

**A COMPARATIVE ANALYSIS OF FORMAL AND INFORMAL SEED SYSTEMS
IN GURUVE DISTRICT, ZIMBABWE.**

**A dissertation submitted in partial fulfillment of the requirements for the Masters of
Science Degree in Food Security and Sustainable Agriculture Production**

Bindura University of Science Education (BUSE)



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The undersigned certify that they have supervised and recommended to the Bindura University of Science Education (BUSE) for acceptance of a dissertation entitled; **“A Comparative Analysis of Formal and Informal Seed Systems in Guruve District, Zimbabwe,”** that is submitted in partial fulfilment of the Masters of Science Degree in Food Security and Sustainable Agriculture Production.

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DECLARATION

I hereby declare that the research project entitled; “**A Comparative Analysis of Formal and Informal Seed Systems in Guruve District, Zimbabwe,**” submitted to Bindura University of Science Education (BUSE), Department of Agricultural Economics, Education and Extension, is a record of an original work done by me under the guidance and supervision of Dr. N. Mafuse and Professor R. Mandumbu. This work is submitted in partial fulfilment of the requirements for the award of a Master of Science Degree in Food Security and Sustainable Agriculture Production. The results embodied in this thesis have not been submitted to any other University or Institute for an award of any degree or diploma.

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DEDICATION

This research project is a special dedication to my wife, Lydia Saga, my children; Tanyaradzwa, Phineas, Precious and Praise, and my brothers and sisters.

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ABSTRACT

This study aimed to conduct a comparative analysis of formal and informal seed systems in Guruve District, Mashonaland Central Province, Zimbabwe. The study involved 240 smallholder farmers, who were randomly selected, sampled, and interviewed using semi-structured questionnaires. This study used a descriptive survey design that combined both qualitative and quantitative research methods. Data analysis was conducted using primary and secondary data from smallholder farmers and other farming sector stakeholders. The results of the study showed that seed storage techniques on seed systems have an effect on crop yield. It was observed that 54% of the participants strongly agreed that seed quality selection affects crop yield, and a further 46% agreed with the observation. Seed quality and storage affect crop yield and sustainable agriculture. The results showed that 76% of the respondents strongly agreed and 24% agreed with the observation. Strengths and weaknesses of both seed systems exist. Methods to improve both seed systems are also available, and these can be tapped to reduce food insecurity and promote sustainable agriculture. The results concluded that smallholder farmers can continue using informal seed systems, since the system has low cost and ensures seed availability in farming communities through exchange processes. Furthermore, informal seed systems can be strengthened, and smallholder farmers in Zimbabwe can improve their access to quality seeds and enhance their productivity and livelihoods.

Keywords: informal seed system, food insecurity, formal seed system, seed storage techniques and sustainable agriculture.

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LIST OF ACRONYMS AND ABBREVIATIONS

FAO	Food and Agricultural Organization
IPES	International Panel of Experts on Sustainable Food Systems
SDG	Sustainable Development Goals
USA	United States of America
UK	United Kingdom
CIAT	International Center for Tropical Agriculture
NGO	Non-Governmental Organization
CSA	Community Supported Agriculture
AGRITEX	Agricultural and Rural Development Technical Services
APRODEV	Association of Protestant Development Organizations
IPCC	Intergovernmental Panel on Climate Change
SSE	Social and Solidarity Economy
ZIMSTATS	Zimbabwe Statistical Agency

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CHAPTER 1

INTRODUCTION

1.1 Introduction to Chapter One

Several interventions aimed at improving the seed security of smallholder farmers exist, and these do not always yield positive results. Government, donors, and other actors have neglected local seed systems because they are assumed incapable of addressing farmers' seed challenges. The first chapter of the research paper focuses on a comparative analysis of formal and informal seed systems. First, it provides background information pertaining to formal and informal seed systems, looking at both the advantages and disadvantages inherent in the seed systems in trying to tackle the issue of food insecurity as a result of the climate change monster. Further, the chapter focuses on the statement of the problem, objectives of the study, and questions of the study to be answered. The focus was on closing this research gap. The significance of the study to stakeholders, such as governments, donors, and other actors who have neglected local seed systems as they are assumed to be incapable of addressing farmers' seed challenges. Additionally, the chapter also examines the delimitation of the study area and the limitations of the study.

1.2 Background of the Study

Global population growth has led to ever-increasing demand for food and other agricultural products. Gebeyaw (2020) noted that world food production must increase by 50% by 2050 to meet the needs of nine billion people. Seeds are key agricultural products that are directly connected to food security. According to McGuire and Sperling (2023), food production and security are enhanced through improved agricultural production and reliable seed systems. Improved agricultural production and reliable seed systems result in Sustainable Development Goal (SDG) 2; "end hunger" to be slowly attained as food production, availability and utilization will be enhanced by improved crop production (IPES, 2022; Gill *et al.*, 2023). Comparing the contribution of formal and informal, also known as local seed systems, has revealed distinct differences in their contributions to household seed security and, hence, to food security globally. Although formal seed systems are critical in modern agricultural production to ensure that the

products of modern breeding programs reach farmers, they have not enjoyed the wide reach of other regions. The informal sector provides a lower cost and, at times, a more resilient means of distributing seeds to farmers, especially to areas impacted by climate change and subsequent crop failures (IPES, 2022; Gill *et al.*, 2023).

Research on formal and informal seed systems in developed countries such as the United States of America and the United Kingdom often focuses on the interplay between large, commercially driven seed companies (formal system) and smaller, community-based seed exchanges or farmer-saved seed practices (informal system), revealing how even in developed nations, informal seed networks play a crucial role in maintaining crop diversity and adapting to local conditions, particularly for niche markets or specific regions where commercial seeds may not be optimal. Formal seed systems in the USA and UK are regulated; they sell certified seeds that are hybrid and genetically modified. According to McGuire and Sperling (2022), the seed industry is dominated by large seed companies, such as Monsanto (now Bayer) and DuPont Pioneer. Informal seed systems were also present. They involve seed saving and exchange, seed libraries, and community-supported agriculture (CSA)-based programs. In these nations, formal seed systems dominate markets, but informal seed systems play a significant role in preserving crop diversity and promoting sustainable agriculture. The issues of crop diversity, local adaptation, access and affordability, community dynamics, and policy and regulatory frameworks often come at huge and high costs for smallholder farmers (McGuire and Sperling, 2022).

In Africa, the agricultural sector dominates rural livelihoods and economies. Smallholder farmers in Southern Africa rely substantially on agriculture, both as a source of food and livelihood (Gollin, 2024). The overwhelming majority of rural residents are smallholder farmers, which is also true for countries such as Malawi, Zambia, and Zimbabwe. Formal seed systems account for less than 20% of planted seeds in Africa and are regulated to ensure that the seeds retain their varietal identity and purity for optimal physical, physiological, and sanitary quality (Gollin, 2024). Informal seed systems dominate most African farming systems, and are farmer-produced seeds or grains that are selected for use in subsequent plantings and exchanged or sold to other farmers through local market systems that are not regulated or monitored by government agencies (McGuire and Sperling, 2022). Without access to alternative sources of food or income, smallholders are highly vulnerable to fluctuations in weather patterns, to changes in government

support, and to shifts in both local and international markets (Di Falco *et al.*, 2020; Joughin, 2020; Thijssen *et al.*, 2020; World Bank, 2020; Joughin, 2021; Alemu, 2022). These contextual variables are directly linked to food security at household and regional levels (Kristjanson *et al.*, 2022). Food insecurity continues to be a pervasive problem in sub-Saharan Africa, especially in smallholder-based food systems (Bangawyo-Skeete, 2022). Therefore, seed systems must be monitored closely to avoid food insecurity in nations.

The formal seed system in Zimbabwe includes a well-functioning seed industry with maize as the staple crop, the focus of breeding, and seed sector efforts. Maize is the main food crop obtained from the formal sector by smallholder farmers (CIAT *et al.*, 2021; Mazvimavi *et al.*, 2021). The local seed system supplies over 90% of the seed Zimbabwean farmers sow, especially sorghum, pearl millet, groundnuts, cowpeas, Bambara nuts, sugar beans, and sweet potatoes (CIAT *et al.*, 2019; Mujaju, 2021). The government, donors, and non-governmental organisations (NGOs) use a combination of seed interventions to assist farmers in recovering from climate-related and other emergencies (Brumel, 2020; Oxfam, 2020; Mujaju *et al.*, 2021). Such initiatives aim to support drought relief, address climate variability, and improve food security and nutrition. Questions remain regarding the extent to which they contribute to improving farmers' seed security, food security, and sustainable agriculture in the country. Seed security is defined as sufficient access to adequate quantities of high-quality seeds and planting materials of preferred crop varieties at all times (FAO, 2021a).

In Guruve, where this research was conducted, smallholder farmers participated in both formal and local seed systems to obtain the quantity and quality of seeds they need. Formal seed systems are typically used by farmers to access specific crop varieties, primarily to sell their produce to the market. In contrast, crop varieties from local seed systems are preferred by farmers for food preparation, culinary, taste, and cultural needs, in addition to selling produce. These are crucial factors that influence the decisions that farmers make regarding which seeds to source. Crop varieties sourced from local seed systems may also originate from different sources, including the formal seed system, because there are many linkages and interdependencies across these systems (Almekinders and Louwaars, 2022; Westengen *et al.*, 2023). Interventions aimed at improving smallholder farmers' seed security do not always yield positive results. Government, donors, and other actors have neglected local seed systems because they are assumed incapable of addressing

farmers' seed challenges (Almekinders and Louwaars, 2022; Westengen *et al.*, 2023). Instead, external actors use seed aid and formal seed-provisioning outlets, such as agro-input dealers, to channel seeds to farmers. This paper compares formal seed systems, mainly comprising certified seeds obtained from the private sector, government and non-governmental organisations and agro-input dealers, with local seed systems that include farm-saved seed, local informal markets, and social networks.

1.3 Statement of the Problem

Crop productivity is hampered by the inability of seed varieties to adapt to climate change. Agricultural productivity, food security, and rural livelihoods in Guruve District are largely dependent on formal and informal seed systems (Maseko *et al.*, 2022). Approximately 70–90% of African smallholder farmers depend on informal seed systems (AfricaSeed, 2021; Louwaars and De Boef, 2022). Seed companies are unable to supply small quantities of high-quality seeds to peripheral areas at affordable prices, which in turn results in difficulties for farmers to access, afford certified seeds, and hinders potential superior returns (Sperling and Almekinders, 2023). Informal seed systems are easily available and less expensive; however, they are not always of high quality, as seed recycling is evident and results in an approximately 32% yield loss (FAO, 2024). Informal seed systems are frequently subject to weevil attacks and erode the genetic composition of local varieties, and there are postharvest losses prior to poor storage in informal seed systems (Sperling and Almekinders, 2023). There is a significant gap in the understanding of formal and informal seed systems in terms of seed quality, storage techniques, and their impact on crop yields and sustainable agriculture in Guruve District. Low income, access to seeds, quality assurance, and adaptability to the ever-changing climate are major challenges in the area. Therefore, research on these two seed systems is necessary, as it creates sustainable seed policies and practices that empower Guruve's smallholder farmers to enhance their agricultural productivity with minimal losses, thus improving food security.

1.4 Objectives of the Study

1.4.1. Main objective

The main objective of this study is to analyze the formal and informal seed systems in Guruve District to ensure sustainable agriculture and food security.

1.4.2. Specific objectives

- i. To analyze seed quality selection practices in formal and informal seed systems in Guruve District.
- ii. To evaluate the effectiveness of storage techniques used in both systems in Guruve District.
- iii. To assess the impact of seed quality and storage on crop yields and sustainable agriculture in Guruve District.
- iv. To identify the strengths and weaknesses of formal and informal seed systems in Guruve District.
- v. To identify ways to improve the two seed systems in Guruve District.

1.5 Research Questions

- i. What criteria do farmers use to select seeds in formal seed systems compared to informal seed systems in Guruve District?
- ii. How do storage conditions affect seed viability in both formal and informal seed systems in Guruve District?
- iii. What relationship exists between seed quality, storage methods and long term agricultural productivity?
- iv. What are the strengths and weaknesses of both seed systems in Guruve District?
- v. What ways are used to improve the two seed systems in Guruve District?

1.6 Justification/Significance of Study

High-quality and diverse seeds adapted to the local environment are necessary for sustainable agriculture. To identify the advantages and disadvantages of each setup, it is crucial to analyze

formal and informal seed systems. Farmers, legislators, seed houses such as SeedCo, Valley Seeds, Klein Karoo Seed Marketing, Pioneer Seed, and others, the Government through the Ministry of Agriculture, and any other relevant stakeholders will receive information from the results of adaptation methods pertaining to seed selection, quality, and storage. To create a more resilient and equitable agricultural economy, this research will offer insightful information about the advantages and disadvantages of Zimbabwe's formal and informal seed systems' associated quality, storage techniques, and the advantages and disadvantages of each system. This information will assist policymakers in making decisions. Smallholder farmers will be made aware of the advantages and disadvantages of the many seed sources that are accessible, and the Ministry of Lands, Agriculture, Water, Fisheries and Rural development (MLAWFRD) may use this information to enhance the aid of the quality seed system for smallholder farmers. Furthermore, the information obtained from this study will be used by other researchers in future studies.

1.7 Scope/Delimitations and Limitations of the Study

1.7.1 Limitation of the study

The findings of this study may be limited in terms of generalizability to other geographical locations or populations outside Guruve District. The specific contents of Guruve's geology and seed systems may restrict the applicability of the study's findings to other settings. Furthermore, the results may have been influenced by the sample size and representativeness of the farmers included in the study. Due to practical constraints, it may not be feasible to include a large and diverse sample, potentially limiting the generalizability of the findings to the broader population of farmers in the Guruve District. The study's reliance on self-reported data from farmers may introduce biases, such as recall bias or social desirability bias. Local farmers may either underreport or overreport certain aspects of their experiences, leading to potential inaccuracies in the data. The findings of this study may be constrained by the non-availability of secondary data and the quality of data related to formal and informal seed systems, the associated quality, storage, advantages and disadvantages of each system, and food security. Additionally, the study's analysis and conclusions may be limited by gaps or inconsistencies in data sources.

1.7.2 Delimitation of the study

It would be more comprehensive if more districts in Zimbabwe were included in this study. However, in the spirit of making this study manageable and thereby investigating the problem deeper, the scope of this study was confined to Guruve District smallholder farmers only. This study primarily examined the difference between formal and informal seed systems and the relationship of both systems with sustainable agriculture in the district. This study utilized both qualitative and quantitative methods to gather data and analyze the research questions. The study was conducted over a space of six months, from October 2024 to March 2025.

1.8 Outline of the Thesis

This paper is organized into five chapters. The first chapter presents the background information of the study, research statement, justification of the study, main and specific objectives, and research questions to be addressed. A detailed literature review on the comparison of formal and informal seed systems is presented in Chapter Two. Chapter 3 describes the methodology used and includes research design, data collection, and data analysis. The results and graphical data presentation and analysis are presented in chapter four. The results covered all the specific objectives of the research, with a total of five. The last chapter of the research paper, Chapter Five, summarizes, concludes, and provides recommendations for the research study. Appendices then close the manuscript.

1.9 Chapter Summary

Chapter one, Introduction, gives a brief background to the comparative analysis of formal and informal seed systems. This chapter also explores the problem in the study. The chapter also uncovered the objectives and questions of the study to be answered. The significance of this study to the seed systems for stakeholders was also highlighted. These included, but were not limited to, farmers, extension staff, government, donors, and seed houses. The limitations of this study were also revisited. Chapter two that follows, focuses on a literature review of the comparative analysis of formal and informal seed systems to stakeholders in the industry.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter reviews the relevant literature. This chapter reviews and assesses the formal and informal seed systems and the effect of these two systems on output. Additionally, the relationship between seed systems and food security, as well as sustainable agriculture for smallholder farmers, was scrutinized. This chapter covers the following sub-topics: the definition of a seed, discussion of the two seed systems, food security, sustainable agriculture, seed policy in Zimbabwe, participatory variety seed selection, capacitation of local communities, and imagined superiority of the formal seed system. Further, this chapter reviews the literature on these objectives. Here, the contributions and contradictions from various literature sources pertaining to formal and informal seed systems will be discussed.

2.2 Seed Defined

The seed is a complex biological structure consisting of a plant in miniature and food reserves protected by covering coats (Gebeyaw, 2020). It is a miniature plant with a remarkable capacity to ensure that the new individual starts life in the right place at the right time (Gebeyaw, 2020). Gebeyaw (2020), postulated that a seed is a basic and crucial input for crop production. A broad definition of seed is that all organs obtained from a plant are capable of creating a new individual that includes both seeds produced from fertilization and asexual planting materials. According to Africa Seeds (2024), seed is a good business tool, and this is supported by the African seed market, which is estimated to increase from US\$ 3.15 billion in 2025 to US\$ 3.99 billion in 2030. This is a compounded annual growth rate of 4.84% (Africa Seeds (2024)). Seeds play an important role in increasing agricultural productivity, as they determine the upper limit of crop yields and the productivity of all other agricultural inputs to the farming system (Munyiri, 2020; Louwaars and de Boef, 2022). Seeds are the basis of agriculture (Munyiri, 2020; Louwaars and de Boef, 2022). When humans stopped being nomads and sedentarized, they began to select seeds. However, in practice, the use of seeds was a means of producing clothes, building, and creating culture and

communities. Seeds contain genetic characteristics that are expressed in subsequent generations of plants. Seeds are one of the most crucial elements in the livelihoods of agricultural communities. It is a repository of the genetic potential of crop species and their varieties, resulting from continuous improvement and selection over time. The potential benefits of seed-to-crop productivity and food security are enormous. In addition, production increases brought about by the use of adapted varieties increase farmers' income when market linkages exist. Food security is heavily dependent on the seed security of farming communities.

2.3 Seed System

Seed systems refer to the different ways farmers access seeds and the actors involved in breeding, seed production, quality control, marketing, and dissemination (Torres *et al.*, 2021; Ndinya *et al.*, 2022). Seed systems are crucial for agriculture, food security, and the livelihoods of many people (FAO 2024). A sustainable seed system will ensure that high-quality seeds of a wide range of varieties and crops are produced, fully available in time, and affordable to farmers and other stakeholders. However, in many developing countries, farmers have not yet been able to fully benefit from the advantages of using quality seeds due to a combination of factors, including inefficient seed production, distribution, and quality assurance systems, as well as bottlenecks caused by a lack of a good seed policy on key issues such as access to credit for inputs. Furthermore, pressure from fluctuating food prices and climate change creates additional challenges. According to Torres *et al.* (2021) and Ndinya *et al.* (2022), there are two types of seed system: formal and informal.

2.3.1 Formal seed system

Formal seed systems are owned by the public or private sector and comply with national seed standards of seed certification (Sperling and Almekinders, 2023). They are the regulated official seed production; thus, all formal institutions, public companies, and private companies are involved in breeding, varietal registration, seed multiplication, quality control, and seed dissemination (Biemond *et al.*, 2023). According to Abebe and Alemu (2021), formal seed systems enhance industrial agriculture, as they are characterized by certified improved seed quality. This results in improved crop production, thus improving food availability and utilization pillars (Traore

et al., 2021; Abebe and Alemu, 2022). Formal seed systems are known for seeds of high quality produced following effective scientific knowledge and using technical tools thus enhancing seed uniformity characteristics (FAO, 2019). Formal seed systems allow for improved seed adaptation to local climates and environments, improved or increased yields as seeds are not accessed from the past season, and new varieties and ensured availability of seeds in all seasons (Sperling *et al.*, 2022). Formal seed systems also increase farmers' trust in genetic purity, physical and physiological quality, quality assurance, and provide technical support (Sperling and Almekinders, 2023). However, formal seed systems are expensive, there are limited selection of crops, and they may offer varieties that are not tolerant to local conditions, especially in the face of climate change (McGuire and Sperling, 2023). Additionally, they rely on external inputs and may face resistance as farmers may not easily accept new seeds. In Africa, 10–20% of seeds are obtained from formal seed systems (McGuire and Sperling, 2021; Wekundah, 2022). What is the Zimbabwean contribution of the Formal Seed system????

2.3.2 Informal seed system

An informal seed system refers to an arrangement in which farmers are directly involved in the selection, production, and dissemination of seeds, and exchanges and sales occur in the local community or setup (Sperling *et al.*, 2022). Informal seed systems are important as they have the ability to withstand the dynamic environment and, in turn, improve the food security status and livelihoods of smallholder farmers (McGuire and Sperling, 2021). Informal seed systems are characterized by low seed quality control and varying maintenance processes, which reduce food and nutritional security (Kusena *et al.*, 2021; Gaffney *et al.*, 2022). Informal seed systems enhance smallholder farming or agriculture, especially in developing countries such as Nigeria, as they make up; 70-90% of the seeds used by farmers (FAO, 2020; FAO, 2024). In Zimbabwe, 70–90% of seeds such as cowpea, groundnuts, finger millet and sorghum, are obtained from informal seed, where the seed is recycled or saved and taken from previous seasons, traded or exchanged with friends, relatives, and neighbors, or purchased in local markets (McGuire and Sperling, 2021). Informal seed systems help enhance the social networks of farmers with possible seed variety suppliers that are adaptive to the local climate, easily accessible, affordable, meet cultural needs, and are diverse, thus improving dietary diversity and food security at large (APRODEV, 2020; Sperling *et al.*, 2022). Informal seed systems are cost effective; for instance, 2 kg of maize seeds

may produce 180 kg of food (Sperling *et al.*, 2022). However, there is limited quality assurance, as no scientific tools are used to determine genetic purity, the seeds are prone to weevil attack due to long-term storage, and the availability of seeds throughout the year is limited (Sperling and Almekinders, 2023). Furthermore, there are diverse foods and dietary diversity in communities with informal seed systems (Gill *et al.*, 2023).

Informal seed systems, seed banks, and Information Knowledge Systems (IKS) are interconnected components that play critical roles in maintaining crop diversity, ensuring food security, and promoting sustainable agricultural practices (Sperling and Almekinders, 2023). Informal seed systems promote crop diversity, support food security, and foster community engagement (Sperling and Almekinders, 2023). Seed banks are repositories that collect, conserve, and distribute seeds in order to preserve crop diversity. Seed banks conserve crop diversity, provide access to seeds, and support climate change adaptation (APRODEV, 2020; Sperling *et al.*, 2022). Information Knowledge Systems (IKS) enhance seed management, support farmers' decision-making, and facilitate collaboration. The relationships among informal seed systems, seed banks, and IKS include seed exchange and conservation, information sharing, and capacity building. By understanding the interconnections between informal seed systems, seed banks, and IKS, there is better support for sustainable agriculture practices, the promotion of crop diversity, and ensuring food security.

2.4 Food Security

Based on the [1996 World Food Summit](#), food security is defined when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. According to McGuire and Sperling (2022), it exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and preferences for an active and healthy life. The four main dimensions of food security are the physical *availability* of food, economic and physical *access* to food, food *utilization* and *stability* of the other three dimensions over time. Seed systems play a vital role in ensuring food security, especially in developing countries. A well-functioning seed system provides farmers with access to high-quality seeds, which can improve crop yields, increase food availability, and enhance dietary diversity (FAO 2024). Key components

of seed systems for food security include the availability of diverse crop and varietal options, access to quality seeds, and seed security. Seed security refers to the availability of seeds in sufficient quantities, quality, and diversity to meet the needs of farmers (FAO 2024). Seed systems affect food security. They ensure improved crop productivity, which provides access to high-quality seeds, can improve crop yields, increase food availability, and reduce the risk of food insecurity. Additionally, they enhance dietary diversity and increase resilience to climate change. Seed systems that provide access to climate-resilient crop varieties can help farmers adapt to climate change and reduce the risk of crop failure and food insecurity (FAO 2024).

2.5 Sustainable Agriculture

Sustainable agriculture refers to farming practices that prioritize environmental stewardship, social responsibility, and economic viability (National Research Council, 2024). It also refers to the growth of crops and/or rearing of animals, and focuses on enhancing productivity while minimizing negative environmental impacts (National Research Council, 2024). Sustainable agriculture involves practices such as conservation agriculture, agroforestry, organic farming, and crop diversification, which promote the efficient use of natural resources, soil health, water conservation, reduced food waste, reduced chemical use, economic viability, and biodiversity conservation to meet agricultural needs without compromising future generations (Ayalew, 2022; Shelar et al., 2023). The core principles of sustainable agriculture include environmental conservation and protection, social equity and justice, economic viability and profitability, the use of renewable resources, and waste minimization.

Seed systems play crucial roles in promoting sustainable agricultural practices. A well-functioning seed system can provide farmers with access to high-quality seeds that are adapted to their local conditions, resilient to climate change, and suitable for sustainable agricultural practices (FAO, 2024). Seed systems conserve and promote agrobiodiversity, which can help maintain ecosystem services, reduce dependence on external inputs, and promote sustainable agriculture practices (IPES-Food, 2023). The use of climate-resilient crop varieties is of paramount importance in sustainable agriculture. Seed systems that provide access to climate-resilient crop varieties can help farmers adapt to climate change, reduce crop failures, and promote sustainable agricultural practices (CGIAR, 2022). Seed systems can also support organic and conservation agriculture.

According to IFOAM (2022), seed systems that support organic and conservation agricultural practices can help reduce the use of external inputs, promote soil health, and conserve water resources. Seed systems affect sustainable agriculture. Access to high-quality seeds can improve crop productivity, reduce yield gaps, and promote sustainable agricultural practices (FAO 2024). They also enhance and promote ecosystem services. Seed systems that conserve and promote agrobiodiversity can help maintain ecosystem services such as pollination, pest control, and soil health (IPES-Food, 2023). Moreover, seed systems increase resilience to climate change. Seed systems that provide access to climate-resilient crop varieties can help farmers adapt to climate change, reduce crop failures, and promote sustainable agricultural practices (CGIAR, 2022).

2.6 Seed Policy in Zimbabwe

In Zimbabwe, the seed policy was captured under CHAPTER 19:13 of the SEEDS ACT, which was enacted in 1971 with amendments up to Act No. 11 of 2001. The Act provides for the registration of sellers of seed and seed testing laboratories to regulate the importation, exportation, and sale of seeds; to provide for the testing, certification, and inspection of seeds; and to provide for other matters connected with the foregoing. Further, the "Seeds Act" governs seed production, sale, and importation, requiring all seeds to be certified and tested in a registered laboratory before being sold, with the primary goal of promoting high-quality seed usage by farmers and ensuring quality control through regulations on labeling and marketing; essentially, it is illegal to sell non-certified seeds except under specific circumstances.

2.6.1 Key aspects of the Zimbabwean seed policy:

Compulsory certification:

All seeds sold commercially must be certified, meaning that they undergo testing to meet quality standards for purity, germination, and variety identity.

Seed testing laboratories:

Only registered laboratories can perform seed testing, ensuring accurate analysis of seed quality. Seed Services as the Certifying Authority have an ISTA certified laboratory while Certifying Agents (Seed-Companies) have their laboratories that are certified by the Certifying Authority.

Variety registration and Certification:

New seed varieties must be registered with the government before they can be marketed. Seed Services as the Seed Certifying Authority oversees the process of variety registration and certification. The Certifying Authority in collaboration with the Certifying Agent (Seed companies) have a mandate to police the production of all certified seed in the country.

Import and Export Regulations:

Strict controls are in place for importing seeds, requiring compliance with prescribed requirements and documentation. Plant Quarantine Services polices the importation and exportation of agricultural products, including seed.

Ministerial authority:

The Minister of Lands, Agriculture, Water, Fisheries and Rural Development (MLAWFRD) has the power to set specific regulations and exemptions regarding seed production and sale.

Enforcement:

The MLAWFRD is responsible for enforcing the Seeds Act, which includes inspections and penalties for non-compliance.

2.6.2 Criticisms and challenges:

2.6.2.1 Access to certified seed

Access to certified seeds is crucial in the face of climate change and for sustainable agriculture. Certified seeds can provide farmers with climate-resilient crop varieties and improve yield and food security. However, the availability and accessibility of these seeds vary significantly across regions and countries. Despite regulations, some small-scale farmers may struggle to access certified seeds because of cost or distribution issues. In addition, access to these devices is limited. Many smallholder farmers in developing countries lack access to certified seeds and rely instead on informal seed systems (Front. Sustain. Food Syst., 2021). The quality of certified seeds can be inconsistent, which affects their performance and adoption by farmers. The development and dissemination of climate-smart crop varieties are critical for adapting to climate change. To

address these challenges, it is essential to adopt a comprehensive approach involving governments, private sector companies, and civil society organizations. This includes investing in seed R&D, strengthening seed regulatory frameworks, and promoting agroecological practices.

2.6.2.2 Informal seed market

Informal seed markets play a crucial role in connecting climate change, sustainable agriculture, and food security. For instance, in Sub-Saharan Africa, most smallholder farmers rely on informal seed systems that involve saving, sharing, and exchanging seeds with fellow farmers (Front Sustain Food System, 2021). A significant portion of the seed circulation occurs through informal channels, potentially compromising quality. Informal seed markets also face challenges, such as limited access to improved varieties and quality control issues. To address these challenges, some experts recommend a more inclusive approach to seed system development that recognizes the importance of both formal and informal seed systems. This approach involves supporting farmer-led seed initiatives, promoting crop diversity, and fostering collaboration between formal and informal seed systems.

2.6.2.3 Colonial legacy

Colonial legacy seed systems continue to influence how seeds are produced, distributed, and accessed in many African countries. These systems were established during the colonial era, with the primary goal of extracting resources and promoting European agricultural interests (African Centre for Biodiversity, 2022). Some argue that the current seed legislation in Zimbabwe is outdated and does not adequately address the needs of modern, small-scale farmers. The key features of colonial legacy seed systems depend on external inputs. Colonial legacy seed systems often rely on external inputs such as fertilizers and pesticides, which can be expensive and environmentally unsustainable. These colonial legacy seed systems impact climate change and sustainable agriculture because of their vulnerability to climate change and loss of crop diversity. Furthermore, reliance on external inputs such as fertilizers and pesticides has led to a dependence on non-renewable resources, which can contribute to greenhouse gas emissions and environmental degradation. To transform colonial legacy, there is a need to promote agroecology, revitalize local crop varieties, and support farmer-led seed systems. Farmer-led seed systems can provide an

alternative to centralized seed systems, allowing farmers to control their own seed production and distribution.

2.7 Participatory Variety Selection

Participatory variety selection (PVS) is a broad term that refers to approaches in plant breeding that engage several actors (including scientists, breeders, farmers, and other stakeholders). Participatory varietal selection has been proposed as a method for identifying acceptable novel varieties and eliminating the constraints that force farmers to grow landraces or obsolete cultivars. Farmers' participation improves variety selection in their own production situations, guaranteeing that improved varieties are accepted and eventually adopted. According to Ashby (2023), participatory varietal selection causes more farmers to adopt improved crop varieties over larger areas, resulting in increased food and income benefits. Farmers are routinely involved in selecting improved crop varieties to prefer desirable traits to boost the adoption rate of superior and stable varieties through participatory variety selection. Farmers are invited to participate in the selection of the best-performing varieties based on the primary criteria of their desirable traits in participatory variety selection. Farmers' engagement in participatory variety selection has a number of benefits, including defining breeding goals and priorities, selecting the best varieties on their farms for further improvement, designing and planning subsequent activities through discussions with scientists, suggesting methodological changes, and multiplying the seed of preferred improved varieties.

2.7.1 Participatory variety selection in formal seed systems

In formal seed systems, PVS involves farmers in the selection process, ensuring that the selected varieties meet their needs and preferences (Witcombe et al., 2023). Decentralized selection approaches have been used in formal seed systems. Decentralized selection approaches such as mother-baby trials allow farmers to select varieties under local conditions (Snapp et al., 2003). According to Kiptot et al. (2023), multi-stakeholder platforms should bring together farmers, researchers, and other stakeholders to select and disseminate improved varieties. This initiative makes the variety selection process easy and involved.

2.7.2 Participatory variety selection in informal seed systems

Community-based selection processes are used in informal seed systems. Community-based selection approaches enable local communities to select and conserve their preferred crop varieties (Sthapit et al., 2023). They also used a farmer-led selection. According to Weltzien et al. (2023), farmer-led selection initiatives allow farmers to take ownership of the selection process and to select varieties that meet their specific needs. Smallholder farmers are also engaged in seed fairs and exchanges. These events occur annually. Seed fairs and exchange events provide a platform for farmers to share and select diverse crop varieties (Jarvis et al., 2021).

2.8 Capacitation of Local Communities

Capacitation of local communities is essential for improving seed systems, promoting crop diversity, preserving genetic diversity, and enhancing community empowerment. While there are challenges and limitations to capacitation, its benefits make it a critical strategy for sustainable agricultural development and promotion of food security in smallholder farming communities.

2.8.1 Capacitation in formal seed systems

Training and extension services are of paramount importance for achieving capacitation. Facilitation of local communities in formal seed systems often involves training and extension services, which enhance farmers' knowledge and skills in seed production, processing, and marketing (Tripp, 2021). The use of demonstrations and farmers' field schools was also helpful. According to Weltzien et al. (2003), farmer field schools are an effective approach to capacitating local communities by providing hands-on training and experience in seed production and management. Furthermore, the use of community-based seed production had positive effects. Community-based seed production initiatives enable local communities to produce and manage their own seeds and improve their availability and quality (Sthapit et al., 2023).

2.8.2 Capacitation in informal seed systems

In informal seed systems, it is paramount to make use of community-led seed initiatives to bolster capacitation. Community-led seed initiatives enable local communities to conserve, produce, and

exchange seeds, promoting crop diversity and resilience (Jarvis et al., 2021). Smallholder farmers also engage in seed exchange programs. They benefit significantly from these programs. Seed exchange programs enable local communities to share and exchange seeds, thereby promoting social cohesion and cooperation (Kiptot et al., 2023). Farmers engage in what are termed farmer-led seed selection. Farmer-led seed selection initiatives enable local communities to select and conserve their preferred crop varieties and improve crop diversity and resilience (Weltzien et al., 2023).

2.9 Imagined Superiority of Formal Seed Systems

The perceived superiority of formal seed systems is challenged by the limitations and challenges associated with them. Informal seed systems, on the other hand, offer valuable benefits, including crop diversity, accessibility, and low costs. A more nuanced understanding of the strengths and weaknesses of both formal and informal seed systems is necessary to ensure that farmers have access to high-quality seeds and improved crop variety.

The perceived superiority of formal seed systems is based primarily on quality control. According to Tripp (2021), formal seed systems are often perceived as superior because of their strict quality control measures and supply of high-quality seeds. Formal seed systems provide access to improved crop varieties, which are often considered superior to traditional or local varieties (Byerlee and Eicher, 2021). They appeared to have a sound regulatory framework. Formal seed systems operate within regulatory frameworks that are perceived to ensure seed quality and safety (FAO, 2024). Challenges related to Perceived Superiority also exist. These include limited accessibility, high costs, and limited crop diversity (Louwaars, 2020; Jarvis et al., 2021; Tripp, 2021).

2.10 Conceptual or Theoretical Framework

Conceptual and theoretical frameworks provide the foundation for understanding the complexities of formal and informal seed systems. By examining these frameworks, researchers and practitioners can design and implement seed systems that meet the needs of smallholder farmers and promote sustainable agricultural development.



Figure 2.1: The conceptual framework of the seed systems

2.11 Seed Quality Selection Practices in Formal and Informal Seed Systems

Seed quality is of paramount importance, as it determines yield and output (Filho, 2024). Yield or output production is greatly determined by seed quality, postharvest handling, and storage (Sperling and Almekinders, 2023). High quality seeds lead to increased yields, and poor quality seeds alter expected output and farmers' income, which overly impacts food security (Kusena et al., 2023). Seed quality is determined or explained by genetics, analytical purity, and pathological and physiological parameters (ISTA, 2022). Genetic quality occurs when the seed lot is true to the type. Analytical purity is defined as the uniformity of a seed lot in terms of seed size, it is free from physical damage, and foreign substances or materials are absent. The quality of a seed lot is high and favorable when the purity of the seed is greater than 98% (ISTA, 2022). Physiological quality is the intrinsic trait of seeds that determines their capacity to germinate, emerge rapidly, and give a resultant uniform output (Filho, 2023). Pathological quality is seed health, that is, bacteria, viruses, fungi, and insects, in either the presence or absence of a disease (ISAT, 2022). The competitiveness of seed systems is influenced by seed quality, which in turn improves availability, accessibility, and utilization of food, and the profits of farmers are increased (Dimitriu and Brezuleanu, 2022).

2.11.1 Seed quality selection practices in formal systems

Seed quality selection practices in formal seed systems involve several key steps to ensure that high-quality seeds are produced and distributed. Seed Quality Evaluation (SQE) is a critical process for assessing seed germination, physical purity, seed health, and varietal purity. Seed certification programs play a vital role in ensuring seed quality. These programs involve certifying seeds that meet specific standards and labeling them accordingly. This helps farmers to make informed decisions when purchasing seeds. Seed Production Standards (SPSs) are essential for formal seed systems. These standards outline the requirements for seed production, including field inspection, seed harvesting, and seed processing. Adhering to these standards helps maintain seed quality throughout the production process. In addition, seed storage and handling procedures are crucial for maintaining seed quality. Formal seed systems have specialized storage facilities that maintain optimal conditions for seed storage, and seeds are handled according to the best practices to prevent damage. Research has shown that formal seed systems can provide high-quality seeds,

but they may not always be accessible or affordable to smallholder farmers. Therefore, it is essential to explore methods to make formal seed systems more inclusive and sustainable. Overall, seed quality selection practices in formal seed systems involve a combination of evaluation, certification, production standards, and appropriate storage and handling procedures. By following these practices, formal seed systems can provide high-quality seeds that meet farmers' needs.

2.11.2 Seed quality selection practices in informal systems

Seed quality selection practices in informal seed systems are crucial for maintaining crop yields, improving food security, and enhancing smallholder farmers' livelihoods. Informal seed systems, prevalent in many developing countries, rely on traditional practices and social networks to select, produce, and disseminate seeds. Smallholder farmers use traditional seed selection practices. They use visual selection, where seeds are selected based on visual characteristics such as color, shape, and size. Smallholder farmers also performed germination tests. Using this method, farmers conducted simple germination tests to assess seed viability. Furthermore, they use tastes and smells. Farmers use their senses to evaluate seed quality, including taste and odor. The seed source is another method of seed selection in an informal seed system. Smallholder farmers often select seeds from trusted sources such as family members, neighbors, or local markets. They also use social networks and seed exchanges. Smallholder farmers engage in seed sharing. Farmers share seeds, often within social networks and communities. Further, they do deed exchange. Smallholder farmers exchange seeds for other seeds, goods, or services. They are also involved in fairs. Community-organized seed fairs provide a platform for farmers to exchange seeds and share knowledge. Recycling in informal seed systems has resulted in a 32% loss of seed quality and output (FAO, 2023).

2.12 Seed Storage Techniques Used in Both Systems

The effectiveness of seed storage techniques in both formal and informal seed systems is crucial for maintaining seed quality and viability. Seed storage is an important and common method for the conservation of plant genetic resources (Gebeyaw, 2022). In many countries, inadequate seed quality and poor storage affect grain production and utilization (Tripathi et al., 2024). Seed storage conditions, packaging, type, and storage duration determine the seed (Marahatta, 2021). Improved storage structures reduce seed loss (Marahatta, 2021). Postharvest storage loss is increasing and

differs according to crop type and area (Sperling and Almekinders, 2023). Storage conditions, such as seed moisture and storage structures, such as old sacks and airtight drums, increase seed loss and viability (Bhandari et al., 2022). The African Postharvest Loss Information system indicated losses in 2021, which varied from 2.2% to 18% for oats and maize crops (APHLIS, 2021). Seeds should be stored in dry and low-humidity conditions to prevent mold growth and maintain viability (Islam et al., 2023). Storing seeds that are refrigerated (below freezing but above room temperature) increases the seed life span as metabolism is slowed and spoilage is reduced (Reddy et al., 2021; Islam et al., 2023). However, storing seeds at low temperatures may result in ice formation, which alters or damages cell structure and reduces seed viability (Islam et al., 2023). Hermetically sealed bags maintain the quality of stored seeds for many crops in Africa, as asserted by Afzal et al. (2023). Coating of seeds before storage improves quality and reduces the risk of vigor loss, thus preserving seed potential for the next season (Mallick et al., 2022; Krishnaarivanandan et al., 2024). The choice of storage container material determines seed quality, as others release toxic chemicals and provide poor moisture control (Ogunwale et al., 2023). Studies by Haque et al. (2023) and Mollah et al. (2023) showed that airtight containers maintain seed viability during the storage of jute seeds. Overall, although formal seed systems have well-established seed storage protocols, informal seed systems require innovative solutions to improve seed storage and maintain seed quality.

2.12.1 Seed storage techniques used in formal systems

In formal seed systems, seeds are stored in specialized facilities under controlled temperature, humidity, and light conditions. This ensured that the seeds remained viable for longer periods of time. Storage facilities include seed vaults, cold storage, and warehouse storage. Formal seed systems use seed vaults to store seeds at optimal temperatures and humidity levels to ensure long-term seed viability (Fowler and Hodgkin, 2024). Cold storage is used to store seeds at low temperatures, slowing down seed deterioration and maintaining seed quality (Justice and Bass, 2022). Warehouse storage facilities are used for short-term storage, providing a dry and secure environment for seeds (SSE, 2023). There are conditions for facilities to work perfectly.

Formal seed systems maintain optimal temperature conditions (usually between 4°C and 10°C) to slow seed deterioration (Ellis and Roberts, 2024). Humidity is of paramount importance. Seeds are stored in airtight containers or bags to maintain low humidity levels (usually below 50%) and to

prevent moisture-related seed damage (Justice and Bass, 2022). Furthermore, formal seed-storage facilities should be able to control pests. Formal seed systems implement integrated pest management strategies to prevent pest infestations and to maintain seed quality (SSE, 2023). Seed packaging and handling are of paramount importance. Seeds are packaged in airtight containers or bags to maintain optimal storage conditions and prevent moisture ingress (Ellis and Roberts, 2022). The seeds were then cleaned and dried. According to Justice and Bass (2024), seeds are cleaned and dried to remove impurities and reduce the moisture content, ensuring optimal storage conditions. Handling and transportation were equally important. Seeds are handled and transported carefully to prevent physical damage and to maintain seed quality (SSE, 2023). Additionally, there is a need to monitor and maintain the seeds. Formal seed systems conduct regular seed viability testing to ensure seed quality and detect seed deterioration (Fowler and Hodgkin, 2024). Storage facilities are regularly inspected and maintained to ensure optimal storage conditions and prevent equipment failure (Justice and Bass, 2023). Formal seed systems maintain accurate records of seed storage, handling, and testing to ensure seed quality and traceability (SSE 2023).

2.12.2 Seed storage techniques used in informal seed systems

In contrast, informal seed systems commonly used by smallholder farmers often rely on traditional storage methods to maintain seed quality and viability. These methods are common in many developing countries. These methods include storing the seeds in clay pots, baskets, or cloth bags, often in uncontrolled environments. Underground and attic storage are also practiced in informal seed systems. Seeds are stored in clay pots, often with a layer of ash or sand, to absorb moisture. Additionally, seeds are stored in baskets, which are sometimes lined with leaves or cloth to protect against pests and moisture. Some smallholder farmers use cloth bags that are often hung from the ceiling or stored in dry places. Dry gourds, which provide a natural airtight container, are used to store seeds. Although these methods are low-cost and accessible, they can lead to reduced seed viability and quality due to exposure to moisture, pests, and diseases. Farmers use local materials, such as bananas or plantain leaves, to wrap seeds or line storage containers. They may also use grasses such as papyrus or thatch to construct storage containers or wrap seeds. Furthermore, mud is used to construct storage containers or seal clay pots. These storage techniques have challenges

and limitations in terms of moisture, pests, temperature fluctuations, and access to improved storage technologies.

2.13 The Impact of Seed Quality and Storage on Crop Yields and Sustainable Agriculture

Seed quality and storage techniques play a crucial role in determining crop yield. High quality seeds with high viability rates result in better germination and emergence, leading to improved crop yields (Copeland and McDonald, 2021). According to Smith et al. (2024), seeds with high purity reduce the risk of weed competition and disease transmission, resulting in improved crop yields. Matthews et al. (2024) contended that seeds with high vigor indices exhibited better germination and growth rates, leading to improved crop yields. Proper moisture control during storage is critical for maintaining seed quality and viability, which in turn affects crop yield. Storage temperature significantly affects seed viability and quality. Optimal storage temperatures vary among crop species but generally range from 4°C to 10°C (Justice and Bass, 2023). Therefore, there is a need for pest and disease management strategies. Effective pest and disease management during storage is essential to prevent seed damage and maintain quality, which ultimately affects crop yield (Maude, 2022). The impact of seed quality on crop yield can be influenced by storage techniques. For example, high-quality seeds stored under optimal conditions may exhibit improved crop yields compared with low-quality seeds stored under suboptimal conditions (Ellis et al., 2023). It should also be noted that different crop species might respond differently to seed quality and storage techniques. For instance, some crop species may be more sensitive to seed quality or storage conditions than others (Bishaw and van Gastel, 2022). As observed in the above literature, seed quality and storage techniques have a significant impact on crop yields. High-quality seeds stored under optimal conditions can result in improved crop yields, whereas low-quality seeds stored under suboptimal conditions can result in reduced crop yields. Understanding the interactive effects of seed quality and storage techniques on crop yields can help farmers and agricultural practitioners optimize seed management practices to improve crop productivity.

2.14 The Strengths and Weaknesses of Formal and Informal Seed System

Formal and informal seed systems have differing strengths and weaknesses. Formal seed systems offer high-quality seeds, access to improved varieties, and a regulatory framework but can be expensive and inaccessible to smallholder farmers. Informal seed systems are often more accessible, low-cost, and community-based, but may have variable seed quality, limited access to improved varieties, and a lack of a regulatory framework. A balanced approach that combines the strengths of both formal and informal seed systems can ensure that smallholder farmers have access to high-quality seeds and improved crop varieties.

2.14.1 The strengths and weaknesses of formal seed system

2.14.1.1 The strengths of formal seed systems

Formal seed systems have strict quality control measures to ensure that high-quality seeds are produced and distributed (Tripp, 2021). This system offers access to improved varieties of seeds. Formal seed systems provide access to improved crop varieties, which can lead to increased yields and improved disease resistance (Byerlee and Eicher, 2021). Additionally, a regulatory framework is available for the system. According to FAO (2024), formal seed systems operate within a regulatory framework that ensures compliance with standards and regulations (FAO, 2024). Formal seed systems have marketing and distribution channels. Formal seed systems have established marketing and distribution channels, making seeds more accessible to farmers (Louwaars, 2023). However, formal seed systems also have weaknesses.

2.14.1.2 The weaknesses of formal seed systems

The first is that there are high costs inherent to the formal seed system. Trip (2021) contends that formal seed systems can be expensive, rendering high-quality seeds inaccessible to smallholder farmers. Limited accessibility is a deterrent to the system. Formal seed systems may not be accessible to remote or marginalized communities (Byerlee and Eicher, 2021). There is also the issue of dependence on external inputs. This is supported by the FAO (2024), who contends that formal seed systems often rely on external inputs, such as fertilizers and pesticides, which can be unsustainable. The issue of limited crop diversity adds to the drawbacks of seed systems.

According to Louwaars (2023), formal seed systems may focus on a limited number of crop varieties, which can lead to loss of crop diversity.

2.14.2 The strengths and weaknesses of informal seed system

2.14.2.1 The strengths of informal seed systems

Seeds are highly accessible to informal seed systems. According to Tripp (2021), informal seed systems are often more accessible to smallholder farmers, particularly in remote or marginalized communities. Smallholder farmers can share and exchange information. Furthermore, there is a low cost inherent to seeds. Informal seed systems can be less expensive because seeds are often exchanged or shared within communities (Byerlee and Eicher, 2023). This results in an increase in crop diversity. According to Louwaars (2007), informal seed systems often promote crop diversity as farmers may grow and exchange a wide range of crop varieties. This boosts smallholder farmers' productivity. Because seeds are sourced from the hood, the seed system can be termed community-based. Informal seed systems are often community-based and can foster social cohesion and cooperation (FAO 2024). However, their strengths can go without weaknesses.

2.14.2.2 The weaknesses of informal seed systems

Variable seed quality exists in the informal seed system as seeds may come from different sources. According to Tripp (2021), informal seed systems may not have strict quality control measures, resulting in variable seed quality. Additionally, there is limited access to improved varieties, as smallholder farmers may rely on yesteryear seeds from their storage. Informal seed systems may not provide access to improved crop varieties, which can limit the yield and disease resistance (Byerlee and Eicher, 2021). Seeds from informal systems lack control measures since there is a lack of a regulatory framework. The FAO (2024) postulates that informal seed systems often operate outside of a regulatory framework, which can lead to inconsistent quality and safety standards. In addition, there is limited marketing and distribution of the seeds. Informal seed systems may not have established marketing and distribution channels, which could limit seed availability (Louwaars, 2021). Another drawback is the issue of vulnerability to climate change.

Informal seed systems are vulnerable to climate change, as farmers may not have access to climate-resilient crop varieties (IPCC 2023).

2.15 Ways to Improve the Formal and Informal Seed Systems

Improving formal and informal seed systems requires a multifaceted approach that addresses regulatory frameworks, access to improved varieties, seed production and processing, and capacity building. Integrating formal and informal seed systems can increase access to high-quality seeds and improve crop varieties, ultimately enhancing crop yields and food security. The integration of formal and informal seed systems, such as the integration of hybrid seed systems, can also yield positive results. Developing hybrid seed systems that combine the elements of formal and informal systems can increase access to high-quality seeds (Tripp, 2021). Public-private partnerships can also be employed to enhance seed systems. According to Kumar et al. (2022), public-private partnerships can leverage resources and expertise to improve seed availability and quality. In addition, seed policy reform is necessary. Seed policy reforms can create an enabling environment for both formal and informal seed systems to thrive (FAO 2024).

2.15.1 Ways to improve the formal seed systems

First, the regulatory framework must be strengthened. According to FAO (2024), improving regulatory frameworks can enhance the quality and safety of seeds in formal systems. Increasing access to improved varieties is of paramount importance to farmers. According to Byerlee and Eicher (2021), expanding access to improved crop varieties can enhance crop yields and disease resistance. Furthermore, there is a need to enhance the seed production and processing. Improving seed production and processing techniques can increase seed quality and availability (Tripp, 2021). Farming stakeholders should develop inclusive business models. According to Louwaars (2023), inclusive business models can increase smallholder farmers' access to formal seed systems. This improves the productivity. Technology is crucial as well. Smallholder farmers must leverage the technology. Utilizing digital platforms and other technologies can improve seed availability, accessibility, and affordability (Kumar et al., 2022).

2.15.2 Ways to improve the informal seed systems

Informal seed systems require community-based production. Community-based seed production initiatives can enhance seed availability and quality (Sthapit et al., 2023). Seed exchange programs need to be employed by smallholder farmers. This has a propensity to promote and improve crop viability. According to (Jarvis et al., 2021), seed exchange programs can promote crop diversity and improve the access to high-quality seeds. Farmer-led seed selection is of paramount importance once it is practiced. Farmer-led seed selection initiatives can increase access to improved crop varieties and enhance crop yield (Weltzien et al., 2023). The FAO (2024) postulates that providing training and capacity-building programs for farmers can enhance their knowledge and skills in seed production and management. Moreover, linking informal and formal seed systems is crucial. Linking informal and formal seed systems can increase access to high-quality seeds and improve crop variety (Louwaars, 2023).

2.16 Summary of Literature Review

Chapter two reviewed the literature on a comparative analysis of formal and informal seed systems among smallholder farmers. This chapter provides an overview of formal and informal seed systems and their effects on food security and sustainable agriculture. Furthermore, the chapter highlights the advantages and disadvantages of formal and informal seed systems. The seed policy in Zimbabwe was discussed at length, along with participatory variety selection by smallholder farmers. The chapter further dealt with the capacity of the local community in trying to curb food insecurity through sustainable agriculture. Furthermore, this chapter highlights the conceptual and theoretical frameworks for formal and informal seed systems. It assessed the five objectives of various authors and the literature. Chapter 3 discusses the research methodology of the study.

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CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter describes the study site, research design, sampling procedure, data collection procedure, data analysis procedure, and ethical considerations. The data collection instruments used in the study are also described. A discussion of each aspect of the research methodology is given here, beginning with a description of the study site.

3.2 Description of Study Site/s

The Guruve District is located in the Mashonaland Central Province of Zimbabwe. It has 24 administrative wards and a general population of 250 833 (ZIMSTATS, 2022). The district falls under latitude -16.3333° S and longitude 30.5833° (MapData, 2024). Alternatively, the coordinates can be expressed as $16^{\circ}19'60''$ S and $30^{\circ}34'60''$ E (MapData, 2024). Guruve District is located at an elevation of 446 m above sea level (MapData, 2024). The district lies in agro-ecological regions 2b and 3 of Zimbabwe with a distinct wet season from November to March. It has an annual temperature range of 18 to 24° C and annual rainfall ranging from 650 to 1000 mm (World Weather Information Service, 2022). Economic activities include agriculture, mining, fishing, and sculptures. In the general population, 95% of households are smallholder farmers who are engaged in subsistence agriculture, and they mainly cultivate maize, millet, sorghum, tobacco, and cotton (ZIMSTATS, 2022). There is dual use of formal and informal seed systems. Formal seed systems provide certified seeds through commercial suppliers and government programs, and informal seed systems are derived from farmers' saved seeds (recycling) and local exchanges. Figure 3.1 shows a map of Guruve District.

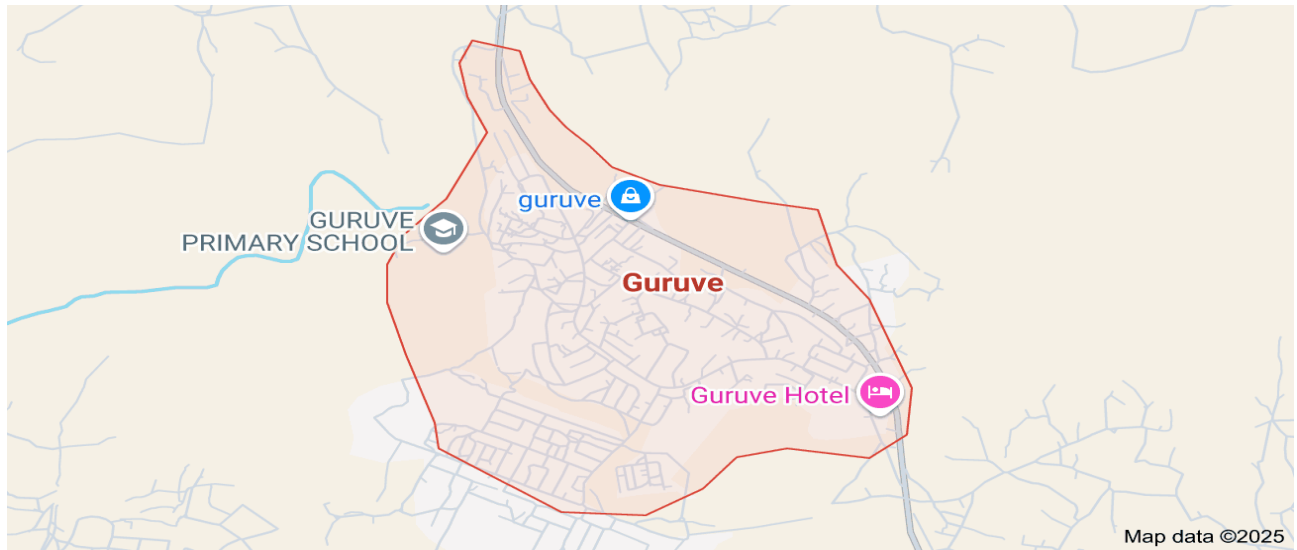


Figure 3.1: Map for GURUVE DISTRICT in Zimbabwe (MapData, 2024)

3.3 Research Design

This study used a descriptive survey design that combined both qualitative and quantitative research strategies. Orodho (2023) noted that a survey is a method of collecting information by interviewing or administering a questionnaire to a sample of individuals; it is the most frequently used method for collecting information about people’s habits in a variety of education or social issues. Gay (2023) noted that the descriptive survey research method of study is used to investigate educational problems and to determine and report the way things are or were. A descriptive research design was adopted, and questionnaires were used to gather information. A cross-sectional survey was used in the study, as both quantitative and qualitative data were collected from lower-Guruve smallholder farmers and local seed suppliers. Surveys collected quantitative data, whereas field observations and interviews provided qualitative information. Data were collected from Guruve District in January and February 2025.

3.4 Sampling Procedure

The target population was smallholder farmers and stakeholders involved in seed systems in Guruve District. A detailed list of farmers from community organizations, farmer cooperatives, and local agricultural officers was compiled to create a sampling frame. This study involved selecting a sample of 240 smallholder farmers from 24 administrative wards in the study area. According to Mugenda and Mugenda (2021), at least 10% of the target population is adequate for social-science research. The study applied a multiple-stage sampling procedure. The first stage involved purposively selecting areas that use both systems. Orodho (2023) notes that purposive sampling involves hand-picking the cases to be included in the sample on the basis of one's judgement of typicality. A stratified sampling method was also used, in which respondents were grouped into similar strata. This method ensured the representation of both formal and informal seed users, and the different strata were defined by the seed system; thus, either formal or informal, the crop type, that is, maize and groundnuts, and farm size. A sample was extracted from each stratum using proportionate random sampling to reduce bias and provide an equal chance of representation. A purposive sampling method was also used to select key informants, those directly involved, and those who contributed to and understood the study. Convenience sampling was also used to ensure a diverse and adequate representation of farmers and associated seed system stakeholders.

3.5 Research Instruments

According to Orodho (2023), a research instrument is used to collect, measure, and analyze data related to research interests. These tools are most commonly used in the health sciences, social sciences, and education to assess patients, clients, students, teachers, staff, and others (Reference). The following research instruments, including interview questions, were used to collect data:

3.5.1 Questionnaires

Questionnaires were used for data collection because, as Kiess and Bloomquist (2022) observed, a questionnaire offers considerable advantages in administration; it represents an even stimulus potentiality to large numbers of people simultaneously and provides an investigation with an easy

accumulation of data. According to Orodho (2023), a questionnaire is a suitable method for data collection because

- i. It can collect a large amount of information in a reasonably quick space.
- ii. Respondents' anonymity ensures that they give honest answers.
- iii. Questions are standardized thus everyone gets the same questions.

3.5.2 Interview questions

Interviews were conducted with agricultural stakeholders in the district. These included government employees in the agricultural ministry, extension staff from both public and private organizations, donors, and non-governmental organizations working with smallholder farmers in the community and farmer representatives to hear their views on the formal and informal seed systems. The research employed a semi-structured interview guide so that the respondents could freely express themselves to some extent. Interviews were appropriate to permit a greater depth of responses, which could not be obtained through any data-gathering tools. The use of closed questions would not suit the data collection because they were not able to obtain sufficient information and probe for more.

3.6 Reliability of Instruments

Reliability is defined as the degree to which a research instrument yields consistent results or data after repeated trials (Mugenda and Mugenda, 2021). Orodho (2023) further noted that the reliability of an instrument is consistent in producing reliable results. Piloting enables researchers to test the reliability of instruments and familiarize themselves with the administration of the instrument.

The split-half technique of reliability testing was employed, where the test items were divided into two halves, each half was scored independently of the other, with items of the two halves matched on content and difficulty. The correlation coefficient was calculated using Pearson's formula:

Product Moment Correlation:

$$r = \frac{\sum[(x_i - \bar{x})(y_i - \bar{y})]}{(\sqrt{\sum(x_i - \bar{x})^2} * \sqrt{\sum(y_i - \bar{y})^2})}$$

Where;

- = Sum of X scores
- = Sum of Y scores
- = Sum of squared X raw scores

- = sum of squared raw Y scores.
- = Sum of products of paired X and Y raw scores
- N = Number of paired scores

3.7 Validity of Instruments

Validity shows whether the items measure what they are designed to measure (Borg and Gall, 2022). According to Wilkinson (2021), a pilot study helps identify those items that could be misunderstood, and such items will be modified accordingly, thus increasing face validity. Expert opinions, literature searches, and pretesting of open-ended questions helped establish content validity. The author prepared the instruments in close consultation with his supervisors, whose expert judgement helped improve the content validity.

3.8 Ethical Considerations

Ethics are crucial in any research. According to McLend (2024), ethics provides guidelines for professional conduct. Ethics have issues with respect that are inherent to basic human rights. Ethical considerations, including fairness, honesty, respect for one’s integrity, and confidentiality of certain information, were practiced. Informed consent was obtained from all participants, and their anonymity and confidentiality were ensured. Necessary research approvals and permissions from relevant authorities and institutions, such as the Chief and Headman, Ministry of Agriculture, and Agricultural Extension offices, were sought. Confidentiality, respect of local knowledge, cultural sensitivity and community engagement was exercised. The research protocols and procedures complied with the ethical guidelines and regulations. The findings were used responsibly by contributing greatly to understanding and improving seed systems as well as policies without misrepresenting the involved persons.

3.9 Data Analysis Procedure

After data were obtained from the field, they were coded and analyzed using the Statistical Package for Social Sciences (SPSS) version 24 software. It was then arranged and grouped according to relevant research questions. Data was then summarized using distribution tables, bar graphs, pie

charts, and tables for all items. According to Piel (2023), percentages have a considerable advantage over more complex statistics in data analysis.

3.10 Summary to Methodology

Chapter 3 focuses on the research methodology. The research methodology included research design, population sampling, and research instruments, such as interviews and questionnaires. The advantages and disadvantages of the research instruments are also examined. Furthermore, the chapter highlights the data validity and reliability of the research instruments, as well as ethical issues. The data collection procedure and presentation are also covered in this chapter. Chapter 4 focuses on the data presentation, analysis, interpretation, and discussion.

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CHAPTER 4

RESULTS

A Comparative Analysis of Formal and Informal Seed Systems in Guruve District, Zimbabwe.

Abstract

The aim of a comparative analysis of formal and informal seed systems is to combat food insecurity and promote sustainable agriculture. This study aimed to analyze the two seed systems so that recommendations could be drawn on the pros and cons of the two to smallholder farmers. A total of 240 respondents were drawn from 24 wards in the study area. Questionnaires and interview questions were used to gather data on seed quality selection, storage techniques, and the effects of seed quality and storage on crop yields and sustainable agriculture. Additionally, the strengths and weaknesses of the two seed systems were investigated with the intention of coming up with the best possible recommendations to assist smallholder farmers in curbing the effects inherent in food insecurity and the promotion of sustainable agriculture. The focus is on promoting sustainable agriculture and food security. The identification of the strengths, weaknesses, and ways to improve the two seed systems have also become pertinent. The results showed that most smallholder farmers use informal seed systems to source seeds, although many advantages exist when using the formal seed system.

Key words: Formal seed system, informal seed systems, food security, storage techniques and sustainable agriculture.

4.1 Introduction

Food security and sustainable agriculture are of paramount importance to smallholder farmers and nations in general. Most smallholder farmers' yields are very low, and one of the reasons is the type of seed used by the farmers. Chapter three, explored and examines the research methodology. The research methodology highlighted the following: description of the study site, which is the Guruve District, the research design, sampling procedure, data collection procedure, ethical considerations, and data analysis procedure. Additionally, it spelt out the research instruments, such as the interview questions and questionnaires that were used to collect data regarding the comparative analysis of the formal and informal seed systems. Chapter four presents the findings of a comparative analysis of formal and informal seed systems. The most desired seed system is recommended for smallholder farmers for future use.

4.2 Materials and Methods

4.2.1 Description of study area

The study site was the Guruve District in the Mashonaland Central Province of Zimbabwe. It is situated 150 km north of Harare. Refer to 3.2.

4.2.2 Research Design

A descriptive survey design was used to undertake the research. Refer to 3.3

4.2.3 Sampling procedure

The study applied a multiple-stage sampling procedure. Refer to 3.4

4.2.4 Data collection procedure

The data collection procedure involved purposive, stratified sampling, proportionate random sampling, and purposive sampling. Convenience sampling was also used to ensure a diverse and adequate representation of farmers and associated seed systems. Refer to 3.5.

4.2.5 Data analysis procedure

Data were coded and analyzed using Statistical Package for Social Sciences (SPSS) version 24 software. Refer to 3.9

4.2.6 Challenges encountered during data collect

The author of this study faces several challenges. Pre-survey problems included difficulty defining the research problem, limited access to relevant literature, securing adequate funding to support the research, and ethical concerns. Furthermore, the author conducted a survey design and data collection problems. These places were too far away from each other. Sample size determination and the selection of data collection methods are also issues. Additionally, there were data collection problems, including non-response, data quality issues, interviewer bias, and technical issues. Data analysis problems were also major deterrents. These included data cleaning and preparation, statistical analysis, and interpretation. Moreover, there are post-survey problems. This included reporting and dissemination, research ethics and confidentiality, and research limitations. Last but not the least, the issue of future research directions was also an issue. This includes the identification and proposal of future research directions.

4.3 Results and Discussion

4.3.1 Socio-demographic information

4.3.1.1 Farmer's age group

Figure 4.1 shows that 45% of the farmers were between 31 and 50 years of age. The age bracket is followed by the age group 51–65 years, which stands at 33%. Twelve percent represented the age group of 65 years and above, with the smallest percentage representing the 18 to 30 years age group. The distribution of the age groups shows that more than 50% of the respondents were within the industrious active group. The general observation shows that most people who reside in the countryside survive on farming, as farming is the only major industry that exists in rural areas. An industrious labor force is a prerequisite if farming must be enhanced. The industrious age group in farming is in the age group that is between 18 and 50 years, with an age group which is above 60 years being uneconomic in farming, causing poor profitability. Older farmers tend to have more

experience and traditional knowledge but may face physical limitations (Lapar and Ehui, 2024). Younger farmers are more likely to adopt new technologies and innovations (Kumar et al., 2021). A labor force is required starting from the preliminary stages of crop production, that is, from sowing until harvesting given that most of the operation in Guruve rural are still being done manually..

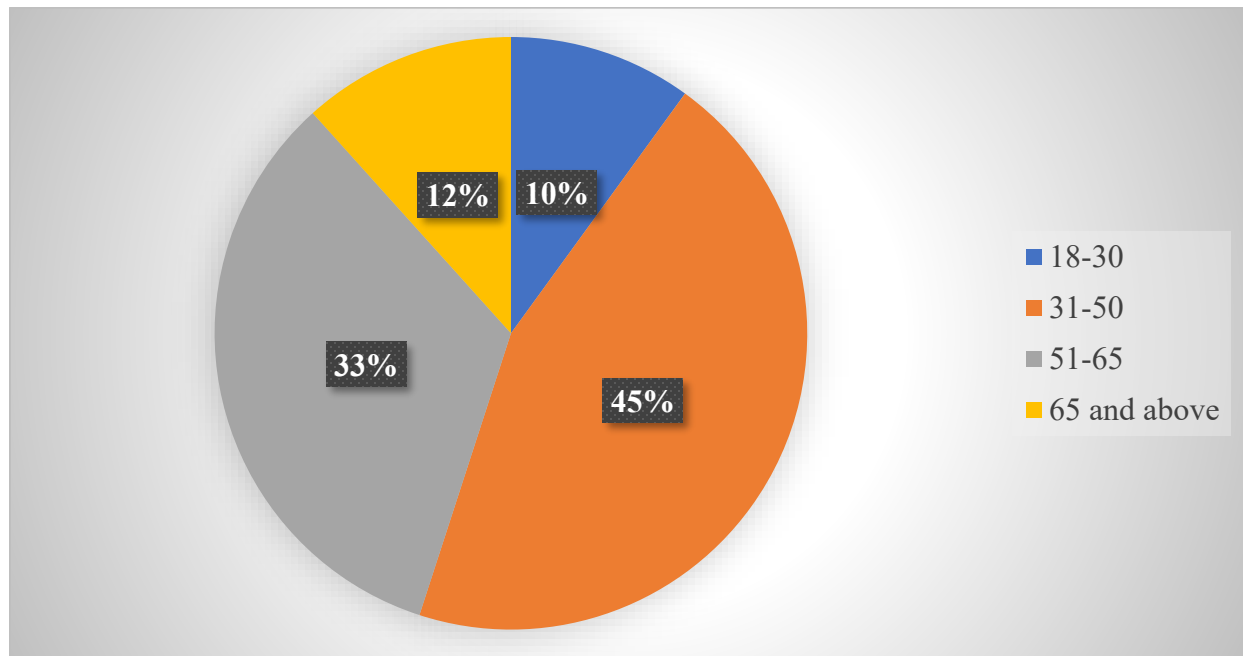


Figure 4.1: Age group distribution (%) of Farmers interviewed

4.3.1.2 Gender of the farmer

Figure 4.2 below, depicts the gender of the participants in the research study. The results showed that 60% were male, while their counterparts represented 40%. This shows that most families were male-headed. This setup has a connotation in decision-making in real-life situations. This shows that most decisions in families are made by the male gender. These include decisions on which crops to grow and which ones not to grow. Further, the decision on which type of seed to grow based on formal and informal seed systems also depends on the household head. In subsistence farming, male-headed households tend to produce more than their counterparts. This finding was consistent with that reported by Wairimu et al. (2021). They reported that the gender of the household head has a positive and significant effect on tomato profitability. The same observation

was also noted, and it also agrees with that of Ojo et al. (2023) in Nigeria, where tomato production is dominated by its male counterpart. Female farmers often face limited access to resources, credit, and markets (Doss, 2021). Male farmers tend to dominate the decision-making processes, but female farmers are more likely to invest in household welfare (Udry, 2024).

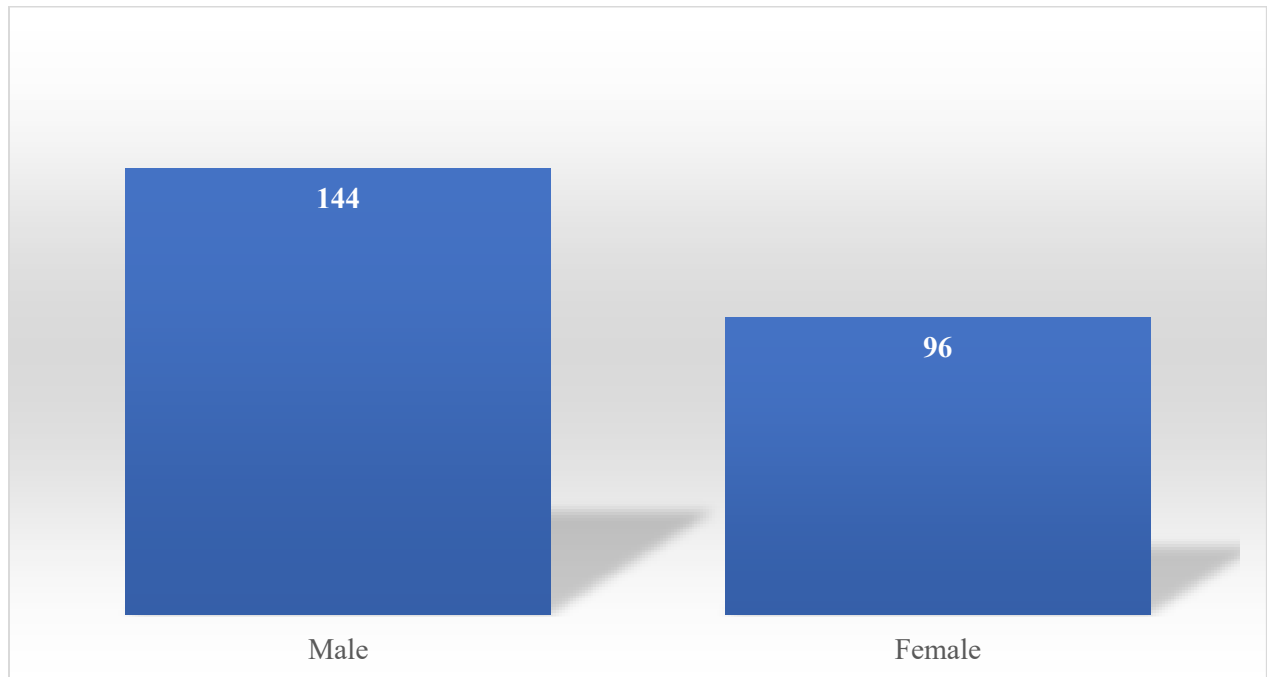


Figure 4.2: Gender of the farmer

4.3.1.3 Farmer's Occupation

Table 4.1 on the occupational distribution of the respondents shows that the highest number (93%) was full-time farming. Only 7% of the respondents were part-time farmers. A large percentage of full-time farming implies that farmers have the best time to practice farming, resulting in increased or improved knowledge of crop seeds and varieties. *Ceteris paribus*, this has a positive impact on seed knowledge, and hence, seed systems. Part-time farmers are not always in the communal areas, but they have other things they do somewhere, and only come to farm during the rainy season, or they send their wives to the communal areas during the rainy season. They are employed most of the time in urban areas. Full-time farmers have a full-time commitment to farming and tend to produce more than part-time farmers do. Farmers who consider farming their primary occupation tend to devote more time and resources to their farms, leading to improved productivity and

efficiency (Lapar and Ehui, 2024). Primary occupation farmers are more likely to develop specialized skills and knowledge, enabling them to adapt to changing market conditions and technological advancements (Kumar et al., 2022). Secondary-occupation farmers, on the other hand, have diversified income streams. Farmers who consider farming a secondary occupation often have alternative sources of income, reducing their dependence on farming and increasing their overall resilience (Doss, 2021). Secondary occupation farmers may have limited time to devote to their farms, potentially leading to reduced productivity and efficiency (Lapar and Ehui, 2024).

Table 4.1: Occupation of the farmer

Occupation	Number of farmers	Percentage
Full-timer farmer	222	93
Part-time farmer	18	7
Total	240	100

4.3.1.4 Educational level of the farmer

Table 3.2 below on educational level of the respondents show that 55% of the participants attained secondary-level education. Forty-three percent attained primary-level education, with a paltry 2% having attained a tertiary level of education. The high numbers of educated farmers result in improved knowledge, which can also be translated into knowledge of crop seeds. The education level of a farmer plays a significant role in profitability. An educated farmer understands farming concepts better than an illiterate farmer does. This finding agrees with Nazare and Nyakudya (2022), who hypothesized that an increase in farmers' education has a positive influence on technical efficiency; thus, an increase in education may bring about increased efficiency for the grower. Education improves farmers' knowledge of how best they strategize and increases their level of adaptation to better farming concepts. The number of years spent in school has a positive effect on growers' crop profitability to the growers (Rahman, 2022). This is in agreement with the observations above. Higher levels of education are associated with improved agricultural productivity and adoption of new technologies (Asfaw and Admassie, 2024). Educated farmers are more likely to participate in extension services and access credit (Kumar et al., 2022).

Table 4.2: Educational level of the farmer

Educational Level	Number of farmers	Percentage
None	0	0
Primary level	103	43
Secondary level	132	55
Tertiary level	5	2
Total	240	100

4.3.1.5 Farming experience of the farmer

Figure 4.3 shows the farming experience inherent with the participants, which was categorized into three groups. Results showed that 51% of the participants had between 11 and 20 years of experience in the field of farming. Those with one–10 years of experience in farming constituted 10%. The majority of farmers in the study area have more than 10 years of experience in farming, implying that farmers are well-versed with the rigors of crop production. Experienced farmers optimize resource allocation, reduce waste, and improve overall efficiency (Asfaw and Admassie, 2024). Farmers have seen this all. They had experience in the knowledge of good seeds. They know the advantages and disadvantages inherent to formal and informal seed systems when it comes to crop production. Farming experience has an added advantage for profitable enterprises. This finding is in line with that of Wairimu et al. (2021), who suggested that farming experience significantly influenced the profitability of diversified cash crop farming among smallholder tea farmers in the Gatanga District, Kenya. A possible explanation for the high profitability due to farming experience would be that as the farmer spends a lot of time in the production and marketing of their commodities, it follows that the farmer participates more and more in the economic transactions, and hence, it results in the farming enterprise becoming more profitable. Experienced farmers tend to have higher yields and better crop management practices (Lapar and Ehui, 2024). Farming experiences make farmers better decision makers. Farming experience enhances farmers' ability to make informed decisions regarding inputs, technologies, and marketing (Kumar et al., 2022).

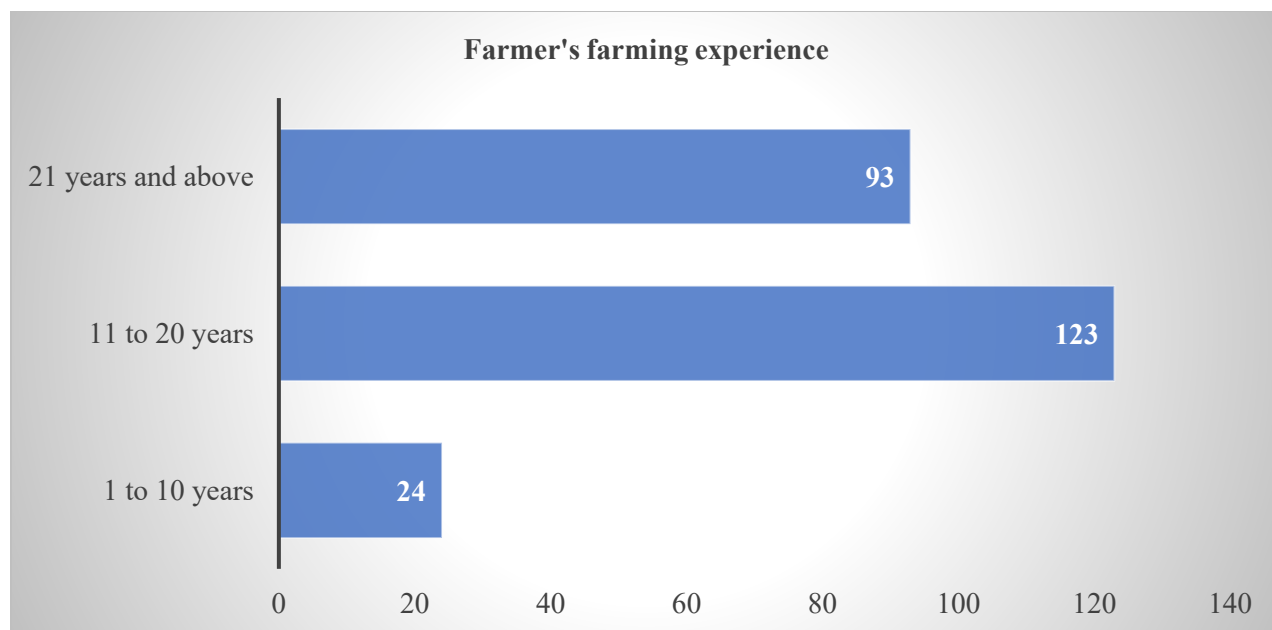


Figure 4.3: Farming experience of the farmer

4.3.1.6 Household size of the farmer

Figure 4.4 displays the family size distribution of the respondents. Families were classified into three groups. The highest number of respondents belonged to farmers with a family size of five to eight family members, representing 61% of the respondents. This is followed by a household size of between one and four family members, which constitutes 29% of the respondents, and lastly, the household size of the above nine members, which constitutes 10%. It therefore implies that there will be a need to supplement insufficient labor to those households with a few family members. This could result in an increase in labor costs or profit reduction. Labor is mostly provided by family members in rural areas. This means that households with a few family members are at a disadvantage for the provision of labor and have to hire labor at a cost. This has detrimental effects on crop production. Larger households tend to have more labor available for farming but may also face higher consumption demands (Lapar and Ehui, 2024). According to Kumar et al. (2022), smaller households may have limited labor capacity but can also be more efficient in resource allocation. A family household that constitutes many industrious aged people provides division of labor on all farming activities on the farm, including planting, spraying, weeding, and timely harvesting, avoiding crops from getting bad.

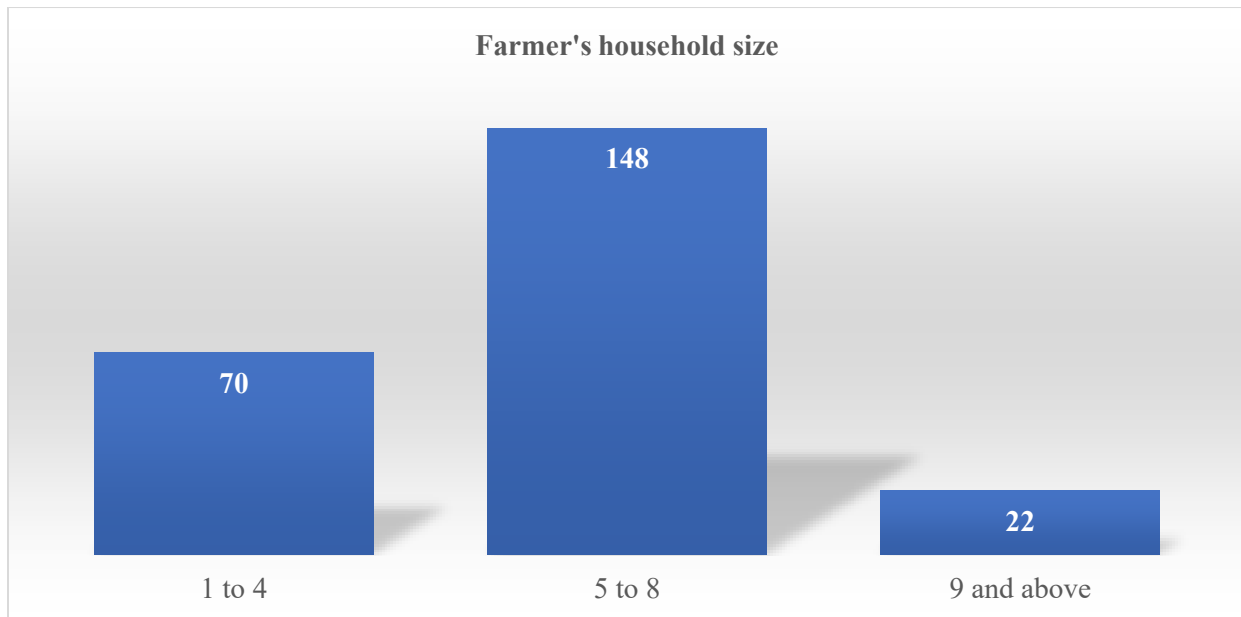


Figure 4.4: Household size of the farmer

4.3.1.7 Farmer's type of land ownership

Table 4.3 shows the land ownership of the respondents. All the respondents owned rural land, constituting 100%, and none rented land for farming purposes. It connotes that the respondents can plan long-term farming operations as they reside permanently on farmlands. Furthermore, the farmers' source of livelihood comes from farming on their own land. As a result, farmers tend to plan farming operations and see that the land becomes productive. They tend to use proper farming methods and practices to obtain the best possible quality from the soil. Farmers have full rights to land, including transfers and uses. Additionally, the land being a communal land is collectively owned and managed by a community or group. Communal ownership promotes social cohesion and collective decision-making (Kumar et al., 2022). Communal farmers use shared resources. The collective management of land and resources can reduce costs and improve efficiency (Asfaw and Admassie, 2024).

Table 4.3: Type of land ownership

Land ownership	Number of farmers	Percentage
Owned	240	100
Rented	0	0
Total	240	100

4.4 Effects of Seed Quality Selection Practices on Crop Yield

Table 4.4 shows the effects of seed quality selection on crop yield. It was observed that 54% of the participants strongly agreed that seed quality selection affects crop yield. A further 46% agreed that seed quality had a positive effect on output. The observations show that all the farmers know that if the crop seed is of good quality, it has a positive effect on its germination and, hence, the yield. None of the participants strongly disagreed, disagreed, or was neutral in their responses. According to Filho (2024), seed quality is of paramount importance, as it determines yield and output. Yield or output production is greatly determined by seed quality, postharvest handling, and storage (Sperling and Almekinders, 2023). High quality seeds lead to increased yields, and poor quality seeds alter expected output and farmers' income, which overly impacts food security (Kusena et al., 2023). Further, and in agreement with the above notion, Dimitriu and Brezuleanu (2022) contended that the competitiveness of seed systems is influenced by seed quality, which in turn improves availability, accessibility, and utilization of food, and the profits of the farmer are increased.

Table 4.4: Effects of seed quality selection

Scale	Percentage
Strongly disagree	0
Agree	46
Neutral	0
Disagree	0
Strongly Agree	54
Total	100

4.5 The Effectiveness of Seed Storage Techniques on Seed Systems

Figure 4.5 on the effects of seed storage techniques on seed systems reveal that 75% of the respondents strongly agree that seed storage techniques have an effect on a seed system. Furthermore, 25% of the respondents agreed to this notion. None of the respondents disagreed, disagreed, or was neutral. This indicates that smallholder farmers have knowledge of seeds and are very much aware of both seed systems. Effectiveness of seed storage techniques in both formal and informal seed systems is crucial for maintaining seed quality and viability. In agreement with the above observations, Gebeyaw (2022) posited that seed storage is an important and most common method used for the conservation of plant genetic resources. In many countries, inadequate seed quality and poor storage affect grain production and utilization. According to Marahatta (2021), seed storage conditions, packaging, type, and storage duration determine the seed quality. Improved storage structures reduce seed loss (Marahatta, 2021). If postharvest storage is not properly handled, farmers may lose many seeds. The African Postharvest Loss Information system indicated losses in 2021, which varied from 2.2% to 18% for oats and maize crops (APHLIS, 2021).

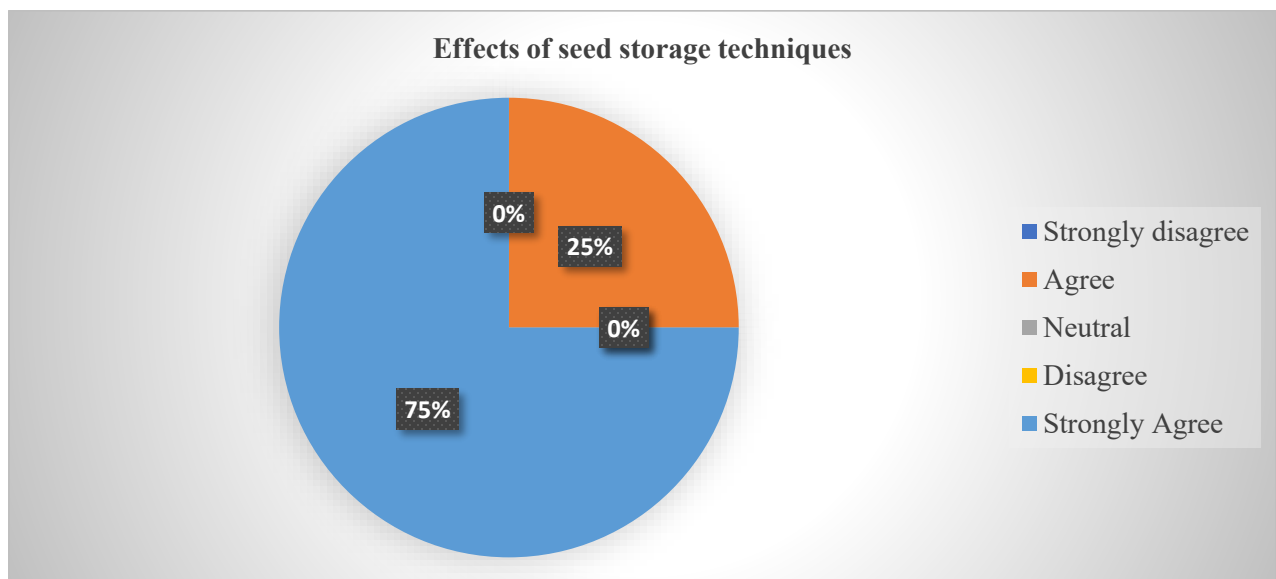


Figure 4.5: Effects of seed storage techniques

4.6 The Impact of Seed Quality and Storage on Crop Yields and Sustainable Agriculture

Figure 4.6 on the impact of seed quality and storage on crop yields and sustainable agriculture shows that the respondents strongly agreed that seed quality and storage have an impact on crop yields and sustainable agriculture. This represented 76% of respondents. In addition, 24% of the respondents agreed with the observations. This resulted in a 100% positive affirmation of the findings. Seed quality and storage techniques play a crucial role in determining crop yield. High quality seeds with high viability rates result in better germination and emergence, leading to improved crop yields (Copeland and McDonald, 2021). According to Smith et al. (2024) and in agreement with the above observations, seeds with high purity levels reduce the risk of weed competition and disease transmission, resulting in improved crop yields. Matthews et al. (2024) contended that seeds with high vigor indices exhibited better germination and growth rates, leading to improved crop yields. The impact of seed quality on crop yield can be influenced by storage techniques. For example, high-quality seeds stored under optimal conditions may exhibit improved crop yields compared with low-quality seeds stored under suboptimal conditions (Ellis et al., 2023). As observed in the above literature, seed quality and storage techniques have a significant impact on crop yields. High-quality seeds stored under optimal conditions can result in improved crop yields, whereas low-quality seeds stored under suboptimal conditions can result in reduced crop yields.

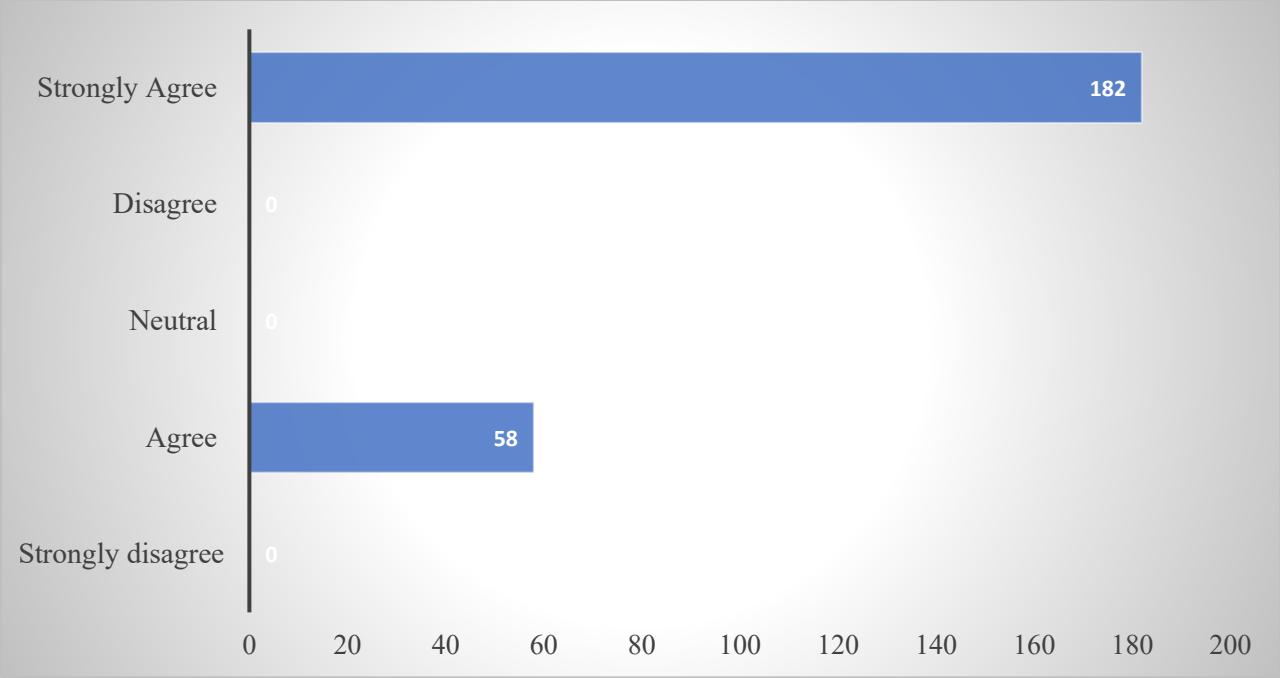


Figure 4.6: Impact of seed quality and storage

4.7 Exploratory Findings on the Strengths and Weaknesses of Both Seed Systems

The results revealed that both formal and informal seed systems have strengths and weaknesses. Formal seed systems ensure high-quality seeds through rigorous testing, certification, and regulation. According to Tripp (2021), and in agreement with the above observations, formal seed systems have strict quality control measures, ensuring that high-quality seeds are produced and distributed. Formal systems promote the development and dissemination of improved crop varieties, thereby enhancing yield and disease resistance. Formal seed systems provide access to improved crop varieties, which can lead to increased yields and improved disease resistance (Byerlee and Eicher, 2021). Furthermore, they are widely available and receive support services. Formal seed systems have established marketing and distribution channels, making seeds more accessible to farmers (Louwaars, 2023). However, formal seed systems incur high costs for small-scale or resource-poor farmers. They have limited access and depend on external inputs. Bureaucratic hurdles also exist in this regard. Informal seed systems have strengths, such as low-cost local adaptation, farmer-to-farmer exchange, and flexibility. Trip (2021) contends that formal seed systems can be expensive, rendering high-quality seeds inaccessible to smallholder farmers. Weaknesses such as variable quality, limited access to improved varieties, lack of support services,

and risk of seed degradation exist. According to Louwaars (2023), formal seed systems may focus on a limited number of crop varieties, which can lead to loss of crop diversity.

Informal seed systems are often low cost or free, making seeds more accessible to resource-poor farmers. Informal seed systems can be less expensive because seeds are often exchanged or shared within communities (Byerlee and Eicher, 2023). According to Tripp (2021), informal seed systems are often more accessible to smallholder farmers, particularly in remote or marginalized communities. Smallholder farmers can share and exchange information. These systems promote the use of locally adapted crop varieties, which are better suited to specific environments. In agreement with the above observations, Louwaars (2023) posited that informal seed systems often promote crop diversity, as farmers may grow and exchange a wide range of crop varieties. This boosts smallholder farmers' productivity. Additionally, there are farmer-to-farmer exchanges, and the systems are flexible. However, informal systems can result in variable seed quality, potentially leading to reduced yield and lower disease resistance. According to Tripp (2021), informal seed systems may not have strict quality control measures, resulting in variable seed quality. There is also limited access to improved varieties and lack of support services. Informal seed systems may not provide access to improved crop varieties, which can limit the yield and disease resistance (Byerlee and Eicher, 2021). Moreover, informal systems can lead to seed degradation over time, thereby reducing their effectiveness.

4.8 Explanatory Findings on Ways to Improve Both Seed Systems

Formal seed system regulations must be streamlined to reduce bureaucratic hurdles. According to Louwaars (2023), inclusive business models can increase smallholder farmers' access to formal seed systems. This improves the productivity. There is also a need to increase access to credit for both seed producers and distributors. Furthermore, efficient seed storage, processing, and distribution infrastructures have been developed. Improving seed production and processing techniques can increase seed quality and availability (Tripp, 2021). There is a need to implement robust quality control measures to ensure high quality and the promotion of public-private partnerships. Additionally, collaboration with private sector entities to increase investment in seed research and development and support small-scale seed producers by providing training, equipment, and market access to small-scale seed producers. According to Kumar et al. (2022),

public-private partnerships can leverage resources and expertise to improve seed availability and quality. Development of seed insurance programs is also important.

On the other hand, informal seed systems require the documentation and conservation of local varieties. Farmer-led initiatives must also be supported. Establishing seed banks is also important. Further, it promotes farmer-to-farmer exchanges and provides training and capacity building to informal seed producers. The FAO (2024) postulates that providing training and capacity-building programs for farmers can enhance their knowledge and skills in seed production and management. Farmer-led seed selection initiatives can increase access to improved crop varieties and enhance crop yield (Weltzien et al., 2023). Market linkages must be developed, and collaboration with formal systems must be fostered. Utilizing digital platforms and other technologies can improve seed availability, accessibility, and affordability (Kumar et al., 2022). Moreover, hybrid approaches must be incorporated into the two seed systems. Formal and informal systems must be combined to create efficient seed delivery mechanisms. Additionally, the creation of seed hubs and implementation of participatory plant breeding also assist in the development of crop varieties.

4.9 Recommendations

Based on the results of the comparative analysis of formal and informal seed systems, it is recommended that other studies be conducted to curb food insecurity due to climate change and promote sustainable agriculture in the country. Seed quality is of paramount importance, as it determines the yield and output. High quality seeds lead to increased yields and poor quality seeds alter expected output and farmers' income, which overly impacts food security. Therefore, there is a need for proper seed-quality selection practices. Seed storage techniques for seed systems must be improved. Seed storage techniques in both formal and informal systems are crucial for maintaining seed quality and viability. Seed storage conditions, packaging, type, and storage duration determine the seed quality. Seed quality and storage have major impacts on crop yield and sustainable agriculture. Seeds with high vigor indices exhibit better germination and growth rates, leading to improved crop yields. These two aspects require the highest level of attention. The weaknesses of both seed systems need to be turned into strengths, for example, by training farmers in seed systems. To reduce bureaucratic hurdles, formal and informal seed systems must be improved by streamlining regulations. Inclusive business models are needed to increase access

to formal seed systems for smallholder farmers. Robust quality control measures need to be employed to ensure high quality and the promotion of public-private partnerships. Additionally, collaboration with private sector entities is needed to increase investment in seed R&D and support small-scale seed producers by providing training, equipment, and market access to small-scale seed producers. On the other hand, informal seed systems require the documentation and conservation of local varieties. Farmer-led initiatives should also be supported. The establishment of seed banks is also of paramount importance, as it assists.

4.10 Conclusion

It has been determined from the results of the analysis of the formal and informal seed systems that seed quality is of paramount importance, as it determines yields and output. It is greatly influenced by seed quality, postharvest handling, and storage. High quality seeds lead to increased yields and poor quality seeds alter expected output and farmers' income, which overly impacts food security. Seed quality and storage have a strong impact on crop yield and sustainable agriculture. High-quality seeds with high viability rates result in better germination and emergence, leading to improved crop yields. Seeds with high purity levels reduce the risk of weed competition and disease transmission, resulting in improved crop yields. Furthermore, seeds with high vigor indices exhibit better germination and growth rates, leading to improved crop yields. Both formal and informal seed systems have strengths and weaknesses. The strengths of formal seed systems include rigorous testing, certification, and regulation. There are strict quality control measures to ensure that high-quality seeds are produced and distributed. There are ways to improve both seed systems. This improves the productivity. There is a need to implement robust quality control measures to ensure high quality and promotion of public-private partnerships.

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CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

Chapter four focused on the results of this study. The results are discussed with literature from other authors in relation to the findings of the study. It presents the processed data in graphical and tabular forms. This chapter also summarizes and interprets the data. This last chapter provides a summary of the findings from Chapter Four and also provides the conclusions and recommendations of the study based on the objectives. Furthermore, this chapter provides the conclusions of the research. This chapter highlights the implications of the research findings on seed systems policy and suggests areas for further research based on the findings of the research paper.

5.2 Research Summary

This study aimed to analyze formal and informal seed systems to ensure sustainable agriculture and food security. It examined the effects of seed quality selection practices on crop yield, and the results revealed that all the participants agreed that seed quality selection has an effect on crop yield. Furthermore, it was observed that seed storage techniques affect seed systems. Effectiveness of seed storage techniques in both formal and informal seed systems is crucial for maintaining seed quality and viability. All respondents agreed that seed quality and storage indeed have an impact on crop yields and sustainable agriculture. Seventy-six percent of the respondents strongly agreed with an additionally, 24% agreeing with the observation. This resulted in a 100% positive affirmation of the findings.

The results revealed that both formal and informal seed systems have strengths and weaknesses. Formal seed systems ensure high-quality seeds through rigorous testing, certification, and regulation. Informal seed systems are often low cost or free, making seeds more accessible to resource-poor farmers. Informal seed systems can be less expensive because seeds are often exchanged or shared within communities. However, formal seed systems have limited accessibility, high costs that depend on external inputs, and limited crop diversity. Informal

systems can result in variable seed quality, potentially leading to reduced yield and lower disease resistance.

There is a need to improve both seed systems. Various ways exist. Formal seed system regulations must be streamlined to reduce bureaucratic hurdles. There is a need for inclusive business models that can increase smallholder farmers' access to formal seed systems. This improves the productivity.

On the other hand, informal seed systems require the documentation and conservation of local varieties. Farmer-led initiatives must also be supported. Establishing seed banks is also important. Further, there is a need to promote farmer-to-farmer exchanges and provide training and capacity building to informal seed producers. The results showed that both formal and informal seed systems can be used by smallholder farmers to curb food insecurity and promote sustainable agriculture in Zimbabwe. However, there is a need to train farmers to become conversant with the merits and demerits of the two seed systems.

5.3 Conclusions

The effectiveness of seed storage techniques in both formal and informal seed systems is crucial for maintaining seed quality and viability in smallholder farming communities, such as Guruve District. Seed quality and storage affect crop yield and sustainable agriculture. High quality seeds with high viability rates result in better germination and emergence, leading to improved crop yields. More than 50% of respondents strongly agreed with the above observations. Both the seed systems have strengths and weaknesses. Strengths should be tapped into, whereas weaknesses should be reduced and strengthened to reduce food instability and promote sustainable agriculture. The formal and formal seed systems should be improved so that smallholder farmers' welfare is improved in Guruve District in particular, and Zimbabwe in general, by ensuring food security.

5.4 Policy Implication and Recommendations

Based on the findings of the study, since seeds for crops such as maize and groundnuts from formal seed systems are expensive for an average rural smallholder farmer to buy from formal seed houses or agricultural input suppliers, smallholder farmers should be encouraged to use informal seed systems. There

is a need to train smallholder farmers with extension staff from both private and public institutions on the best possible practices or ways to improve crop production to enhance food security and sustainable agriculture. This results in smallholder farmers improving their technical knowledge of modern-day agriculture, resulting in improved or increased yields. This averts hunger and food insecurity, caused mainly by climate change. The promotion of the use of seeds from the informal seed system calls for stakeholders in agriculture, such as the government, through the Ministry of Lands, Agriculture, Fisheries, Water and Rural Development, Non-governmental Organizations, and private institutions to work with smallholder farmers to curb food insecurity. To further promote the use of seeds from informal seed systems, policymakers should consider the following recommendations.

- Therefore, informal seed systems must be strengthened. The documentation and conservation of local seed varieties is a pre-requisite. Smallholder farmers must be encouraged to document and conserve local crop varieties to preserve genetic diversity.
- Promoting farmer-to-farmer exchanges should be a priority. Facilitation of farmer-to-farmer exchange of seeds, knowledge, and best practices to enhance informal seed systems is of paramount importance.
- Community seed banks should also be supported. This can be achieved by establishing community-managed seed banks that store and exchange local crop varieties.
- Improving access to quality seeds is a pre-requisite. Therefore, farmers must be trained in seed selection and storage. This can be achieved by providing training on proper seed selection, storage, and handling techniques to ensure seed quality.
- Promoting the use of improved seed varieties: This entails encouraging smallholder farmers to adopt improved crop varieties that are resilient to climate change and diseases.
- Facilitate linkages with formal seed systems that is, working with seedhouses such as SeedCo and Valley Seeds. Linkages should be established between informal and formal seed systems to provide smallholder farmers access to certified seeds.
- Enhance policy and regulatory frameworks by reviewing and revising seed policies. These need to be reviewed and revised to recognize and support informal seed systems.

- Development of regulations for informal seed systems. These regulations promote the use of informal seed systems, while ensuring quality and safety standards. Furthermore, they provide incentives for seed production and exchange by offering incentives such as tax exemptions or subsidies to encourage smallholder farmers to produce and exchange seeds through informal systems.

In conclusion, by implementing these recommendations, informal seed systems can be strengthened and smallholder farmers in Zimbabwe can improve their access to quality seeds and enhance their productivity and livelihoods.

5.5 Areas for Further Research

Based on the findings of the study, several areas exist that require further study to enhance food security and sustainable agriculture through the use of seeds from informal seed systems. These areas include:

- Effects of seed quality selection practices on crop yield: Further investigation and analysis of formal and informal seed systems considering the effects of seed selection practices on crop yield should be conducted. A thorough investigation is required to compare the output from the seeds obtained from the two seed systems.
- Effectiveness of seed storage techniques on seed systems: The effectiveness of seed storage techniques in both formal and informal seed systems is crucial for maintaining seed quality and viability. Further studies should be conducted on the storage facilities of informal seed systems to determine the safety of these systems and whether they affect seed germination, pestilence, and pest attack on the stored seeds.
- Impact of seed quality and storage on crop yields and sustainable agriculture: High-quality seeds with high viability rates result in better germination and emergence, leading to improved crop yields. A study could be conducted to measure how seeds from the formal and informal systems differ in terms of yield and sustainable agriculture. The results

obtained from the two systems can then be used to determine a better seed in terms of performance.

- Strengths and weaknesses of both seed systems: Both formal and informal seed systems have strengths and weaknesses. Research should be conducted on how the weaknesses of informal seed systems can be transformed into strengths. By so doing, the use of informal seeds that are often low-cost or free and more accessible to resource-poor farmers could be promoted to avert food insecurity and promote sustainable agriculture by smallholder farmers.

- Ways to improve both seed systems: Formal and formal seed systems need to be reviewed and revisited to streamline and reduce bureaucratic hurdles. Inclusive business models are needed to increase smallholder farmers' access to both formal and informal seed systems. Investigations need to be conducted to combine both formal and informal systems to create efficient seed delivery mechanisms.

APPENDICES

Appendix I: Questionnaire

A Comparative Analysis Of Formal And Informal Seed Systems In Guruve District, Zimbabwe.

INTRODUCTION

JANUARY 2025

I am a student in the Department of Agricultural Economics, Education, and Extension at Bindura University of Science Education. I am conducting a research on “**A Comparative Analysis of Formal and Informal Seed Systems in the Guruve District, Zimbabwe**”. The respondents of this survey were maize and groundnut farmers who were randomly selected from a district in the Mashonaland Central Province of Zimbabwe. Participation in the survey was voluntary. The information obtained in this survey will be kept confidential and will be strictly used for academic and research purposes. The survey interview will require about thirty (30) minutes to complete.

IDENTIFICATION

My interview code: Date of interview:

Point of interview: Home/ Residential area or field

SECTION A: Socio-demographic information

A1). Farmer’s age:

A2). Farmer’s gender: 1- Male, 2-Female

A3). Farmers’ occupation: 1 - full-time farmer, 2-part-time farmer

A4). Farmer’s age group: 1 - 18-30, 2- 31-50, 3- 51-65, 4 - 66 and above

A5). Farmers’ educational levels: 0 – None, 1 - Primary level; 2, secondary level; 3, tertiary level

A6). Years of farming experience: 1 – 1-10 years, 2 – 11-20 years, 3 – 21 years, and above

A7). Household size: 1 – 1-4, 2 – 5-8, 3 – 9 and above

A8). Type of land ownership: 1 – Owned, 2 – Rented

A9). Primary source of income: 1 – Own financing, 2 – Borrowed funds, 3 – Other sources.

SECTION B: Farmer’s socio-economic characteristics

B1.) What type of land ownership do you have? 1 – Owned, 2 – Rented

B2.) Do you have land under maize and groundnut production (acreage)?

B3.) Do you have experience in maize and groundnut production (years)?

B4.) Did you receive training in maize and groundnut production? Y/N

B5.) Do you have any irrigation facilities? Y/N

B6.) What assets do you own?

Asset	Quantity
Tractor	
Trailer	
Disc plough	
Disc harrow	
Scotch Cart	
Mouldboard plough	
Cultivator	
Fertilizer applicator	
Other (specify).....	

B7.) What livestock types do you own? Cattle..... Goats Sheep
Other.....

B8.) How big is your labour force? 1 - Permanent, 2 – Temporary

B9.) What other major crops do you grow apart from maize? (1- Sugarbeans, 3- Cabbages, 4- Onions, 5- Bar
Other [Specify.....]

B10.) What is your cost of production per acre of maize and groundnuts?

Input	Maize Costs (\$)	Groundnuts Costs (\$)
Land preparation		
Seed		
Basal fertilizer		
Top dressing		
Chemicals		
Labour costs		
Marketing costs		

B11.) Average maize and groundnut yields per hectare (kg) during the last three seasons.

Year	Maize Yield (kg)	Groundnuts Yield (kg)
2023		
2022		
2021		

B12.) What is the average selling price per tonne of?

Maize.....

Groundnuts.....

B13.) What challenges are you facing from maize and groundnuts production?

Maize:

Groundnuts:

SECTION C: Institutional Services

C1.) For the last 12 months, have you accessed extension services? (1- Yes, 2- No)

C2.) If yes, how many times have you received extension services from an agricultural extension officer in the last 12 months?

C3.) Have you won any farming PRIZE in the past five years? (1- Yes, 2- No).

C4.) If yes, please provide details:

C5.) Have you ever accessed any maize or groundnut production credit facility in the past 12 months?

If yes, from where and for how much?
.....
.....

SECTION D: Specific objective number 1: Seed quality selection practices

D1). Seed quality selection practices have an effect in crop yield.

1 – Strongly agree, 2 – Agree, 3 – Neutral, 4 – Disagree, 5 – Strongly disagree

SECTION E: Specific Objective number 2: The effectiveness of seed storage techniques

E1). Seed storage techniques have an effect on a seed system.

1 – Strongly agree, 2 – Agree, 3 – Neutral, 4 – Disagree, 5 – Strongly disagree

SECTION F: Specific Objective number 3: The impact of seed quality and storage on crop yields and sustainable agriculture

F1). Seed quality and storage affect crop yield and sustainable agriculture.

1 – Strongly agree, 2 – Agree, 3 – Neutral, 4 – Disagree, 5 – Strongly disagree

SECTION G: Specific Objective number 4: The strengths and weaknesses of formal and informal seed systems.

G1). What are the strengths and weaknesses of the formal and informal seed systems?

Thank You for Your Cooperation: Lorence Usayi

Appendix II: Frequency Tables

Age of the farmer

Age	Frequency	Percentage
18-30		
31-50		
51-65		
66- Above		
Total		

Gender of the farmer

Scale	Frequency	Percentage
Male		
Female		
Total		

Farmer's occupation

Scale	Frequency	Percentage
Full-time farmer		
Part-time farmer		
Total		

Education level of the farmer

Education	Frequency	Percentage
None		
Primary		
Secondary		
Tertiary		
Total		

Experience in farming (years)

Years	Frequency	Percentage
1-10		
11 - 20		
>21		
Total		

A7). Household size

Number of members	Frequency	Percentage
1-4		
5-8		
Above 9		
Total		

Type of land ownership

Scale	Frequency	Percentage
Owned		
Rented		
Total		

Appendix III: Interview Questions

The author used the following interview questions to guide formal interviews held with the seed houses, AGRITEX officers, and other farming stakeholders to assess their views on formal and informal seed systems.

1. What are the seed quality selection practices available or do you know in the formal and informal seed systems?
2. How effective are the storage techniques used in both systems?
3. What is the impact of seed quality and storage on crop yields and sustainable agriculture?
4. What do you think are the strengths and weaknesses of formal and informal seed systems?
5. What do you think needs to be done to improve seed systems in the Guruve District?
6. Where is the maize and groundnuts seed purchased from?
7. What factors influence a farmer's choice of seed suppliers? (for example, price, quality, and availability).
8. Do you think it is important to conduct any seed germination tests before planting? If yes, why?
9. How are seeds selected from formal suppliers by smallholder farmers? (For example, seed size, color, and shape).
10. Where is seed from the informal seed system normally obtained from?
11. How do you rate the seed from the informal seed system in terms of performance?
12. How are seeds purchased from formal suppliers and that from the informal seed system stored?
13. Do farmers treat seeds with any chemicals or pesticides before storage?
14. How long do you think farmers store seeds before planting?

15. Do you think farmers are satisfied with the quality of seeds purchased from formal suppliers?
16. How do you assess the quality of seeds? (For example, germination rate, vigor)
17. What is the average yield of crops grown from both the formal and informal seed systems?
18. Do farmers experience seed-related problems (for example, poor germination, low yield, and disease)?
19. What are the main challenges farmers face in accessing quality seeds?
20. What are the benefits of using formal and informal seed systems?

Appendix IV: Pictures of formal seed systems







Appendix V: Pictures of informal seed system







