in South Africa

Therefore, future research should examine the link between pest infestation and mental health using a series of mental health measures instead of one. Studies have also neglected research on mental readiness for disaster that could be caused by pest infestation around poor communities in South Africa. Therefore, future research should divert their resources to address the situation. Our study therefore recommends that future studies should look at the mental health issues and threats that come with fall armyworm, the literature has not been extensively studied.

6.3.6 Mitigation of fall armyworm

Future studies should focus on estimating how much losses were accounted for in South Africa which may have an impact on food security in South Africa. Therefore, future studies is recommended to consider broadening the scope to cover the area of effectiveness of control measures to manage fall armyworm.

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APPENDICES

Appendix 1: Questionnaire

Questionnaire to determine the impact of fall armyworm in the Thulamela local municipality, in the Limpopo Province of South Africa.

Please indicate your choice with an[X] where applicable

1. Date completed (dd/mm/yy)

_____/_____/_____

2. Do you consent to participate in this questionnaire?

1.	Yes	
2.	No	

Section A: Demographic characteristics of the respondents

3. Gender

1.	Male	
2.	Female	
3.	Prefer not to say	

4. Age

1.	18-25	
2.	26-35	
3.	36-45	
4.	46-55	
5.	56-65	
6.	Above 65	

5. What is your level of education?

1.	No schooling	
2.	Abet education	
3.	Primary education	
4.	Secondary education	
5.	Tertiary education	

6. Marital status

1.	Single	
2.	Married	
3.	Widowed	
4.	Divorced	
5	Cohabiting	
6.	Other, specify.	

7. Employment status

1.	Unemployed	
2.	Permanently employed	
3.	Temporarily employed	
4.	Self employed	
5.	Student	
6.	Retired	
7.	Other, specify.	

8. Do you own the farm?

1.	Yes	
2.	No	

9. If yes, what is the size of your farm?

1.	0 ha- 5ha	
2.	5ha-10ha	
3.	10ha-15ha	
4.	Over 15ha	

10. Do you have water in your farm?

1.	Bore hole	
2.	River streams	
3.	Dams	
4.	Municipality	
5. Other, specify		

Section B: Impact of fall armyworm on livelihoods

11. Do you know fall armyworm?

1.	Yes	
2.	No	
3.	Not sure	

12. If yes, how did you hear about fall armyworm?

1.	Other farmers	
2.	Agricultural extension officers	
3.	Traders	
4.	Researchers	
5.	Radio/TV	

6.	Other	
7. If other, please specify:		

13. When did you hear about fall armyworm?

1.	2016-2017	
2.	2018-2019	
3.	2020-2021	
4.	2022-2023	
5.	Not sure of the year	

14. What did you do when you hear about fall armyworm?

1.	Inform other farmers	
2.	Report to the authorities	
3.	Report to the Municipality	
4.	Report to the Department	
5.	Inform traders	
6. If other, please specify:		

15. Has the fall army worm impacted you and your family in any way?

1.	Yes	
2.	No	
3.	Not sure	

16. If you answered yes above, please explain how it has impacted you and your family on the space provided below.

_____

_____

_____

_____

_____

17. How would you rate the impact or damage caused by fall armyworms in your farm?

1.	Very high	
2.	High	
3.	Medium	
4.	Low	
5.	Very low	

18. Do you sell/export your crops after harvesting?

1.	Yes	
2.	No	
3.	Not sure	

19. If yes, to whom do you sell your crops?

1.	Local traders	
2.	Provincial traders	
3.	National traders	
4.	SADC	
5.	Internationally	
6. If other, please specify:		

20. Do you encounter challenges in your farm when selling/exporting your crops?

1.	Yes	
2.	No	

21. If you answered yes above, please explain what the challenges are when selling and exporting your crops on the space provided below.

_____

_____

_____

_____

_____

22. How much do you generate from selling/exporting your crops?

1.	A lot of money	
2.	Little	
3.	Nothing	
4. If other, please specify:		

23. Does the presence of fall armyworm affect your livelihoods?

1.	Yes	
2.	No	
3.	Not sure	

24. If yes, how did fall armyworm affect your livelihoods?

1.	Reduced income	
2.	Increased income	
3.	No impact	
4.	I do not know	
5. If other, please specify:		

25. Do the communities receive support from the government due to the presence of fall armyworm which is damaging their crops?

1.	Yes	
2.	No	
3.	Not sure	

26. If yes, what type of support do you receive from the government?

1.	Money	
2.	Seeds	
3.	Fertilizers	
4.	Chemicals	
5. If other, please specify:		

Section C: Impact of fall armyworm on food security

27. What type of crops do you grow in the farm?

1.	Maize	
2.	Sugarcane	
3.	Legumes	
4.	Sorghum	
5.	Millet	
6. If other, please specify:		

28. When do you grow these crops?

1.	Winter season	
2.	Summer season	
3.	Autumn season	
4.	Spring season	
5. If other, please specify:		

29. What is the minimum temperature in the area?

1.	Temperature ranges from 20 °C and below	
2.	Temperature ranges from 27 °C to as high as 45 °C	
3.	Temperature ranges from 45 °C and above	
4.	I know a little about temperature	
5.	Uncertain about temperature	

30. Do you think the temperature is worsening the spread of fall armyworm?

1.	Yes	
2.	No	
3.	Not sure	

31. Do you think fall armyworm reduces crop yield in your farm?

1.	Yes	
2.	No	
3.	Not sure	

32. In which season do you think crop yield is reduced the most in your farm?

1.	Winter season	
2.	Summer season	
3.	Autumn season	
4.	Spring season	
5. If other, please specify:		

33. What is the estimated cost of crop losses due to fall armyworms?

1.	R0-R500	
2.	R501- R1000	
3.	R1001-R2000	
4.	R2001- R3000	
5.	R3001-R4000	
6.	R4001-R5000	
7	above R5000	
5. If other, please specify:		

34. Do you think fall armyworm cause food insecurity?

1.	Yes	
2.	No	
3.	Not sure	

35. If you answered yes above, please explain how it has impacted communities on the space provided below.

_____

_____

_____

_____

Section D: Mental health issues due to the presence of fall armyworm on communities

36. What is your worst memory about the outbreak or presence of fall armyworm?

_____

_____

_____

_____

_____

37. Please briefly describe how your normal day-to day life, has generally changed since the stressful experience you might have experienced due to the fall armyworm?

_____

_____

_____

_____

_____

38. How are you feeling when you are preparing for planting season especially with the fear that fall armyworm will damage crops again?

1.	Nervous	
2.	Anxious	
3.	Afraid	
4.	Happy	
5.	Not sure	

39. Please select only one option after reading the following questions about stress and fall armyworm on the below table.

Stress measure	**Not at all**	**A little**	**Moderately**	**Quite a lot**	**Extremely**
39.1 Do you have repeated, disturbing, and unwanted					

memories of the stressful memory?					
39.2 Do you avoid memories, thought, feelings, external reminders of the fall armyworm?					
39.3 Do you have trouble remembering important parts of the stressful experience about the fall armyworm?					
39.4 Do you have strong negative beliefs about yourself, other people, or the world because of the fall worm impact in your community?					
39.5 Do you blame yourself or someone else for the stressful experience due to fall armyworm?					
39.6 Are you ready to start planting for the current season?					

SECTION E: Mitigation for Fall armyworm

40. How do you control fall armyworm?

1.	Chemicals	
2.	Cultural control	
3.	Biological control	
4.	Integrated pest management (IPM)	
5. If other, please specify:		

41. If the answer is 1. Where do you get the chemicals?

_____

_____

_____

_____

_____

42. Does the government also assist with providing chemicals to manage fall armyworm?

1.	Yes	
2.	No	
3.	Not sure	

43. If the answer is yes, do you know how to use the chemicals?

1.	Yes	
2.	No	
3.	Not really	

44. Did chemicals work in killing fall armyworm?

1.	Effective	
2.	Little bit effective	
3.	Not effective	
4.	Not working at all	

45. Do you know the effect of chemicals on human health?

1.	Yes	
2.	No	
3.	Not really	

46. If the answer is Yes, please provide more detail?

_____

_____

_____

_____

47. If the answer is No, please provide more detail?

_____

_____

_____

_____

48. Besides chemicals, do you know intercropping (planting various crops on the same ha)?

1.	Yes	
2.	No	

49. Do you practice intercropping on the same ha of your farm?

1.	Yes	
2.	No	

50. Through previous experience of mitigating impact of fall armyworms, how much knowledge have you gained which can assist you in the coming growing season to make sure that the impact is reduced?

1.	I know a lot about fall armyworm	
2.	I know a little about fall armyworm	
3.	I know nothing about fall armyworm	
4.	Uncertain about fall armyworm	

51. If you know a lot, from where did you get the information about fall armyworm?

1.	Extension officers	
2.	Plant health clinics	
3.	Farmers	
4. Other, please specify		

Appendix 2: Ethical clearance

UNIVERSITY OF THE FREE STATE
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UFS UV

GENERAL/HUMAN RESEARCH ETHICS COMMITTEE (GHREC)

05-Oct-2023

Dear Ms Maria Mafadza

Application Approved

Research Project Title:
The impact of fall armyworm in the Thulamela local municipality, in the Limpopo Province of South Africa

Ethical Clearance number:
UFS-HSD2023/1519

We are pleased to inform you that your application for ethical clearance has been approved. Your ethical clearance is valid for twelve (12) months from the date of issue. We request that any changes that may take place during the course of your study/research project be submitted to the ethics office to ensure ethical transparency. furthermore, you are requested to submit the final report of your study/research project to the ethics office. Should you require more time to complete this research, please apply for an extension. Thank you for submitting your proposal for ethical clearance; we wish you the best of luck and success with your research.

Yours sincerely

Dr Adri Du Plessis
Chairperson: General/Human Research Ethics Committee

Adri Du Plessis
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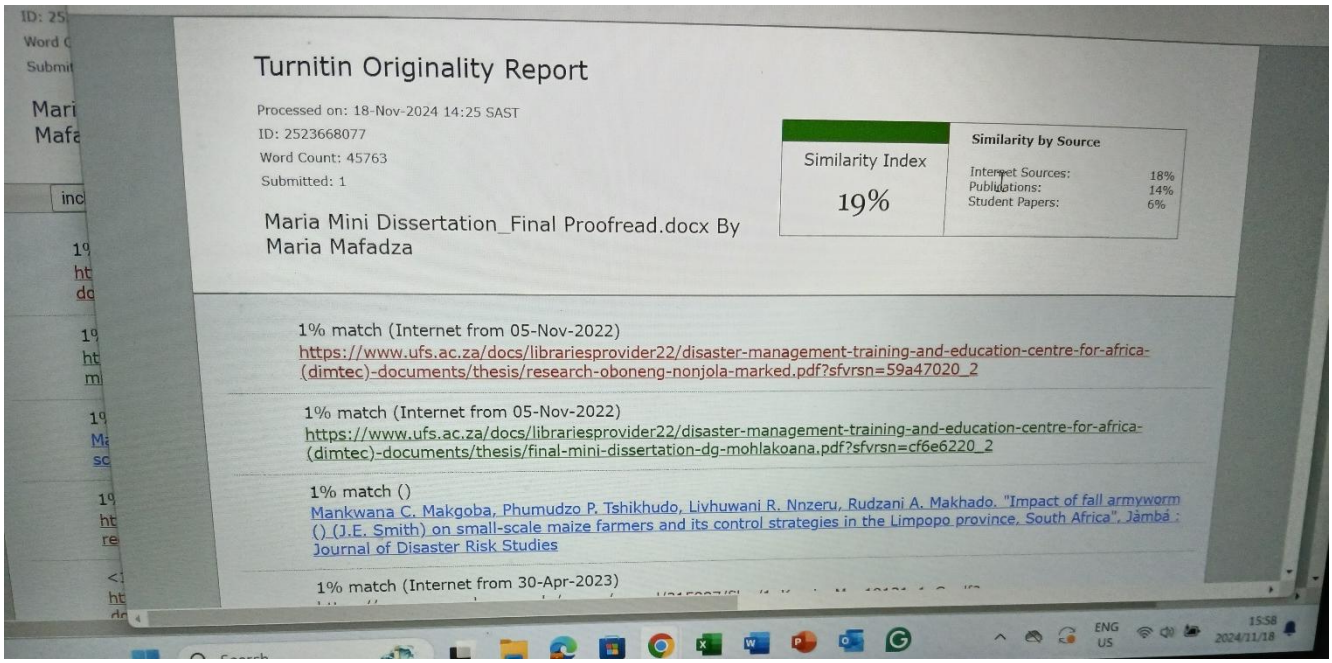
Appendix 3: Plagiarism report



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Appendix 4: Proofread letter

FACULTY OF HUMANITIES, SOCIAL SCIENCES AND EDUCATION
DEPARTMENT OF ENGLISH, MEDIA STUDIES AND LINGUISTICS

Inquiries: Dr. MJ Maluleke 16 November 2024

To whom it may concern

This serves to certify that I have edited a full thesis for Maria Mafadza for Master of Disaster Management. He is a student attached to the Department of Disaster Management Training and Education Centre for Africa in the Faculty of Natural and Agricultural Sciences at the University of the Free States. The editing entails correcting grammatical errors, rephrasing sentences, ensuring consistency in British English and improving readability.

The title of the study is: **The impact of fall armyworm in the Thulamela Local Municipality, in the Limpopo Province of South Africa.** I have read the whole document and made suggestions reflected through track changes, as well as effecting changes in some areas.

Yours Sincerely

Maluleke

Mzamani J. Maluleke

University of Venda

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