Assessing the Impact of Crop Diversification on Rural Household Food Security in Mutare District, Manicaland Province, Zimbabwe

A dissertation submitted in partial fulfilment of the requirements for the Master of Science Degree in Food Security and Sustainable Agriculture

(Policy)

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DECLARATION

I hereby declare that the research project entitled "**Assessing the Impact of Crop Diversification on Rural Household Food Security in Mutare District, Manicaland Province, Zimbabwe,"** submitted to Bindura University of Science Education, Department of Agricultural Economics, Education, and Extension, is a record of original work done by me under the guidance and supervision of **Ms. A. Kamota**. 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. The results embodied in this thesis have not been submitted to any university or institute for the award of any degree or diploma.

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DEDICATION

This thesis is dedicated to my loving family, especially my husband, whose unwavering support, patience, sacrifice, and encouragement sustained me throughout this demanding academic journey. Your belief in my vision and constant reassurance strengthened my resolve during both the challenging and rewarding moments of this research and have been the foundation upon which this achievement stands.

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ABSTRACT

Zimbabwe's smallholder farming systems remain highly exposed to climate variability, a challenge intensified by the long-standing dominance of maize monoculture. This study explored how crop diversification influences household food access and dietary quality in Mutare District, Manicaland Province. A cross-sectional survey of 382 households was conducted using structured questionnaires. Food security was assessed through two primary metrics: the Household Food Insecurity Access Scale (HFIAS) and the Household Dietary Diversity Score (HDDS). Meanwhile, diversification intensity was measured using the Herfindahl Index. Analytical techniques included ordinal and multinomial logistic regression, as well as multiple linear regression. Results show that food insecurity is widespread, affecting nearly four out of five households. Diets were mainly cereal- and vegetable-based, with limited inclusion of nutrient-dense foods such as fruits and animal products. Statistical analysis revealed that households practicing greater crop diversification were less likely to experience severe food insecurity and achieved higher dietary diversity scores, with diversification accounting for about half of the variation in HDDS. In contrast, reliance on monoculture was associated with deeper food poverty. The study concludes that diversification strengthens both food access and diet quality by stabilizing yields, reducing climate-related risks, and broadening food sources. Policy recommendations include shifting support away from staple-focused approaches toward diverse seed systems - particularly legumes and small grains - while improving access to inputs, extension services, and markets. Such measures can foster resilient farming systems and advance sustainable food and nutrition security in semi-arid regions.

Key Terms: *Crop diversification, Household food security, Dietary diversity, Nutrition security, Rural livelihoods, Climate resilience.*

LIST OF ACRONYMS AND ABBREVIATIONS

CRISPR - Clustered Regularly Interspaced Short Palindromic Repeats

CSA - Climate-Smart Agriculture

CSAIP - Climate-Smart Agriculture Investment Plan

FAO - Food and Agriculture Organization

HDDS - Household Dietary Diversity Score

HFIAS - Household Food Insecurity Access Scale

HI - Herfindahl Index

LAP - Land Administration Project

NGOs - Non-Governmental Organizations

RA - Regenerative Agriculture

SSA - Sub-Saharan Africa

ZimLAC - Zimbabwe Livelihoods Assessment Committee

ZimVAC - Zimbabwe Vulnerability Assessment Committee

Table of Contents

CHAPTER ONE: Introduction 1
1.1 Background of the study 1
1.2 Problem Statement 2
1.3 Research Objectives 4
1.4 Research Questions 4
1.5 Hypotheses 4
1.6 Significance of the Study 5
1.7 Scope of the study 6
1.8 Outline of Thesis 8
1.9 References 8
CHAPTER TWO: Literature Review 10
2.1 Introduction 10
2.2 Research Frameworks 13
2.3 Empirical Review on the Effects of Crop Diversification on Food Security 15
2.4 Empirical Studies on Crop Diversification 16
2.5 Policy and Institutional Context 18
2.6 Research Gaps 19
2.7 Summary 20
2.8 References 21
CHAPTER THREE: Methodology 25
3.1 Introduction 25
3.2 Study Area 26
3.3 Outline of Research Design 29
3.4 Sampling Design 30
3.5 Techniques of Data Collection 31
3.6 Data Analysis Methods 32
3.7 Ethical Considerations 32
3.8 Summary 35
3.9 References 36
CHAPTER FOUR: Determinants of Crop Diversification and Household Characterization among rural Smallholder Farmers in Mutare District, Zimbabwe. 39

4.1 Introduction 39
4.2 Materials and Methods....40
4.3 Results....42
4.4 Discussion....51
4.5 Recommendations....52
4.6 Conclusion....52
4.7 References 54
CHAPTER FIVE: Quantity and Quality: Assessing the Dual Impact of Crop Diversification on Rural Household Food Access and Dietary Diversity in Mutare District, Manicaland Province, Zimbabwe. 56
5.1 Introduction 56
5.2 Materials and Methods....57
5.3 Results....59
5.4 Discussion....68
5.5 Conclusion....69
5.6 References 70
CHAPTER SIX: Summary, Conclusion, and Recommendations....73
6.1 Introduction 73
6.2 Research summary....73
6.3 Research Conclusion....74
6.4 Policy implications and recommendations....76
6.5 Areas for further research....78
6.6 References 80
5.7 Appendices 82

List of Tables

Table 1: Ordinal Logistic Regression (OLR) Results for Determinants of Crop Diversification 43
Table 2: Percentage of Household Consuming Different Food Groups (24-hour Recall) 60
Table 3: Multinomial Logistic Regression (MLR) Estimates for Factors Influencing Household Food Insecurity (HFIAS) 63
Table 4: Multiple Linear Regression for Factors Influencing Household Dietary Diversity (HDDS).....66

List of Figures

Figure 1: A conceptual framework illustrating the impact of crop diversification and food security 14
Figure 2: Map showing Zimbabwe, Manicaland Province, and Mutare District (Mabaso et al., 2015)....29
Figure 3: Distribution of crop diversification categories among rural households in Mutare District.....44
Figure 4: Respondents' education level among surveyed rural households in Mutare District 45
Figure 5: Gender distribution of household heads in the study area 46
Figure 6: Respondents' Farmer Group Membership distribution 49
Figure 7: Crop diversification distribution among surveyed rural wards in Mutare District 51
Figure 8: Household food insecurity status based on HFIAS classification.....60
Figure 9: Distribution of household dietary diversity (HDDS) among surveyed households 62
Figure 10: Standardized Residual plot for HDDS Regression model 67

List of Appendices

Appendix A: Household Survey Questionnaire 82

Appendix B: SPSS (Regression) Case Processing Summary 86

CHAPTER ONE: Introduction

1.1 Background of the study

"Food security is a long-term problem in Sub-Saharan Africa where more than 230 million people are suffering from hunger." This is according to the Food and Agriculture Organization (FAO) (2021). Zimbabwe, like other countries within the region, faces recurring problems with food shortages owing to irregular rainfall patterns, economic hardships and reliance on mono-culture of maize (Hughes, 2025). Rural households in the province of Manicaland whose main source of income is agriculture are prone to climatic shocks including prolonged droughts, floods and attacks from pests (Hughes, 2025). In Zimbabwe, rural households in provinces such as Manicaland are vulnerable to food insecurity owing to irregular rainfall patterns, soil degradation and lack of availability of agricultural inputs and markets (Food and Nutrition Council [FNC], 2024).

The Sustainable Development Goal (SDG) 2 has been able to show clearly that by supporting sustainable agriculture food and nutritional security can be achieved. "Food security will exist 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" (FAO, 1996). Cereals, legumes, tubers, fruits and vegetables can be introduced to the food security. Moreover, complementary studies conducted by Makate et al. (2016) examining the relationship between crop diversification and the livelihoods of smallholders in rural Zimbabwe confirm these results. Their research emphasizes the presence of positive connections between diversification strategies and productivity improvements, increased income, and better diet quality outcomes, implying the necessity of adaptive management in order to cope with environmental change.

While the practice of crop diversification is nothing new, the issue of climate change has brought its relevance up again. Implementation of the strategy in question can contribute to the reduction of risks in agriculture as well as the improvement of productivity, food and nutrition security, income, and resilience to climatic change in the rural smallholder farming system. The adoption of crop diversification can be determined by the following factors: geographical location, economic situation, and climate change. "Crop diversification may increase farm income,

generate employment opportunities, decrease poverty levels and conserve soils and water resources which are important to address these issues in developing countries" (Tesfaye & Tirivayi, 2020). Agricultural diversification can lead to improvement in diets and the environment. Diversification of cultivated crops may become an effective means to diversify diets and mitigate nutritional deficiencies. The process has numerous positive implications on the accessibility of food and nutrition within households. Recently, crop diversity has become an increasingly used strategy to ensure that crop production is protected from climatic variations, increase household income, protect from economic instability and stabilize food availability (Nahar et al., 2024).

Even with the existence of policies favoring diversification in the context of the national agriculture and food systems transformation strategy of Zimbabwe (2020-2025), there is very little local research about the impact that crop diversification can have on household food security and dietary diversity. The current research is designed to fill this gap through obtaining empirical evidence in the case of Manicaland province, in particular in Mutare.

1.2 Problem Statement

Nutritional vulnerability remains a multifaceted issue in Manicaland province. In this locality, agricultural activities remain the main source of livelihood for local rural communities. The district's rural communities rely mostly on rain-fed smallholder farming, where maize constitutes the basis of production. The dependence on the sole staple food causes diets to be highly based on carbohydrates, thus being unbalanced and contributing to malnutrition and deficiency of nutrients, especially amongst children aged below five and reproductive-age women (UNICEF, 2022; FAO, 2023). From the findings of the Zimbabwe Livelihoods Assessment Committee (ZimLAC, 2024), the Mutare District has one of the highest cases of child malnutrition in Manicaland, where 68% of children are found in food-insecure homes and lack adequate dietary diversity.

Agro-ecologically, the Mutare District is found in Agro-Ecological regions II and III, where there is a medium to low level of rainfall and high variability in the seasonal rainfall distribution patterns. In the past two decades, there has been an approximate decrease of 15-20% in rainfall amounts while the occurrence of drought years has doubled (World Bank, 2022). The Mutare

District was one of the worst hit by Cyclone Idai in 2019, where there was destruction of crops, infrastructure, and topsoil in some wards like Zimunya, Dora, and Watsomba (Government of Zimbabwe & UNDP, 2022). Recurrent droughts, flash floods, and pests, including the invasion by the fall armyworm from 2017 to 2019 (FAO, 2020), have worsened livelihood conditions. With poor soil fertility, insufficient irrigation facilities, and poor access to quality inputs, many households have faced progressive yield reductions and seasonal hunger.

Production in Mutare continues to be highly skewed towards maize cultivation, with the crop taking up over 70% of all farmed areas, whereas food-crop diversification forms 21.3% of all agricultural production in Mutare as of 2024 (ZimLAC, 2024). The challenge has been compounded by crop failure in at least three out of the last five years' agricultural season amongst small-scale farmers in semi-arid wards in southern and central Mutare. Thus, about half of all rural households in Mutare survive on market purchases or food aid in the face of poor harvests (ZimVAC, 2024). These limited crops grown in the district make the rural population extremely susceptible to adverse impacts in terms of food security in times of climatic shocks and pest infestation, which affect maize production. Moreover, the diets of the population mainly comprise sadza without much protein or vegetables included in them. According to UNICEF (2023), the prevalence of stunting among children aged 0-5 years in Mutare is 29%, higher than the national average in the 2023 Zimbabwe National Nutrition Survey.

Despite its inclusion in Zimbabwe National Development Strategy 1 (2021 – 2025) and the Climate-Smart Agriculture Investment Plan (CSAIP, 2022), as an effective approach that ensures climate-smart and nutrition-sensitive agriculture, the practice of crop diversification is not widely used in Mutare District. Barriers mentioned by farmers include low levels of knowledge, insufficient extension support, weak market linkages for other crops, and lack of irrigation facilities (FAO, 2023; ZimVAC, 2024). In general, agricultural development projects implemented in Mutare have mostly emphasized increasing yields of maize rather than diversification of the farming system. This lack of experience has resulted in insufficient knowledge about the actual impact of the implementation of the crop diversification practices on food security and nutrition of local people. The absence of data-driven insights leads to generic, temporary, and inappropriate interventions for Mutare's agroecological peculiarities.

In this project, I would like to investigate the mechanism of the impact of crop diversification on food security and nutritional intake among rural households in Mutare District, Manicaland Province. It quantifies the relationships among on-farm diversity, food availability, and nutrition outcomes, and identifies the socio-economic and agroecological factors influencing diversification decisions in Manicaland Province, Zimbabwe.

1.3 Research Objectives

1.3.1 Main Objective

To assess the influence of crop diversification on supporting food availability and nutritional access among rural households in Manicaland, Zimbabwe.

1.3.2 Specific Objectives:

1. To quantify the crop diversification practices adopted by rural households in Mutare District, Manicaland Province, using the Herfindahl Index.
2. To ascertain the impact of diversified cropping systems on household food security.
3. To analyze the relationship between crop diversification and household dietary diversity and nutritional outcomes.
4. To identify socio-economic and agroecological determinants or factors that influence effective crop diversification among rural households.

By addressing these objectives, the study aims to offer a holistic understanding of how varied cropping systems enhance food stability, including nutritional access, and improve overall household welfare under climatic stress conditions.

1.4 Research Questions

1. What is the current crop diversification level in rural Mutare District, Manicaland Province?
2. How does the level of on-farm crop diversification influence household food security status?
3. To what extent does crop diversification influence dietary diversity among rural families?
4. Which socio-economic and institutional factors facilitate or inhibit effective diversification strategies in Manicaland?

1.5 Hypotheses

H_0 (Null Hypothesis): Crop diversification does not contribute to the improvement of food security among rural households in Mutare District, Manicaland Province.

H_1 (Alternative Hypothesis): Crop diversification contributes positively to the improvement of food security among rural households in Mutare District, Manicaland Province.

1.6 Significance of the Study

Agriculture forms the backbone of the rural economy in Zimbabwe, offering livelihood support to about 70% of the country's population (ZimStat, 2022). The agricultural sector forms the pillar upon which the rural economy and food production rest in Zimbabwe. However, agriculture in Zimbabwe is grappling with the issues of climate change, land degradation, and low productivity, thus becoming a threat to the food security of the rural community. There are numerous problems faced by smallholders in the Mutare district of Manicaland province as a result of overreliance on monoculture production systems without diversifying their livelihoods. Nevertheless, there is little and scattered empirical information on how crop diversification can contribute to multi-dimensional food security (availability, access, utilization, and stability) in Zimbabwe. The vast majority of studies focus on yield and income effects while ignoring the nutritional and climate change adaptation aspects. Therefore, scientific justification for conducting this study lies in bridging that gap through the use of agroecological indicators together with household food security indicators and socio-economic indicators in order to quantify the impact of crop diversification on household well-being under changing climatic conditions.

This study is aligned with various national and international policy frameworks. It is consistent with the goals of the Zimbabwe National Development Strategy 1 (NDS1) (2021-2025) where the government of Zimbabwe stresses sustainable and inclusive agricultural development. Indeed, the research project complements the Climate-Smart Agriculture Investment Plan (CSAIP) put forward by the Ministry of Lands, Agriculture, Fisheries, Water, and Rural Development together with the World Bank (2022), where one of the identified adaptation measures is crop diversification towards resilience and food security. This implies that the relevance of the research to the existing policies is very practical. The research fills the gap in knowledge through providing useful insights that can be used in future disaster response and preparedness.

The academia/research institutions like Bindura University of Science Education and the University of Zimbabwe will benefit from empirical and theoretical knowledge for purposes of teaching, research, and curriculum development related to sustainable agriculture and food systems. The NGOs such as CARE International, Practical Action, and World Vision will be able to design livelihood and nutrition programs based on this evidence. On the other hand, the government of Zimbabwe will benefit from localized and evidence-based information, which it can use for policymaking and extension services provision, especially among smallholder farmers in vulnerable districts. The United Nations organizations like FAO, WFP, and UNDP will be assisted by the empirical evidence to continue building resilience and monitoring SDGs 2 (Zero Hunger) and 13 (Climate Action). The development and donor agencies, including USAID, IFAD, and GIZ, will utilize the results to develop and evaluate their climate-smart investment programs. The technical agencies and extension services (AGRITEX and AREX) will get the locally specific information to help in improving farmer education, crop mixing, and promoting sustainable crop production.

In general, the study is useful in closing the gap between academic research and policymaking. It makes scientific contributions by deepening our knowledge about the role of crop diversification in ensuring food security, nutritional status, and climate resilience. As a result, the study helps Zimbabwe to make its transition to a sustainable and climate-smart economy (FAO, 2021; World Bank, 2022; ZimStat, 2022).

1.7 Scope of the study

1.7.1 Limitations

Dietary intake recall bias may arise when not all foods consumed within the 24-hour recall period are accurately recalled or reported, leading to possible overestimation of “healthy” foods due to social desirability bias. This limitation can influence the reliability of data derived from HDDS and HFIAS indicators. To minimize this, enumerators will use food portion aids, detailed probing techniques, and, when possible, cross-verification with household meal observations.

Generalizability: The findings are context-specific to Mutare District, whose agroecological and socioeconomic characteristics, such as rainfall variability, altitude, and market access, differ

from those of other regions in Zimbabwe. Consequently, extrapolating the results nationally must be done cautiously, with consideration for regional diversity. The research is confined to Mutare District, Manicaland Province, excluding other Zimbabwean provinces and their respective districts. It focuses on rural smallholder households, rather than urban households or large-scale commercial farms.

Time constraints: Due to the study's limited timeframe, thorough data triangulation and longitudinal tracking could not be conducted. While the mixed-methods design enhances validity, limited time may constrain the depth of qualitative exploration and the inclusion of seasonal variations, potentially undermining consistency across datasets and negatively affecting the results. The study period will be limited to a single agricultural season (2025-2026), rather than multi-year longitudinal data.

Causality vs. correlation: Given the cross-sectional design, the study identifies associations rather than causal relationships between crop diversification and food security outcomes. Other confounding variables, such as household income, remittances, education, and proximity to markets, may mediate or amplify observed relationships. To address this, multivariate models will include control variables to partially account for these confounders.

Spatial and resource limitations: Some remote wards may be inaccessible due to poor road networks, limiting household coverage. Resource limitations may also restrict sample size, affecting statistical power and representativeness.

1.7.2 Delimitations

Notwithstanding the limitations, the research is both scientifically correct and methodologically sound. In order to avoid biases on the food consumption of the respondents, structured Food Frequency Questionnaires can be quite helpful in collecting data for this research. As was already mentioned above, the current research focuses only on crop diversification and does not consider other types of livelihood diversification, like livestock, off-farm income, or fisheries. Multi-stage sampling increases representativeness and saves resources. The data obtained through this sampling can be analyzed using quantitative methods, including descriptive

statistics, correlation, and multiple regression. Qualitative information shall add depth to quantitative findings by putting the dynamics of farmers' actions, limitations, and institutional assistance. The research is based on the theories of Sustainable Livelihoods and Climate-Smart Agriculture, with crop diversification being viewed not only as an adaptation strategy but also as a livelihood resilience approach. The anticipated results are an empirical exploration of the multidimensional nature of diversification and its contribution to food security, as well as policy, extension, and programming recommendations for climate-smart agriculture in Zimbabwe.

1.8 Outline of Thesis

The structure map of the following parts of this thesis is presented below. The next chapter presents the literature review, setting a basis for the rest of the research. The part includes a discussion of theories, applications, and data trends concerning the effects of agricultural diversification on food sufficiency and household livelihoods. Specifically, under a theoretical perspective, the frameworks of smallholder agriculture and multi-crop production are discussed, while from an empirical perspective, diversification motives and impacts are described.

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CHAPTER TWO: Literature Review

2.1 Introduction

Food security is a serious problem facing Sub-Saharan Africa (SSA), where 20.2 percent of the population is undernourished, and over 282 million people are chronically food insecure (FAO, IFAD, UNICEF, WFP & WHO, 2023). This problem is also faced by Zimbabwe, which reports national rates of food insecurity in rural areas ranging from 38% to 52% during the agricultural seasons from 2022 to 2024 (ZimVAC, 2024). The situation in the province of Manicaland is particularly dire as a result of the recurring problems of drought, erratic rainfall patterns, and poor soil fertility in the area. In accordance with the statistics provided by the Zimbabwe Vulnerability Assessment Committee (ZimVAC, 2023), over 60 percent of rural households in Manicaland province are cereal-insecure, while nearly 68 percent of children suffer from diet-based malnutrition as a result of low dietary diversity.

In this difficult agro-ecological and economic environment, crop diversification stands out as an important resilience and adaptation strategy. Crop diversification is increasingly appreciated as a multi-faceted strategy that improves food security through improving its four dimensions: availability, access, utilization and stability, as defined at the World Food Summit in 1996 and further confirmed by WFS (1996). Using diversification techniques, farmers incorporate different types of crop species or varieties in their farming systems, making sure that they do not depend on one crop such as maize and protect themselves from market and climate risks (Makate

et al., 2016). The practice is also linked to dietary diversification, better nutrition and sustainability (Mabhaudhi et al., 2019; Waha et al., 2020).

Manicaland province, specifically Mutare district, provides an excellent environment for examining this correlation. It is one of the most biodiverse provinces in Zimbabwe. The region features high-rainfall regions on the eastern side and semi-arid regions on the western side. The average annual rainfall in Mutare ranges from 700 mm to 1,000 mm, with an annual temperature range of 18-26°C. The environmental conditions are favorable for growing a wide range of crops including maize, beans, groundnuts, sweet potatoes, bananas and small grains (Meteorological Services Department of Zimbabwe, 2024). However, being dependent on rain-fed agriculture, practiced by about 80% of the rural population, exposes the households to climatic risk factors such as drought and mid-season dry spells (ZimStat, 2023). Thus, diversifying crops has become the main means of developing climate-resilient and nutrition-sensitive agriculture.

According to FAO (2023), conceptually, food security involves a situation in which "all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food." While the HDDS represents dietary diversity and acts as an indicator for food access and nutrition, crop diversification can be defined as the practice of increasing the farm crop portfolio to have various species or cultivars with regard to risk management, income generation, and ecological equilibrium (FAO, 2020; Ellis, 2000). It is empirically evident that diversified farms have 20-35% increased yield stability and 25% higher scores in dietary diversity than monocultures (Makate et al., 2018; Mango et al., 2020).

The conceptual base of this research rests on the combination of the Sustainable Livelihoods Framework (DFID, 1999) and the model of food security presented during the World Food Summit (1996). Both frameworks highlight the role played by household assets, institutions, and vulnerability conditions in shaping livelihoods, including food security. From this perspective, crop diversification serves as a livelihood strategy used to convert natural and human capital into consistent food and income results. Diversification decisions are highly influenced by factors like level of education, age, farm size, labor, income, gender, market and extension availability, and agroecological circumstances (Adjimoti & Kwadzo, 2018; Baba & Abdulai, 2021). The interplay of the aforementioned determinants results not only in the adoption of diversification practices but also in their impact on food security and household resilience.

Various empirical studies conducted in Africa offer solid proof of the existence of a positive relationship between crop diversification and food security. For example, Appiah-Twumasi & Asale (2024) demonstrated in their study on the case of Ghana that households engaged in crop diversification had a 30% lower risk of food insecurity. Moreover, Mango et al. (2018) concluded that diversified farms in Malawi showed better Household Food Insecurity Access Scale (HFIAS) and Food Consumption Scores (FCS). This was confirmed by several studies in Ethiopia, Kenya, and Tanzania, proving income stabilization and dietary adequacy associated with diversification practices (Lovo & Veronesi, 2019; Waha et al., 2020; Vernooy, 2022). Nevertheless, in the case of Zimbabwe, although a number of studies have been conducted on diversification either at national or provincial levels, not much research has focused on Mutare District despite its heterogeneity regarding agroecological zones and farming practices (Mutami, 2017; Makate et al., 2018).

Indeed, there exists an important research void, and that is the absence of evidence on the relationship between the extent of crop diversification and the levels of food security at the household level using quantitative methods and measures, such as HDDS and HFIAS. Most previous work has been descriptive, and none has been able to explain the processes through which the socio-economic and environmental determinants influence this relationship. The inability of past works to integrate nutritional and ecological perspectives limits the ability to design appropriate policies for promoting food and nutrition security.

This research seeks to fill this important knowledge gap through empirical research on the ways in which crop diversification increases the levels of availability, access, and utilization of food for rural households in Mutare District. In doing so, this study will be anchored in the climate-smart agriculture approach.

2.1.1 Definition of key terms

Food security exists “where all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs for an active and healthy life” (World Food Summit, 1996; FAO, 2023).

Dietary diversity quantifies the number of food groups that an individual consumes in a particular period of time. Dietary diversity is used as an indicator of the nutritional adequacy of

diets. In this research, the Household Dietary Diversity Score (HDDS) has been used to assess the extent to which crop diversification leads to improvement in nutrition among households.

Crop diversification, the practice of growing various crops within a particular agricultural system, has been recognized as one of the CSA practices that increase food availability, ensure dietary diversity, and minimize climate-related risks (Makate et al., 2018).

Crop diversity includes the diversity of crop species, varieties of crop species, and the diversity of genes within species (Walia, 2020).

Crop diversification is viewed by the Food and Agriculture Organization (FAO, 2020) as "a process of increasing diversity of crops to increase productivity, minimize risks, and maintain ecological balance."

2.2 Research Frameworks

2.2.1 Theoretical Framework: Sustainable Livelihoods Framework (SLF)

This research work is based on the Sustainable Livelihoods Framework (SLF) (DFID, 1999). The SLF is highly relevant to the rural Mutare District because it explains how the households manage in an environment of vulnerability, like irregular rainfall and market shocks, by using the livelihood assets (human, social, physical, financial, and natural capital). In the framework, crop diversification is described as a livelihood strategy. The theory states that by diversifying crops, households will be able to enhance their livelihoods and particularly will improve the four dimensions of food security, which are food availability, accessibility, utilization, and stability. This model is based on two categories of drivers, namely physical and temporal determinants. Food stability is regarded as the temporal dimension of food and nutrition security, which influences the performance of the first three physical elements. The first three elements are presented as the physical determinants (Gross et al., 2000).

2.2 Conceptual Framework of Crop Diversification and Food Security

In the following section, the conceptual framework (Figure 1) shows how the SLF can be operationalized into variables in the Zimbabwean smallholder situation. The framework explains the causal path from household input to food security status. Crop diversification, the independent variable, is measured using the Herfindahl Index (HI). This mathematical approach accounts for both the variety of crop species cultivated and how equitably they are distributed

across the cultivated land. The dependent variables (outcomes) are HFIAS and HDDS. Access-based food security is measured using the categories of the HFIAS. Nutritional and utilization-based food security is measured using the Household Dietary Diversity Score (HDDS). Explanatory/Control Variables as depicted in Figure 1: This model takes into account factors at the household level affecting the capability of the households to diversify; these are human capital (gender, level of education, age, experience in farming, and family labour); financial/physical capital (size of the farm, irrigation availability, farm income, and non-farm income); and institutional social capital (availability of farming training and extension services and belonging to farming groups). The hypothesis is that the integration of socio-economic factors to pursue diversification (either spatially or temporally) will lead to a sustainable agricultural system.

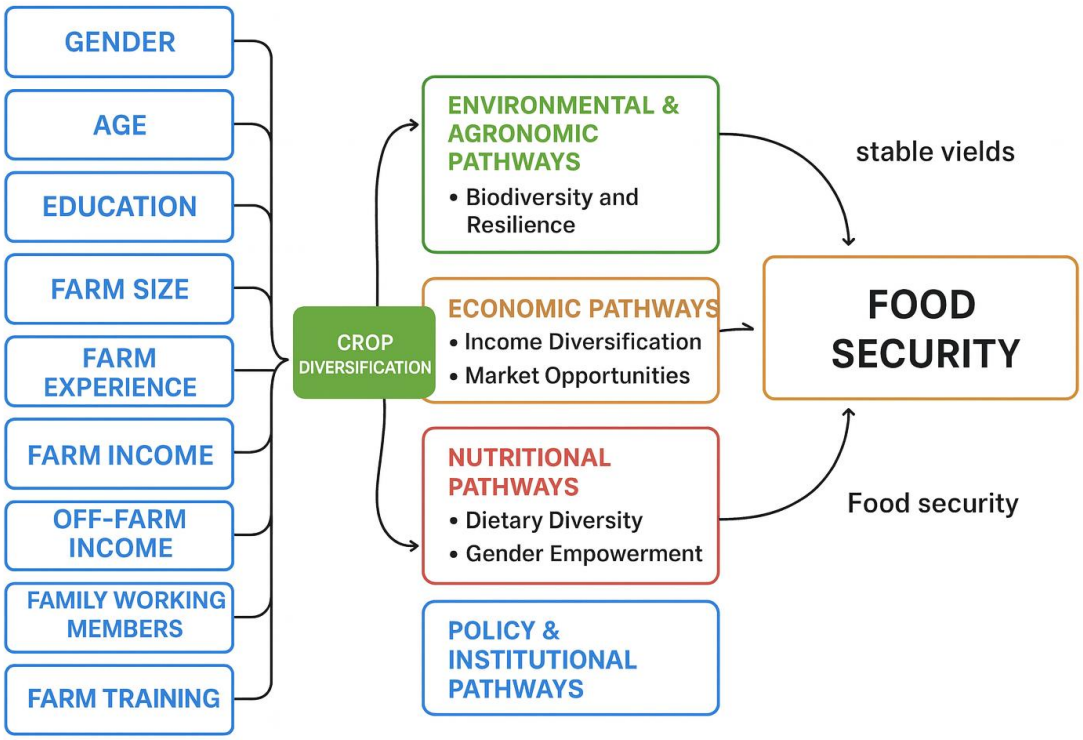


Figure 1: *A conceptual framework illustrating the impact of crop diversification and food security*

2.3 Empirical Review on the Effects of Crop Diversification on Food Security

Food security, as defined at the World Food Summit in 1996, is "a state when all individuals at all times have physical access to sufficient, appropriate, affordable, and nutritious food to satisfy their dietary needs for a healthy lifestyle." Crop diversification has been established as one of the solutions to the problem of food insecurity. Various studies conducted over the years about the relationship between crop diversification and food/nutrition security in Africa show varying outcomes (Jones et al., 2014). Crop diversification refers to the practice of growing various crops either in space (intercropping or mixed cropping) or time (crop rotation). According to Makate et al. (2018), "diverse cropping systems increase adaptation to drought and income stability." The positive impacts of crop diversification cover the four dimensions of food security, which are availability, access, utilization, and stability, and provide the theoretical basis of this research.

2.3.1 Impact on Food Availability

The impact of crop diversification on food availability is achieved by increasing the production of crops throughout the year. The diversified crop systems lead to improvement of soil fertility, water conservation, and pest management (Khangura et al., 2023; Shah & Wu, 2019). For example, the introduction of legumes and small grains in maize-based farming. Diverse crops contribute significantly to ecology through their contribution to controlling pest pressure and vectors, provision of ideal soil conditions, nurturing of pollinators, and supporting sub-soil biodiversity (McLennon et al., 2021). Refined and innovative techniques in managing agroecological resources lead to efficient agricultural production. For example, the use of nitrogen-fixing crops and vegetative forage consisting of woody shrubs and trees provides natural soil amendments in diversified rotation, strip cropping, and intercropping systems. This is an effective risk management technique that results in high productivity, nutritious food, and minimized cost on agricultural inputs (Vernooy, 2022).

2.3.2 Effect on Food Access

Diversification enhances access because it earns income from different crop types. It helps spread the risks of production and diversifies sources of income, enabling families to earn enough money to buy food and agricultural inputs (Mango et al., 2018). Access to varied crop varieties enhances income-earning channels through developing a value chain of products and selling major products and by-products such as seeds and vegetative propagating materials.

Some research shows that homestead gardening helps in earning income and ensuring food security in vulnerable groups of people in basin areas (Nahar et al., 2024). The application of advanced and innovative management methods with respect to agroecological resources can ensure optimal levels of agricultural productivity and efficiency. In particular, the use of nitrogen-fixing vegetation and forage, consisting of woody shrubs and trees, serves as a natural fertilizer in the case of diversified rotation, strip cropping, and intercropping. These measures serve as tools for risk reduction and will eventually yield higher harvests, improved quality of agricultural produce, and decreased costs associated with the purchase of additional agricultural inputs (Vernooy, 2022).

2.3.3 Effects on Food Utilization

Diversification of cultivated crops increases variety and nutrient intake, thus improving food utilization. Ngwenya and Moyo (2020) stated that diversified households had healthier diets compared to those engaged in monoculture agriculture. Indigenously grown crops usually include neglected and orphan plant species. As Mabhaudhi et al. (2019) found, continuous cultivation of landraces made many of these orphan crops extremely nutritious, resilient, and adapted to poor agricultural conditions.

2.3.4 Effects on Food Stability

Thirdly, diversification ensures stability by spreading risk and making one less vulnerable to market and climatic shocks. Generally, better livelihood results lead to better capacity for shock anticipation and coping, such as sharing agricultural uncertainty and risks in space and time (Vernooy, 2022). There is evidence from studies in Zimbabwe, Malawi, and Ethiopia that diversified farms are less vulnerable to seasonal hunger gaps (Mhlanga et al., 2021; Jones et al., 2014).

2.4 Empirical Studies on Crop Diversification

The move from monoculture to diversified farming has not been abrupt in Zimbabwe. In a recent study, Moyo et al. (2019) indicated that households engaged in mixed cropping systems (alternation of maize and legumes) exhibited high food consumption scores and shorter periods of hunger. Mutami (2017) emphasized that farmers in Manicaland grow vegetables, legumes,

and cereals in order to cope with rainfall fluctuations. According to Appiah Twumasi and Asale (2024), "Crop diversification positively affects the food security results of rural farmers in northern Ghana" (p. 12). They stated that, among other determinants, crop diversification contributed to food access and food insecurity reduction in rural farmers' households (Appiah Twumasi & Asale, 2024). "Crop diversification has a positive and significant impact on household food security status in rural households in the Collines region of Benin" (Adjimoti & Kwadzo, 2018, p. 45). The same researchers indicated that apart from diversification of crops among farmer characteristics, other important variables such as education, credit access, herd size, storage, and extension are factors that contribute to the food security status of the rural household (Adjimoti & Kwadzo, 2018). Evidence from Malawi indicated that farmers practicing crop diversification have a tendency to be healthier as compared to those not using the strategy because of the diversity of foods in their diet and food security status. Farmers producing different crops stabilize their food supply and income (Mango et al., 2018).

In neighboring Southern African countries, the same effects have been reported. Makate et al. (2018) found that crop diversification contributes positively to the food security status of a household, with access to extension and gender involvement acting as mediators. Heumesser and Kray (2019) revealed that diversification decreases the chances of complete crop failure in erratic climatic conditions, thus stabilizing the yields. Lovo and Veronesi (2019) indicated that crop diversification positively influences a child's long-term nutritional status. Evidence of a similar positive relationship between crop diversification and improved household diets has also been found in several studies across various developing countries, including Bangladesh (Nahar et al., 2024).

Findings from studies conducted in South Asia and other parts of the world indicate that diet diversity among households is influenced not only by factors within the farm but also by those outside the farm. Findings from studies conducted in Bangladesh have established a positive relationship between women's empowerment, access to markets, farm commercialization, and dietary diversity in relation to income diversification from off-farm activities (Alam et al., 2023). In a study conducted in coastal regions of Bangladesh, it has also been found that household integration of farming, aquaculture, and agroforestry results in high household dietary diversity, implying that an integration of different farming systems increases the availability and diversity

of nutritious foods within the household (Bernzen, Mangnus, & Sohns, 2022). Similar findings have been established by Herforth and colleagues, who reported a strong association between crop diversity within the farm and diversity of food groups consumed by households and their children due to increased availability of fruits and vegetables produced on the farm (Herforth & Harris, 2014). Such positive relationships have also been observed in the highland region of Ecuador, where local traditional foods and species richness contributed to nutrient adequacy and dietary diversity (Penafiel et al., 2019; Melby et al., 2020). In West Africa, studies conducted in Mali reveal that the diversity of crops produced is an important determinant for nutrient adequacy among adults and dietary quality (Torheim et al., 2004).

One such study conducted in Ghana further reiterates the idea that increasing the diversity of crops can contribute towards food security outcomes, as a study in Northern Ghana revealed that crop diversification contributed greatly towards enhancing the food security situation within households through a combination of occupation, technology adoption, labour availability, extension visits, and farm size as important factors that determine the extent of crop diversification (Baba & Abdulai, 2021). Syntheses across regions have also stressed the importance of productive factors such as access to fertilizers, tillage tools, credit, and market information in helping farmers to diversify their crops and benefit from the process. Policy measures recommended include improving access to credit for farmers and providing opportunities outside farming to enhance food security (Tesfaye & Tirivayi, 2020; Nahar et al., 2024).

2.5 Policy and Institutional Context

The agricultural policy framework of Zimbabwe from 2019 to 2030 focuses on climate-smart agriculture practices and the promotion of small grains and legumes to improve food security. According to ZimVAC (2021), coverage of extension services and input distribution programs remains insufficient, especially in far-flung parts of Manicaland. In its 2020 report, FAO recommends local seed systems and capacity development efforts to increase diversification interventions. The effectiveness of crop diversification depends on the existence of social and political networks, as they provide avenues for developing complementary livelihood options, including income generation from off-farm activities. Incentive policies that promote agrobiodiversity through various activities like training, dissemination of information, market

development, and incentives will enhance adaptation processes, enabling farmers to harness the potential of biodiversity in terms of alternative production and marketing (Fraval et al., 2019).

2.6 Research Gaps

Even though there are quite a number of studies that look into the relationship between diversified agriculture and food security in Zimbabwe, little attention has been paid to the Mutare district within Manicaland province, where agro-ecological, socio-economic, and climatic conditions result in particular livelihood outcomes. Such research has mainly been done either nationally or provincially through cross-sectional surveys or policy analysis, ignoring localized variations in farming practices, markets, and climate that significantly affect household food security. While most studies done to date on crop diversification have focused mainly on general benefits associated with yield improvement, income stabilization, and resilience (FAO, 2023; ZimVAC, 2024), there are no specific quantitative estimates on how intensity and diversity of crop production affect household food security metrics like Household Dietary Diversity Score (HDDS) and Household Food Insecurity Access Scale (HFIAS). This way, the exact mechanism that underlies the correlation between diversification and nutrition, economic access, and resilience remains unexamined within the Zimbabwean context.

It is also worth noting that there is little literature on the integrated analysis of the effects of diversification on nutrition and the environment. The majority of existing studies only deal with either production efficiency or income diversification, ignoring key issues of diet quality and nutrient availability. It becomes virtually impossible to develop an appropriate strategy for improving food quality and nutritional value in terms of policies, as there is a lack of evidence. Contextual variables that include gender roles, secure land tenure, income from other sources, and access to extension services are usually viewed as secondary. Because of the heterogeneity in terms of agroecological zones (II and III), precipitation, and markets available, there is a dire need to come up with empirical information on how these socioeconomic and ecological parameters affect diversification.

Finally, the institutional context and the policy angle on agricultural diversity have been ignored, especially in relation to how the provision of extension, inputs, and assistance through the government or NGOs makes it difficult or easy to adopt. Without this kind of information, the lack of contextualized knowledge hampers the ability to develop effective agricultural strategies

in semi-arid areas in Zimbabwe. In this light, the current research attempts to fill the data gap with the provision of localized, empirical information on how expansion in crop choice affects nutritional security and dietary diversity. Through measuring how agro-heterogeneity relates to nutritional outcomes, this paper contributes to building the required body of knowledge for designing specific strategies.

2.7 Summary

The academic works clearly show that there is a clear relationship between crop diversity and increased food production in small-scale agriculture. Crop diversity increases yield stability, nutrition level, and sustainability (Makate et al., 2016). However, the strength of the relationship heavily depends on various conditions like access to markets, involvement of women, etc. The proposed research adds value to the existing literature since it attempts to measure the level of influence of agricultural diversity on nutritional security in rural Manicaland communities in Zimbabwe.

The literature review introduces an important aspect of increasing crop diversity that leads to the transformation of society into sustainable systems. In the field of agriculture, the aspect is associated with the introduction of circular farming practices. While mitigation of yield risks is a key element of the process, the diversification of crops will contribute to the modification of material flows in huge agroecosystems. To be successful, the process requires the support of global ecological approaches to agriculture. For example, the process can include the replacement of monoculture systems with planting either one or several kinds of legumes to increase soil nitrogen or cultivating specialized livestock forage plants. Such changes will be fast-tracked if opportunities exist from institutional policies and market reformation. Yet, according to Vernooy (2002), “the most important ones are those that help and empower smallholder farmers (and their communities and organizations) in meeting local needs and providing ecological services, as well as promoting diverse cultural lifestyles and community-based modes of living” (Vernooy, 2022).

Several researchers have developed this macro perspective further by applying a landscape management paradigm, in which the focus is on achieving the most effective integration of agricultural activities in vast geographical spaces or, alternatively, using a livelihood management paradigm, which aims at combining agricultural and non-agricultural activities for

optimizing food output, food intake, and income generation (e.g., Fraval et al., 2019). An analogous comprehensive paradigm is provided by the assessment of diversification in Sub-Saharan Africa, provided by Heumesser & Kray (2019). According to their findings, growing more crop types should become only a part of a broader diversification strategy that embraces both the agrarian and non-agrarian economies. The implementation of this broad-based multi-sector approach presents a very efficient risk mitigation strategy for households.

However, these authors argue that such standard approaches cannot be applied in all Sub-Saharan regions or in the distinct agroecological systems. These frameworks need to take into account the diverse challenges that local farmers face. Instead of insisting on one solution, the approach should provide a range of possibilities for diversification both on and off farms that are adapted to the particular situation of small-scale farmers. In other words, if the diversification of crops is not feasible for a particular farm, then a strategy for specialization in agriculture may be considered instead.

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CHAPTER THREE: Methodology

3.1 Introduction

This chapter highlights the approach used to analyze the role of expanding the variety of crops grown on the nutrition stability in rural households within the Mutare area in the province of Manicaland, Zimbabwe. In view of the variable climate, soil nutrient depletion, and other socio-economic factors affecting the agriculture of smallholder farmers in the area, a context-specific methodological approach was critical for the analysis. An investigation approach that is made up of qualitative and quantitative cross-sectional information, where statistics and econometric analysis, together with descriptions, are utilized, provides both a statistically robust and contextually oriented approach to studying the phenomenon being investigated. This allows for a complete analysis of the connections between agriculture and household food security through diversification. Quantitative data collected from household surveys were used to measure the extent of diversification by using the Herfindahl Index (HI) and food security by using metrics such as HFIAS and HDDS, coupled with descriptive information obtained from FGDs and KIIs.

Mutare District, with its different agro-ecological regions and high climate variability, is a perfect case study to analyze the way farmers cope with environmental and economic uncertainty through crop diversification. The section explains the choice of research framework as well as field data collection methods, data analysis, and ethical issues in the research. All these research procedures contribute to ensuring the reliability and validity of the research results, as well as their ethical integrity, in accordance with the standards of both the national research ethics protocols and international research ethics guidelines. By integrating methodological rigor with ethical accountability, the study provides a foundation for generating evidence-based insights that can inform sustainable agricultural policy, food security programming, and local adaptation planning in Zimbabwe's smallholder sector.

3.2 Study Area

Mutare District is located in eastern Zimbabwe and forms one of the seven districts in Manicaland Province which is located in the central region of the province. The location of Mutare District is approximately 265 kilometers southeast of Harare, the capital of the country, 18°58′S and 32°39′E, thus being an important agricultural and administrative center in the proximity of the border with Mozambique. Mutare District is the provincial capital of Manicaland Province.

It constitutes a component of Zimbabwe's eastern highlands consisting of both mountainous regions, valleys, and plateaus. The district has Mutasa bordering its north while the design parameters place Makoni to its northwest boundary, Buhera bordering its west while Chipinge is located on the southern boundary of the district, Chimanimani to its southeast, and Mozambique covering its eastern borders as shown in Figure 2 below. Mutare city is located along the Harare-Mutare Highway (A3) serving as a transport link between Zimbabwe and Beira in Mozambique. While making the district accessible to markets and enhancing trade, the proximity of the district to the highway makes local farmers susceptible to price fluctuation and market competition from agricultural products imported into the country. The district covers an area of 5,523 square kilometers.

The climate of the district is subtropical to warm-temperate with rainfall varying between 800 mm and 1,200 mm and falling mainly during the months of November to March (Meteorological Services Department of Zimbabwe, 2023). In addition, the eastern highlands of Mutare receive

relatively higher rainfall compared to the western lowlands owing to orographic influence. However, rainfall variability has become more pronounced lately, resulting in dry spells and mid-season droughts affecting rain-fed agriculture. The temperatures range between 15°C and 28°C. The cool climatic conditions can be found in high-altitude areas like Vumba and Penhalonga, whereas warm climatic conditions prevail in low-altitude regions like Odzi and Marange. The district includes Agroecological Regions I to V that have varying levels of soil fertility and moisture availability. The areas in Region II have relatively fertile soils with adequate moisture, allowing the cultivation of maize, horticultural crops, and coffee. Region III has relatively more semi-intensive agriculture, with a higher likelihood of experiencing drought and cultivating small grains, legumes, and other drought-resistant crops. However, the challenges include soil erosion and nutrient depletion, which call for sustainable diversification of cropping systems (FAO, 2023).

The agrarian activities form the main economic backbone of the region, as the vast majority of the rural population is involved in small-holder agricultural activities. The dominant crops in the area include cultivated maize, groundnuts, different beans, sweet potato tubers, cassava, sorghum, and horticultural crops such as tomatoes, head cabbage, and leafy vegetables. In some highland areas, tea, coffee, and fruits are produced by small- and large-scale farmers.

In spite of these varying attributes, Mutare District is still susceptible to climatic shocks such as droughts, which often hinder its food security. Mutare District operates under the administrative jurisdiction of Manicaland Province, which is one of the socio-economically diverse provinces in Zimbabwe with very high poverty levels and diverse agroecological zones, hence posing opportunities and threats to smallholder farmers. This province is characterized by irregular rainfall patterns and poor soils, which require adaptation and risk management strategies. Eighty percent of the rural population in Zimbabwe depends on farming systems in meeting their households' requirements, whereby the majority of farmers depend on rainfed systems, which are highly affected by climatic changes (ZimVAC, 2024; FAO, 2023). In light of this, diversification of agriculture forms an important critical pathway for dealing with climate risks, enhancing dietary diversity, and economic resilience.

The Mutare district has two local authorities, that is, the Mutare City Council and the Rural District Council. Mutare district has fifty-five (55) wards, thirty-six (36) are rural (Mutare Rural

District Council), and nineteen (19) are urban (Mutare City Council). Both the main offices and the main council offices are situated in Mutare urban. Mutare rural has 1 ward in natural region 1, 9 wards in region 2, 9 wards in region 3, 11 wards in region 4, and 6 wards in region 5. There are 262,124 people who reside in Mutare Rural with 57,683 households, and there are 170,106 people living in Mutare Urban with 44,918 households (2012 Census). Mutare District is situated centrally on the Eastern Highlands of Zimbabwe with its high relief ranging from 1000-2000 meters above sea level, and mountain ranges running in a north-east-south-west direction (FNC, 2022). The mountains, which have plateaus and valleys in the east, have a great influence on climate, human activities, transport, and tourism in the district and province.

Besides agricultural activities, mining (gold and diamonds), small-scale trading, forestry, and tourism also occur in Mutare District. Mutare District is blessed with various natural resources such as gold, diamonds, wildlife, water bodies, and vegetation. Penhalonga area has its main activity as artisanal mining, whereas the Vumba and Bvumba Highlands are tourist attractions due to their beautiful scenery and biodiversity.

However, agriculture remains the most common means of earning a living in rural settings, in direct connection with food security and livelihoods. The selection of Mutare District as the research area is justified by the presence of a variety of agroecological, climatic, and socioeconomic conditions that represent a microcosm of the problems of rural agricultural communities in Zimbabwe. The fact that this district is close to both urban areas and rural areas vulnerable to climate change makes it a good case for studying crop diversification.

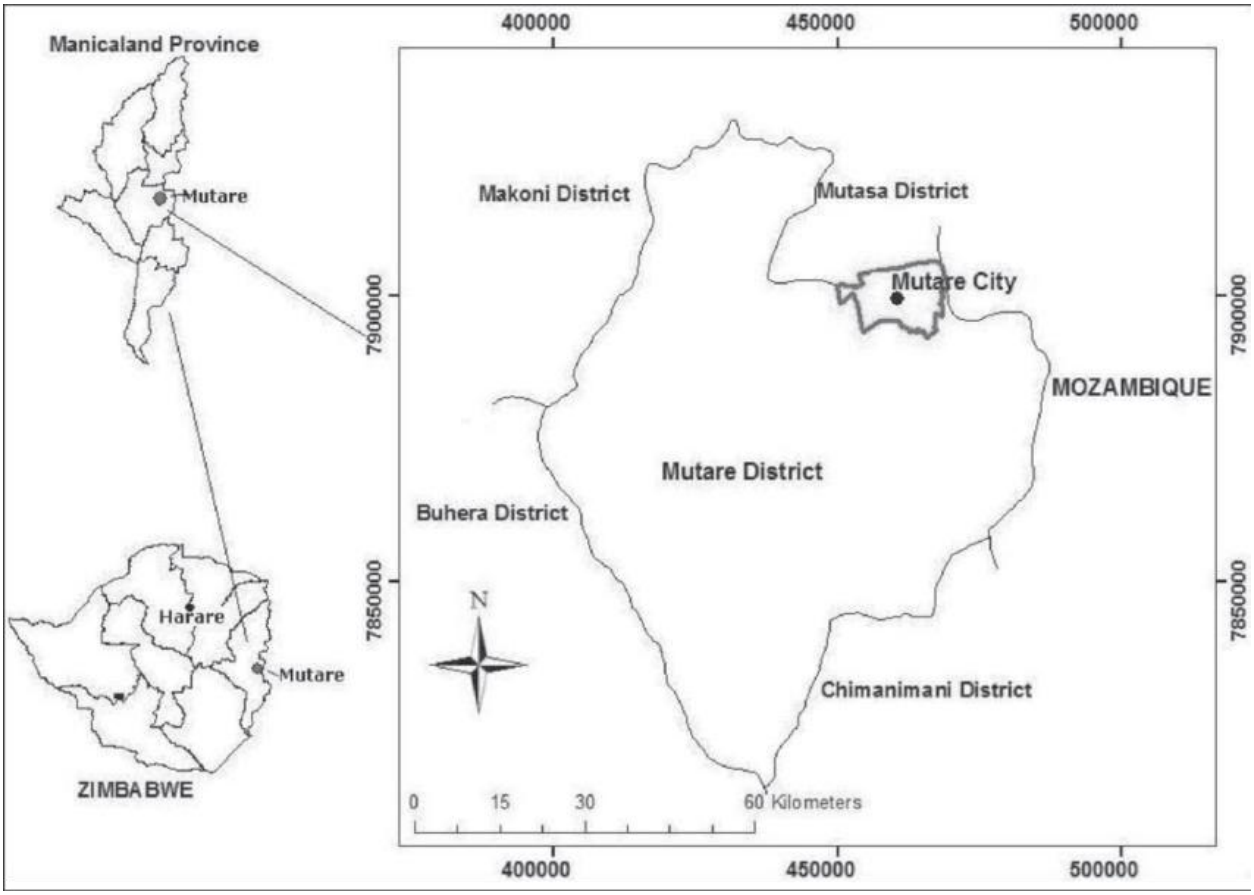


Figure 2*: Map showing Zimbabwe, Manicaland Province, and Mutare District (Mabaso et al., 2015)*

3.3 Outline of Research Design

The current study employs a mixed-method approach using both qualitative and quantitative cross-sectional data employing statistical econometric analysis (household surveys). The quantitative study mainly uses structured survey data collected from small-scale farmers, with critical variables like the Herfindahl index being used to determine crop diversification. The current study further uses Ordered and Multinomial Logistic Regression models as well as Multiple Linear Estimation models to identify factors that significantly influence the level of diversification. The study employed quantitative research methodology enlightened by descriptive statistics and exploratory research designs. Qualitative research methodology involved collecting the views and experiences of the participants about the phenomenon under study. A study by Tenny et al. (2017) argues that descriptive qualitative research methods are used to understand not only structural aspects but also the processes of people's experiences and behaviours that cannot be quantified and that are explored through interviews. Mwongera et al.

(2017) argue that interviews are conducted on an individual basis with individuals who have experience of the phenomenon being investigated. Descriptive statistics are used since they provide a deeper description of the sample being studied (Kaliyadan & Kulkarni, 2019). The descriptive statistical technique used in this study was a survey technique. An exploratory research design was used due. Descriptive statistics and exploratory inquiries will help the researcher in gaining insights about how climate-smart agricultural approaches work to protect their livelihood (Muzorewa & Chitakira, 2022).

3.4 Sampling Design

3.4.1 Definition of the Target Population

The participants that will be used in this research include all smallholder farms located within the rural wards of Mutare District in Manicaland Province. Such smallholder farms are determined mainly by the level of their dependence on rain-fed agriculture, and their vulnerability to the climate shock discussed above, such as droughts and flooding. Based on the ZIMSTAT data from Manicaland Province, the district of Mutare continues to represent one of the densely-populated agricultural regions, thus serving as a significant population base for exploring how agricultural diversification affects household food security. "Household" can be defined as the key sampling unit.

3.4.2 Sampling procedure

This study involved taking a sample from farming households in Mutare District, Manicaland Province. A hierarchical sampling strategy was employed in this study. The hierarchical sampling strategy is a multi-stage stratification technique (district → wards → villages → households) used in the selection of the sample wards, villages, and households in this study. To begin with, this particular region was purposively chosen based on its prominence and ability to grow corn. Thereafter, representative wards were randomly chosen by using the lottery method. In the last stage, villages and households were randomly sampled from a list of household heads in the villages using computer-generated numbers. Multi-stage sampling is an effective strategy that substantially cuts down the costs of conducting fieldwork in a large subject/geographic area. The number of respondents in this case was computed using Cochran’s formula at 95% statistical significance with allowance for non-responses. About 350 to 400 rural households with both sexes aged 30 to 60 were selected in this study.

$$n = \frac{z^2 p(1-p)}{e^2}$$

, in which Z represents the standard normal deviate corresponding to the target significance degree, *p* signifies the expected prevalence or distribution within the target community, and *e* denotes the acceptable margin for sampling inaccuracies.

3.5 Techniques of Data Collection

Primary data were mainly collected by interviewing the heads of households via questionnaires (Appendix A), whereas institutional informants such as ward councilors, village medical support (workers), outreach officers, academic evaluators, and other development specialists in Mutare district were involved in primary data collection using FDGs and KIIs. Pretesting of the questionnaire was carried out before conducting field work. After analysis of the results obtained during the pilot study, necessary adjustments were made to the data-gathering instrument. Interactive focus group discussions were held, consisting of groups of males and females. The issues under discussion were related to income generation activities of the households, availability matrices of food, and expenditure patterns in rural households. In all, a dozen interactive sessions were held, equally divided between the two villages of interest.

Focus Group Discussions (FGDs), particularly heterogeneous FGDs, were more appropriate for getting an overview of the situation within a short time. Key Informant Interviews (KIIs) of religious and traditional leaders, village headmen, farmers, millers, extension officers, NGO workers, and policy makers were conducted in each selected ward. Open-ended questionnaires were used to match the level of understanding and intelligence and to give them a chance to express themselves on the influence of crop diversification on their livelihood outcomes. Those households that do not feel confident expressing themselves in English will be interviewed in their local Shona dialect, and the questionnaires had easy questions that avoided deep vocabulary. Field observations were used to validate the responses of participants. Data triangulation is very useful at this point, too. To prevent intake, recall, and memory biases, Food Frequency Questionnaires (FFQ) were employed.

To account for agricultural heterogeneity, the Herfindahl index was used as the driver variable and calculated using 1 minus the sum of squares of crop proportions. This indicator ranges from 0 (total diversification) to 1 (total specialization).

Any value above zero reflects the existence of agricultural diversity. The main indicator for estimating the degree of vulnerability of people's diet is based on the HFIAS approach (Household Food Insecurity Access Scale) which reflects food security access and psychological aspects, while the evaluation criterion is based on the HDDS (Household Dietary Diversity Score) which improves nutrition assessment and acts as a marker of nutrient adequacy. The level of domestic deprivation of diet is measured by means of the Household Food Insecurity Access Scale (HFIAS). The particular evaluation reflects the level of nutritional instability that is found within the household. The value of the food insecurity scale ranges from 0 (optimal food security) to 27 (severe food insecurity). At the same time, the HDDS reflects the indirect assessment of nutritional balance in a family's everyday meals when the score varies from 1 (a very restrictive diet) to 12 (high dietary diversity). The determinant variables include income, landholding, land tenure security, educational level, gender roles, livestock units, access to irrigation, farmer groups and extension services.

3.6 Data Analysis Methods

Data analysis was done using SPSS software version 20.

3.6.2 Regression Analysis

OLR, MLR, and Multiple Linear Estimation have been used to test the hypotheses. Model specifications are further extended to examine the effect of diversification on outcome variables like food security and dietary diversity. Endogeneity in crop diversification may lead to substantial over/under-estimation of the effect of crop diversification on farm productivity and welfare. Various sensitivity tests, including IV regressions, are conducted to make sure that the overall robustness of the research design.

3.7 Ethical Considerations

3.7.1 Ethical Approval

Before the data collection began, the researcher obtained formal ethical clearance from the BUSEC-REC of Bindura University of Science Education. Permission has been sought from the Manicaland Provincial Agricultural Office and Mutare District Council institutions that regulate the conduct of agricultural research in the area. Community gatekeepers, who include ward councilors, village heads, and headmen, have been approached for permission to access the community. The above procedure complies with the ethics of community-based research, which

emphasize cultural autonomy and community leadership roles (Research Council of Zimbabwe [RCZ], 2019).

3.7.2 Informed Consent

All the participants received detailed information about the study's goals, purposes, dangers, procedures, and benefits. The voluntary nature of the research was emphasized to ensure respondents knew that they could withdraw at any time without any consequences. Consent forms were made in both English and Shona languages to promote understanding and to avoid deep vocabulary whenever possible. For those who cannot read, verbal consent will be sought in the presence of witnesses. This procedure meets the requirements of ethics described in the Belmont Report (1979) and the RCZ (2019).

3.7.3 Confidentiality and Anonymity

Confidentiality and anonymity were guaranteed by safeguarding the personal data and making the data anonymous to protect participants and their families from being identified. In order to protect the privacy of the respondents, none of the personal data will be used in the research results. All data will be coded with unique codes and kept in password-protected electronic files. Paper questionnaires will be kept in a locked file cabinet accessible only to the researcher and supervisor. The researcher is committed to securing all information against any form of access or abuse, according to the tenets of data protection and participants' confidentiality (World Health Organization [WHO], 2021).

3.7.4 Minimizing Harm and Research Bias

This research takes into consideration that there is a possibility that the discussion on sensitive topics such as food security, poverty, or vulnerability may lead to psychological/emotional pain or distress. Enumerators were trained on ethical interviewing, empathic listening, being respectful, and being culturally sensitive in their communication. Respondents were made to answer questions that made them feel uncomfortable. Also, steps were taken to reduce any social desirability bias in which the respondents gave socially desirable answers instead of honest ones. The researcher remained neutral and did not ask leading questions to ensure validity and reliability of the collected data.

3.7.5 Cultural Sensitivity and Community Engagement

This research has been carried out in the most respectful manner possible concerning local customs and traditions in the Mutare District. Cultural sensitivity through respecting the local customs, traditions, and values and making sure that data collection tools were culturally sensitive for the *Manyika* community. The time frame for data collection was carefully designed in relation to the agricultural calendar so as not to cause disruption during important farming practices. Post-study community meetings were planned for the sharing of results to build on trust within the community and ensure reciprocal benefit. This is an approach that supports the principle of beneficence in that the participants are beneficiaries of the findings that will guide future interventions that meet the nutritional needs of people of Mutare.

3.7.6 Data Integrity and Use

Data analysis was objective, and all results were reported objectively without any form of falsification. Appropriate referencing was used for secondary sources to ensure academic integrity and avoid cases of plagiarism. The results were made available to key stakeholders like the ministries, NGOs, and academic institutions to support evidence-based policy making in agricultural and food security planning. Data will be used for no purposes other than those stated above.

3.7.8 Ethical Principles Guiding the Study

The study is underpinned by the four main principles identified in the Belmont Report (1979) as well as the Research Council of Zimbabwe (RCZ) in the Ethical Guidelines (2019). Firstly, respecting participants' rights to freely and independently choose whether to participate in non-maleficence should be exercised through the practice of not inflicting pain, suffering, and exploitation of any kind on the participants, while practicing justice through the application of equality and fairness in the selection of the participants and their treatment. The researcher adheres to high levels of honesty and accountability during the research process as required by both local and international research ethical guidelines.

3.8 Summary

In this chapter, the methodological design employed in conducting research on the effect of different cropping patterns in enhancing food security of rural households in Mutare District has been explained. The use of both qualitative and quantitative methods of research has been explained as an approach that offers a comprehensive way of addressing the research problem through the use of statistical data and the interpretation of the farmers' experiences through qualitative research. The use of descriptive statistics will provide data on the patterns of demographics, resource availability, and production patterns of the households. Thematic analysis of the qualitative data will offer insight into the local knowledge systems, adaptation strategies, and institutional influence on diversification. The upcoming chapter critically interprets these findings in relation to existing literature and theoretical frameworks, providing a basis for policy recommendations and future research.

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CHAPTER FOUR: Determinants of Crop Diversification and Household Characterization among rural Smallholder Farmers in Mutare District, Zimbabwe.

Abstract

The emergence of increased climatic variability in Manicaland Province makes crop diversification one of the major mechanisms to help create resilience. But there is limited research on how socio-economic features of smallholders contribute to this process, in particular, in agro-ecologies such as the Mutare District. The paper aims to define rural smallholder households in Mutare District, determine and analyze crop diversification through the Herfindahl-Hirschman Index (HHI). The research used a multistage sampling method in which 382 households were selected in various wards. Data collection entailed using summary, descriptive statistics, ordinal regression, and HHI analysis, whereby low index values imply high diversity levels. The preliminary results show the average HHI value of 0.43, implying a moderate diversification level. Drier areas like Buwerimwe had a high concentration of small grains, and proximity to urban markets contributed to more diversification into horticulture. It is also evident that socio-economic factors such as household head age, land size, and extension services were significant. In particular, larger land size was associated with high levels of diversification, and labor-constrained households relied heavily on maize monocropping. This paper concludes that although diversification is prevalent, it seems to be more survivalist than a market-based approach. Policy intervention strategies to adopt in Mutare include improved seed systems for non-food crops and market linkages to move from subsistence farming to sustainable diversified agriculture.

Keywords: *Crop Diversification, Herfindahl Index, Ordinal Logistic Regression, Smallholder Farmers, Mutare District.*

4.1 Introduction

This section presents and explains the findings from the research conducted on crop diversification and its contributions towards food security among rural households in Mutare district of Manicaland province in Zimbabwe. This chapter presents results based on the methodology discussed in Chapter Three and will attempt to address the research objectives of this study. The chapter combines both descriptive and econometric results generated through

SPSS. The quantitative data were analyzed using Ordinal Logistic Regression (OLR). The qualitative findings offer contextual explanations for observed patterns.

4.2 Materials and Methods

The methods and materials used in this chapter are completely explained in Chapter Three. In this section, there is brief mention/reference of the methodological elements that were used in the analysis, without any repetition.

4.2.1 Study Area Description

The study was conducted in Mutare District, Manicaland Province, where the geographic, climatic, agroecological, and socioeconomic aspects are elaborated in Section 3.2. The agroecological heterogeneity, precipitation variability, and dependence on small-scale rainfed agriculture of the district make it suitable for assessing the impact of crop diversification on food security.

4.2.2 Research Design

The research employed an analytical approach based on qualitative and quantitative cross-sectional data, combining structured household questionnaire data with descriptive FDGs consisting of KIIs as described in Section 3.3. This design allowed for measuring the statistical relationship and interpreting farmers' experiences in a particular context. The use of the ordinal regression model increases the strength of results by verifying not only the overall association but also the determinants of each category. The study used data obtained from 382 rural households. Ordinal logistic regression was used to identify the determinants of crop diversification among rural households.

4.2.3 Sampling Procedure

The sampling technique adopted a multi-stage design, whereby wards, villages, and households were sampled as per Section 3.4. The sampling of wards involved random sampling based on Zimbabwe's Economic Zones and Natural Regions. Vumba (Ward 33) lies within the Eastern Highlands of Commercial Farming and Natural Region 1. Ward 6 (Gombakomba) lies within Highveld Prime Communal Economic zoning and lies within Natural Region 3. Ward 15 (Chishakwe), 35 (Dora B), and 23 (Buwerimwe) lie within the Manicaland Middle-veld Smallholder Economic zone with respective Natural Regions 3, 4, and 5. Finally, Ward 2

(Mutanda) lies within Highveld Prime Cereal and Cash Crop Resettlement Economic Zone and Natural Region 2. The sample size adopted was 382 households (sampled from Mutare's rural household population using Cochran's Formula at 95% confidence interval). The ward of residence was treated as a categorical variable and incorporated in the model as a factor.

4.2.4 Data Collection Procedure

Data Collection methods are detailed in section 3.5. The quantitative primary data were collected through the use of structured questionnaires among the households. Seven variables were considered in this chapter. They include the crop diversification index, gender of the household head, education level of the household head, agricultural labour availability, size of the cultivated land, farmer group membership, and access to extension services and irrigation. Gender is coded as either 'Male' or 'Female'. Education level has been classified into three levels that include: No Formal Education, Primary School Completion, and Secondary School and above. Access to extension services, irrigation, and farmer group membership have been coded as Binary Variables (yes/no). Household Size and Cultivated Land were coded as Continuous Variables. The data was collected using actor-specific questionnaires from December 2025 to February 2026.

4.2.5 Measuring Crop Diversification

Herfindahl index (HI)

To calculate the crop diversification index, the Herfindahl-Hirschman Index (HHI) was used in this study. This index is obtained by summing up the square of fractions of the land dedicated to each particular crop variety over the entire cultivated land. The HHI serves as a reverse measure of variety since its scale value decreases with greater variety in agriculture. This happens progressively as the structure of crop variety increases. The index measure is used to examine the level of crop variety. The Herfindahl index is used to examine the extent of crop diversification. HHI parameters are at their highest possible value when there is a complete monoculture, while they get close to zero as more varieties of crops are grown (Ojo et al., 2014). It is computed by summing up the square of the fraction of land devoted to each particular crop over the total cropped land.

$$\text{HI} = \sum_i^n p_i^2$$

, where, p_i represents the specific spatial percentage of the *i*th crop in the total cropped area.

4.2.6 Data Analysis Procedure

SPSS version 20 was the software used for this process. The dependent categorical variable was crop diversification, which was subdivided into three different categories (low, medium, and high). The socio-economic and institutional variables were considered explanatory variables, with categorical variables referred to as factors and continuous variables as covariates. More information on data analysis techniques can be found in section 3.6. Thresholds for categorization were according to WFP, FAO, and empirical evidence from southern Africa. Crop diversification strategy was considered as an outcome and thus an Ordinal Logistic Regression. There were significant differences in education level, land holding sizes, extension services, irrigation, household labor, and farmer group membership, among other important determinants of crop diversification and food security strategies.

4.3.7 Challenges Encountered in Data Collection

Some of the challenges that were faced in data collection include: Recall biases in dietary data, difficult access to some villages because of poor roads, and timing when agricultural activities were at their peaks. The language barrier was solved by using the *Shona* language for interviews. Despite these challenges, triangulation of quantitative and qualitative data enhanced the credibility of the findings.

4.3 Results

From the OLR, socio-economic capital was found to be the major determinant of crop diversification in Mutare District. Land size and household labour appeared to be the key constraining variables for physical and human capital ($p < 0.05$). Importantly, social capital, defined through farmer group membership, was identified as an important variable: households that did not belong to the farmers' groups were much less likely to realize high diversification ($\beta = -1.298$, $p < 0.001$). The model produced three categories of households, namely, Low (reference category), Medium, and High crop diversification. The Pseudo-R^2 Nagelkerke=0.277 (Table 1) shows a very good fit of the model to the data, as the null hypothesis cannot be rejected.

Table 1: *Ordinal Logistic Regression (OLR) Results for Determinants of Crop Diversification*

Variable	Estimate (β)	Std. Error	χ^2	Sig. p-value	Odds Ratio Exp(β)
Land_size	0.197	0.037	28.388	0	1.218
Household_labour_avail	0.079	0.032	5.988	0.014	1.082
Educ_cat=0	-1.227	0.351	12.253	0	0.293
Educ_cat=1	-0.763	0.244	9.776	0.002	0.466
Gender_cat=0	0.279	0.223	1.568	0.211	1.322
Irrigation_access=0	0.053	0.212	0.063	0.803	1.054
Extension_access=0	-0.131	0.234	0.315	0.574	0.877
Farmer_group=0	-1.298	0.25	26.895	0	0.273

Notes: Link Function: Logit, N=382, Pseudo-R^2 Nagelkerke=0.277, Crop diversification was categorized into Low, Medium, and High=3 (**reference**); *Significant at $p < 0.05$

Reference categories: Crop Diversification (High)=3, Education (Secondary+) =2, Gender (Male), Irrigation (Yes), Extension (Yes), Farmer group (Yes).

Positive coefficients indicate a higher likelihood of being in a higher crop diversification category.

4.3.1 Level of Crop Diversification of Rural Households in Mutare District

The results of the Herfindahl Index show that the majority of the respondents practiced crop diversification at a moderate level (54.7%) with maize, groundnuts, beans, sweet potatoes, vegetables, and small grains (Figure 3). The average Herfindahl index is 0.425 (SD = 0.156). This indicates a moderate level of crop diversification among the rural householders. The households in relatively high rainfall zones had higher levels of crop diversification, while the farmers in low rainfall zones practiced crop diversification to drought-resistant crops.

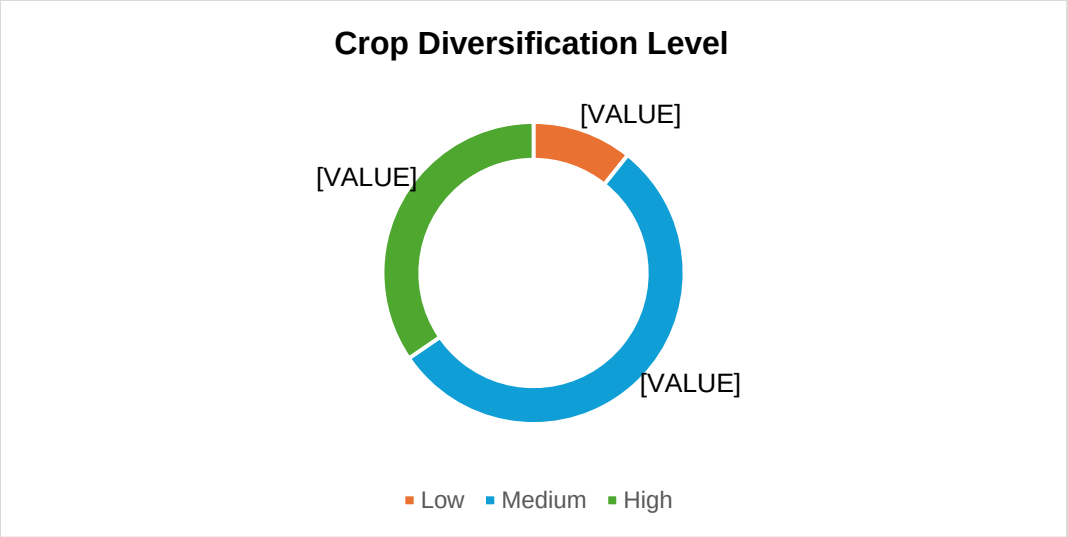


Figure 3: *Distribution of crop diversification categories among rural households in Mutare District*

4.3.2 Human, Physical, Socio-Economic, and Institutional Determinants of Crop Diversification

4.3.2.1 Education Level of Household Head

Educational status increases farmers' ability to acquire, analyze, and use agricultural information. Educated farmers will diversify crops since they understand the advantages of doing so. Education will increase record-keeping and decision-making on how to allocate resources. Highly educated households are more food secure (Magaña-Lemus et al., 2012). Lower education status reduces the chances of earning from non-farm employment (Adjimoti & Kwadzo, 2018).

Education level significantly influenced crop diversification. Farmers with no formal education ($\beta = -1.227$, $p < 0.001$, OR = 0.293) and those with primary education ($\beta = -0.763$, $p = 0.002$, OR = 0.466) were significantly less likely to diversify than those with secondary education or above (reference category). This means that higher levels of education increase farmers' ability to use diversified farming. This result is in line with past studies that have shown that education status is one of the main determinants of food security in rural areas of Africa (de Graaff et al., 2011; Makate et al., 2016). It is possible that higher education status leads to allocative efficiency in the processing of information related to agriculture and the handling of various crop cycles. The mean education status was 1.24, meaning that most household heads had attained primary to lower secondary education.

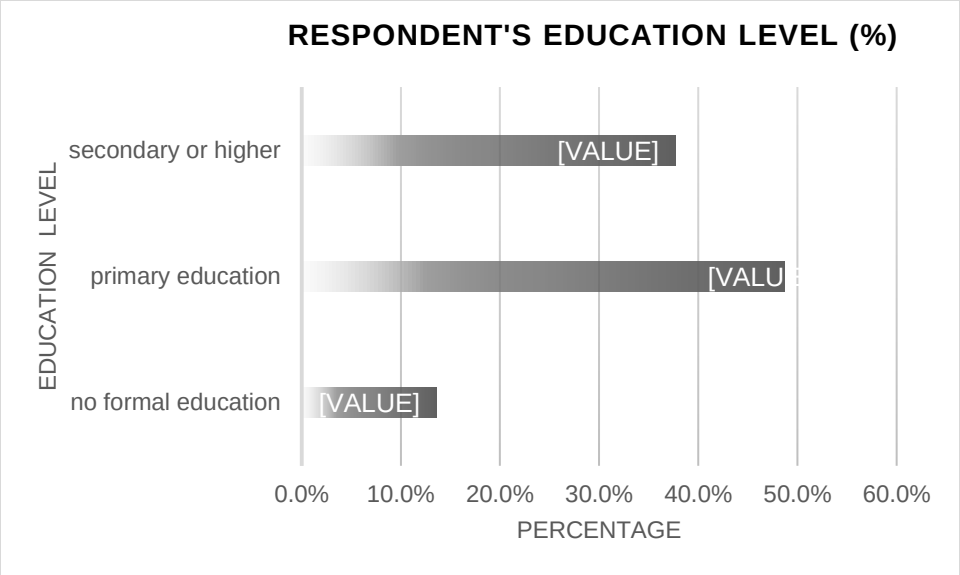


Figure 4: *Respondents' education level among surveyed rural households in Mutare District*

4.3.2.2 Household Labor Availability

Household size affects labour distribution among the different crop enterprises. Labour-intensive methods, like inter-cropping and horticulture, require more labour, hence affecting diversification decisions. Also, household labour availability was significantly positive ($\beta = 0.079$, $p = 0.014$). The odds ratio value of 1.082 suggests that an increase in labour availability in a household increases the chances of high crop diversification by 8.2%. This implies that labour availability enhances diversification activity. Diversification activity is labour intensive (due to differences in the time of planting and harvesting periods). Therefore, in rural Mutare, households with many non-disabled members will be able to handle more diversified crops than small households or households headed by elders.

4.3.2.3 Gender of the Household Head

Gender is another factor that plays a critical role in access to land, labour, and credit. Normally, households headed by males own bigger land sizes while those by females tend to diversify crops into food/nutrition crops like legumes and vegetables for consumption at home. Hence, gender affects the level of diversification as well as its purpose. Usually, women's involvement is correlated with higher adoption of nutrition-based crops such as vegetables and legumes. It is normally noted that households headed by women are more food insecure in developing countries than male-headed households (Mallick & Rafi, 2010). Additionally, according to Magaña-Lemus et al. (2012), due to the lack of resources, female-headed households in Mexico

have a greater chance of food insecurity compared to male-headed households. (Adjimoti and Kwadzo, 2018).

With regard to the gender of the household head, the analysis revealed that female-headed households had an increased likelihood of having a high crop diversity level than male-headed households (β = 0.279, OR = 1.322). Nevertheless, this association was not statistically significant for this research ($p > 0.05$), indicating that the gender of the household head is not the main factor influencing the number of species grown in the Mutare District. This result means that both men and women encounter the same structural limitations, like land and labour, while trying to diversify their crop systems. About 43% of households had male-heads, while 57% were female-headed.

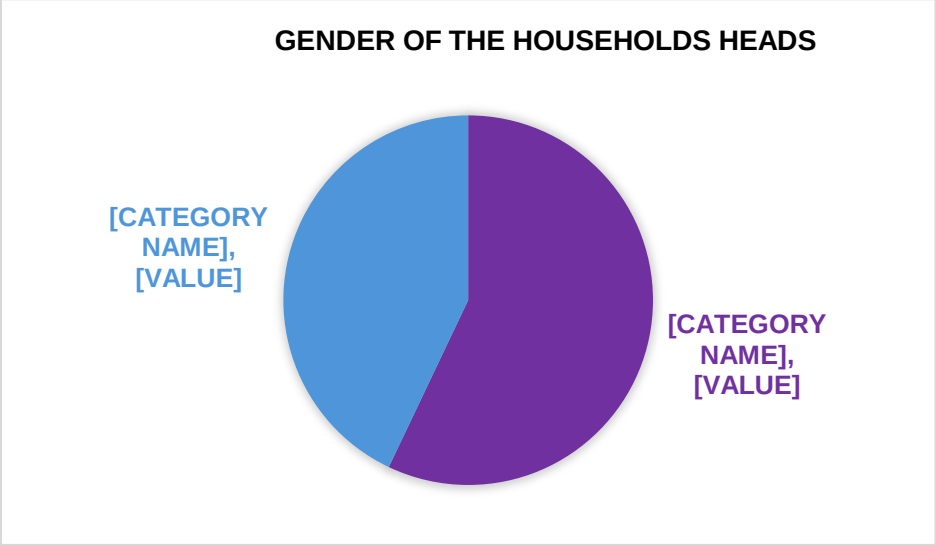


Figure 5: *Gender distribution of household heads in the study area*

4.3.2.4 Age of the Household Head

Age affects experiences, perception of risks, and openness towards adopting innovative ways. Older farmers might depend on the conventional method of monocropping, while young farmers will be more willing to try out the method of crop diversification because of their wider experience with regard to the extension service and innovation. However, older farmers have indigenous knowledge that relates to the use of mixed cropping, which suits local areas. Perz (2002) argues that older household heads (above 45 years of age) have more experience in allocating resources in meeting the needs of the household.

4.3.2.5 Land Size, Access, and Tenure Security

The larger the farm, the more room there is for farmers to experiment with different crop enterprises in order to manage risks and optimize the use of land. Larger farms have more ability to diversify than smaller farms do. Farmers who own small pieces of land are likely to plant staple crops such as maize, hence reducing their ability to diversify. The total land size owned by a household highly influences the agricultural output of that particular household. Those with secure land tenure are likely to engage in diversification programs such as agroforestry or crop rotation, which will lead to improved soil conditions. On the contrary, insecure tenure hinders sustainable land use practices.

The regression analysis results (Table 1) show a very significant positive correlation between land tenure size and agricultural diversification intensity ($\beta = 0.197$, $p<0.001$). The odds ratio ($Exp(\beta) = 1.218$) means that for each additional unit of land size, the odds of being in a higher crop diversification category rise by approximately 21.8% while controlling for other factors. It means that those with larger land sizes will have a greater likelihood of engaging in agricultural diversification and increasing production levels. This finding supports the findings in Malawi and Zimbabwe, in which the availability of land strongly determines agricultural diversification and food security (Mango et al., 2018; Moyo, 2016). Land fragmentation is thus a challenge. Those farmers with more land in Mutare are able to experiment with different crops (for instance, small grains and legumes) without putting at risk their total maize production. In terms of resource endowment, the average land size was 5.7 hectares (SD = 3.18).

4.3.2.6 Irrigation Access

Access to irrigation was not significant in the study, showing that the impact of this factor can be very context-dependent. Only 46% of the respondents have access to irrigation services. It can indicate that the area has low levels of irrigation coverage or mostly rain-fed farming practices. These results are supported by research conducted in other rural areas of Africa, where institutional support is insufficient (Giller, 2020).

4.3.2.7 Access to Extension Services and Farming Training

Extension and training in agriculture are essential for increasing diversification. Those farmers who received education in sustainable agricultural practices are more aware of the ecological and

nutritional advantages of growing several different crops at once. In Manicaland, the role of extension officers in promoting drought-resistant and nutrient-rich crops cannot be underestimated. According to Makate et al. (2018), access to agricultural extension services has a significant positive effect on the probability of crop diversification adoption. Adjimoti and Kwadzo (2018) have proven that repeated interactions with extension services are an intellectual resource that helps improve cultivation processes and increase productivity. The assumption was that increased contact with extension services would show a positive correlation with nutritional security among respondents. Extension services were found not to have any statistical significance on crop diversification within this study because 66% of the surveyed households had access to extension services, implying that there could be other factors that may influence the effect of extension services.

4.3.2.8 Membership in Farmer Group

The membership variable in farmer groups was statistically significant ($\beta = -1.298$, $p < 0.001$, OR = 0.273). Non-membership in farmer groups was associated with a 72.7% reduced chance of belonging to higher crop diversification classes compared to farmers in farmer groups. 68% of the sampled households were part of farmer groups, and hence being a member of farmer groups in Rural Mutare is likely to result in the provision of social capital, shared labour, and improved seed varieties to the farmers. This shows the importance of collective action and information sharing in promoting crop diversification.

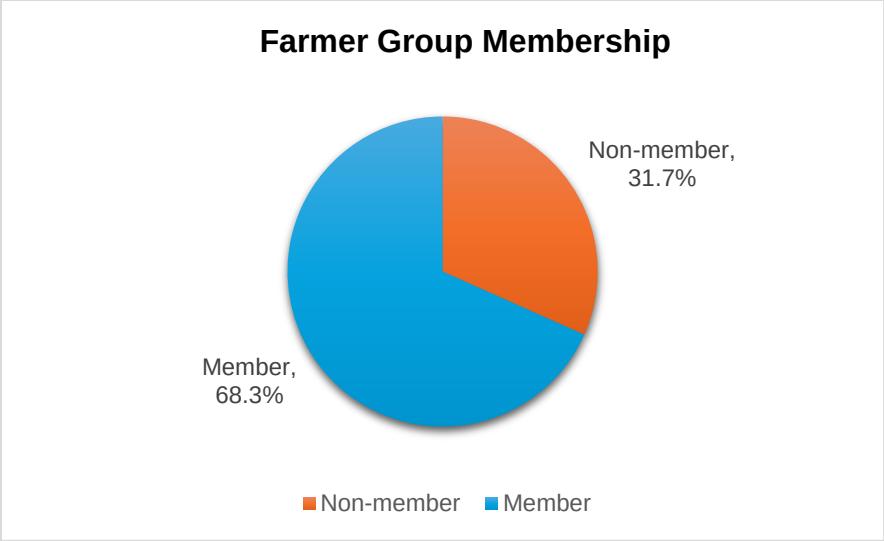


Figure 6: *Respondents' Farmer Group Membership distribution*

4.3.2.9 Farming Experience

Exposure helps in learning about agroecological conditions, pest management, and market dynamics. Experienced farmers can identify appropriate crop mixes that will do well in the region's unpredictable climatic conditions, thus making it easier to diversify their production.

4.3.2.10 Farm Income

Higher farm incomes enable farmers to purchase farming inputs like seeds, fertilizers, and irrigation equipment, which will enable them to engage in diversification. Low incomes hinder the choice of crops and force farmers to grow low-value crops. Diversification is also an income risk management tool in the context of uncertain markets and climatic conditions.

4.3.2.11 Off-Farm Income

Off-farm income creates a margin that enables farmers to diversify into new crops while maintaining basic needs. Off-farm income can also affect the households' risk preference, with financially sound households adopting diversification techniques.

4.3.2.12 Credit Access and Input Availability

Credit enables investments in diversified crops, which may require more capital in the form of high input use (e.g. legumes and horticultural crops). Lack of credit and inputs is a hindrance to diversification among smallholder farmers in Zimbabwe. Accessing credit ensures a household's ability to acquire inputs and food products. Given the importance of the availability of resources

as a basis of agriculture, this accessibility implies higher productivity. A positive relationship is expected between chemical fertilizers use and the enhanced status of the family regarding food safety issues. All other conditions being equal, Stewart (2012) argues that fertilizers are vital for achieving yields and food safety.

4.3.2.13 Market Access and Infrastructure

Distance to markets affects the viability and profitability of crop diversification. Those farmers who have nearby markets can sell perishable products, including vegetables or groundnuts. Bad infrastructure and a lack of transportation options will dissuade farmers from growing crops beyond their own consumption. Mengistu et al. (2021) estimated that distance to commercial trading areas is the first factor determining the level of food safety for the household. According to this study, marginal effect estimates point out a negative relationship; the closer distance to the market implies a lower risk of food vulnerability. The more one minute is reduced from the walking distance to the nearest market, the less the likelihood of food vulnerability increases by 1.00%.

4.3.2.14 Agroecological Conditions

Climate conditions, soil quality, altitude, and temperature determine the type of crop that will grow in the respective area. There are many agroecological zones in Mutare, such that some areas are favorable for cereals while others are favorable for legumes, root crops, or horticultural crops. This will directly impact the level of diversification achievable. Location serves as a dummy control in this case to account for the variations.

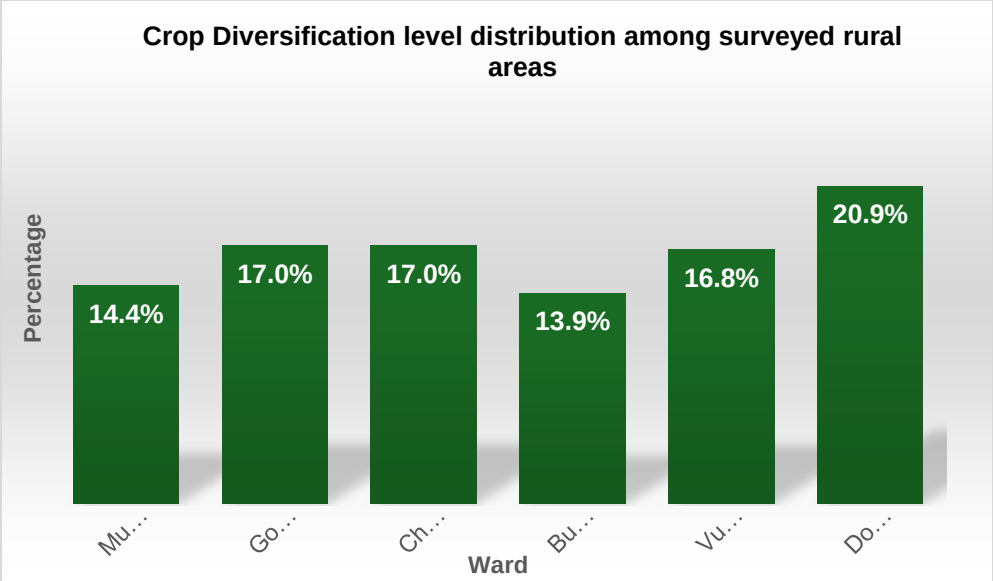


Figure 7: *Crop diversification distribution among surveyed rural wards in Mutare District*

4.4 Discussion

Socio-economic factors directly influence food security outcomes. Education contributes to household food security through improving farm management skills on the farm as well as promoting diverse agricultural practices. Access to land is one of the main determinants of food security since households that have large landholdings have the capacity to practice diversification and produce more. Negative contribution of gender shows that households that are headed by women are relatively food insecure owing to gender inequalities in access to productive assets. Joining farmer groups positively influences food security through increased access to information, inputs, and marketing possibilities. Absence of significant effects from irrigation, extension, and labor could be due to inadequate coverage and poor delivery, or dominance of rain-fed agriculture in the study location. Related results have been found in cases where institutional support systems are lacking (Giller, 2020).

In the context of smallholder farming systems in Manicaland Province, a mean HI of 6 reveals partial success of the diversification approach as well as the existence of several constraints like low landholdings, market access, irrigation facilities, and income diversification. These limitations may limit the extent to which households can turn their diversified cropping into improved diets. However, the lack of inputs, extension, and irrigation services limits the potential of diversification, especially among poor households.

4.5 Recommendations

Considering the interaction between regional differences, which include differences in agro-ecological zones, socio-economic environment, and periodic shocks, the use of a multi-faceted approach will be required in tackling the problem of poor household diversification in these regions. Livelihood diversification, such as encouraging small-scale food processing, small businesses, and crafts, will help minimize the dependence on rain-fed farming systems and hence widen household income sources. Such activities form important avenues through which additional income can be generated. Hence, making it possible for households to buy more diverse foods. Agricultural interventions would have to be made to promote planting of more resilient crop varieties and the adoption of climate-smart agricultural techniques. It is equally important to enable smallholders to access good seeds, fertilizer, and training in sustainable agricultural practices.

It is very important to strengthen the safety net system in order to cushion households against any shock. Expanding cash transfers, targeting food aid, and providing emergency relief, along with credit facilities to the affected households, will help to retain food access and facilitate recovery. Resilience strategies, including the adoption of climate-smart agriculture, setting up an early warning system, provision of improved health services, and conducting peace-building initiatives, would tackle vulnerabilities associated with droughts, pests, diseases, deaths, and conflicts. These strategies will work effectively only when they are contextual and adaptive in nature and designed through partnerships between the local government, extension services, and NGOs so that training, inputs, and technical expertise is provided to the communities. A combined effort of livelihood diversification, resilient farming practices, and strengthening of the safety nets can increase diet diversity, nutrition status, and food security among rural households in Mutare district.

4.6 Conclusion

In this chapter, it has been established and discussed how crop diversification contributes to improving food security among rural households in Mutare through empirical evidence. The results of regression analysis proved that diversifying crops improves food security through enhanced nutritional diversity and reduced vulnerability to food access problems. Despite challenges, diversification still proves to be an effective and sustainable livelihood approach

amidst increasing climate variability. The high explanatory power of the models supports the reliability of the findings and provides a strong empirical foundation for the concluding remarks and policy insights presented in Chapter Six.

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CHAPTER FIVE: Quantity and Quality: Assessing the Dual Impact of Crop Diversification on Rural Household Food Access and Dietary Diversity in Mutare District, Manicaland Province, Zimbabwe.

Abstract

Although crop diversification is strongly advocated in Zimbabwe as a climate adaptation strategy, little empirical work exists regarding the relationship between crop diversification and food access. This research explores the effect of crop diversification (measured by the Herfindahl Index) on the food security status of rural small-scale farmers in Mutare District. Using a cross-sectional research design, food security status was measured through the HFIAS 30-day recall and the 24-hour recall HDDS. The findings from 382 households were analyzed using descriptive statistics, multinomial logistic regression, and multiple linear regression. From the results, households engaging in monoculture (High Herfindahl Index) were found to be highly prevalent among those classified as being 'Severely Food Insecure.' The regression analysis showed that crop diversification increased the odds of moving into a more food-secure class, thus safeguarding the households against the effects of lean-season shocks. Crop diversification is a fundamental approach to enhancing food security status and dietary quality. Policies should shift away from maize promotion and subsidize seeds for a variety of crops (legumes and small grains) to ensure dietary access.

Keywords: *Crop Diversification, Food Security, HFIAS, HDDS, Multinomial Logistic Regression, Multiple Linear Regression.*

5.1 Introduction

Food security is not only about the quantity of calories; it also means having proper access to food and a proper nutritional variety. Maize-based farming in rural Zimbabwe leaves people vulnerable to the risks of adverse climate changes and unstable market conditions. The aim of this chapter is to investigate food security using two measures: HFIAS (Household Food Insecurity Access Scale), which measures food access, anxiety, and severity for 30 days, and HDDS (Household Dietary Diversity Score), which measures dietary diversity using 12 FAO food groups in 24 hours. The discussion will include empirical findings and literature to improve the comprehension of how crop diversification can contribute to food security under climate threats and socio-economic challenges. This discussion connects empirical evidence to the

literature review and the conceptual framework of the study. Through the analysis of quantitative data, this chapter explains how crop diversification acts as a strategy to increase resilience and improve nutrition.

Hypothesis:

A lower Herfindahl Index (greater crop diversification) significantly improves:

1. HFIAS category outcomes (reduces severe food insecurity).
2. HDDS scores (increase the number of food groups consumed).

5.2 Materials and Methods

The fieldwork was conducted in Mutare, Zimbabwe. Sampling Procedure: Multi-stage sampling of smallholder farming households (Sections 3.3 and 3.4). Primary data were collected using HFIAS and HDDS questionnaires. HFIAS: 30-day recall (9 standardized questions; classified as Secure, Mild, Moderate, Severe). HDDS: 24-hour recall using 12 FAO food groups to obtain dietary intake (Section 3.5).

5.2.1 Measurement of food security

Household Food Insecurity Access Scale (HFIAS)

HFIAS was employed to determine household food poverty. The tool measures the extent to which and frequency of household food access problems occurred in the past four weeks. The HFIAS consists of 9 questions assessing the three main dimensions of food insecurity, namely: worry regarding food supply, poor quality and quantity of food, and food coping strategies (such as reduced meal sizes and skipping meals) within the previous 30 days. The participant reports the occurrence of each situation (Questions Q1a-Q9a as adapted from Mango et al., 2018). The response to each question is assigned based on the HFIAS frequency scale, and the scores obtained for the individual items are summed according to the HFIAS formula below. The total score varies from 0 (food secure) to 27 (food insecure), depending on the level of food insecurity, where higher scores indicate higher levels of food insecurity (Deitchler, 2011; Sankar, 2022). Categorical scores were calculated using the classification scheme of the HFIAS. Food Secure (0-1), Mildly Food Insecure Access (2-8), Moderately Food Insecure Access (9-14), and

Severely Food Insecure Access (15-27) were used to analyze households' responses across the nine domains.

The formula is expressed as:

$$HFIAS = Q1a \times F1 + Q2a \times F2 + Q3a \times F3 + Q4a \times F4 + Q5a \times F5 + Q6a \times F6 + Q7a \times F7 + Q8a \times F8 + Q9a \times F9$$

The outcomes of each question are summed to yield the final score, which ranges from 0 (food secure) to 27 (severely food insecure). A high HFIAS score implies severe food insecurity, whereas a low score indicates reduced food insecurity (Sankar, 2022).

Household Dietary Diversity Score (HDDS)

The Household Dietary Diversity Score (HDDS), which estimates the number of different types of food consumed by a particular household, is a widely used proxy measure of the nutritional security of a household and has been found to be strongly correlated with anthropometric measurements of nutrition and food security. Due to this correlation, a lot of research has used HDDS to evaluate the nutritional status of households (Headey & Ecker, 2013; Maxwell, Vaitla, & Coates, 2014; Feyisa et al., 2025; Aweke, Lahiff, & Hassen, 2020; Nkonde et al., 2021; Ogunniyi et al., 2021). The HDDS used in this study was obtained from a 24-hour food consumption survey. Consumed items were put into 12 categories normally used for dietary diversity evaluation: (1) cereals (maize, sorghum, wheat), (2) roots and tubers (potato, sweet potato, yams), (3) vegetables (carrot, cabbage, tomato), (4) fruits, (5) meat, offal and poultry, (6) eggs, (7) fish and seafood, (8) pulses and legumes, (9) milk and dairy products, (10) oils, fats and butter, (11) sweets (sugar, honey), and (12) condiments, spices and others.

The consumption of foods in each category during the last 24 hours by any household member was recorded, and the number of categories consumed was used to generate the HDDS score. In terms of interpretation, households are categorized based on the level of diversity of the diet: Low Dietary Diversity (HDDS 0-3); Medium Dietary Diversity ($3 < HDDS \leq 7$); High Dietary Diversity ($HDDS > 7$), which is similar to common HDDS cut-offs as per the literature.

5.2.2 Data Analysis Procedure

Different models were applied to the two selected food security indicators. The multinomial logistic regression model (as discussed in Section 3.6) was applied to the analysis of HFIAS, where the data are ordinal categorical. The HFIAS categories are ordinal, and an ordinal logistic regression model was initially estimated. However, the test of parallel lines revealed that there was a violation of the proportional odds assumption ($p<0.05$). A Multinomial Logistic Regression model was applied to overcome the violation since it does not require the proportional odds assumption to provide a consistent estimation of the categorical outcome. In the case of HDDS, the count is from 0 to 12 foods, and a Multiple Linear Regression model was applied to estimate the data.

5.3 Results

5.3.1 Descriptive Statistics: Food Access (HFIAS)

The results indicate that the majority of households in the study area experience some level of food insecurity. Only 22% of households were food secure, while 78% were food insecure to varying degrees. Mild food insecurity was the most prevalent category (39%), followed by moderate (24.9%) and severe food insecurity (14.1%). These findings suggest that a large proportion of households face challenges in accessing adequate food, with many experiencing compromised food quality and quantity. The presence of severe food insecurity further indicates that some households are highly vulnerable and may experience extreme food deprivation.

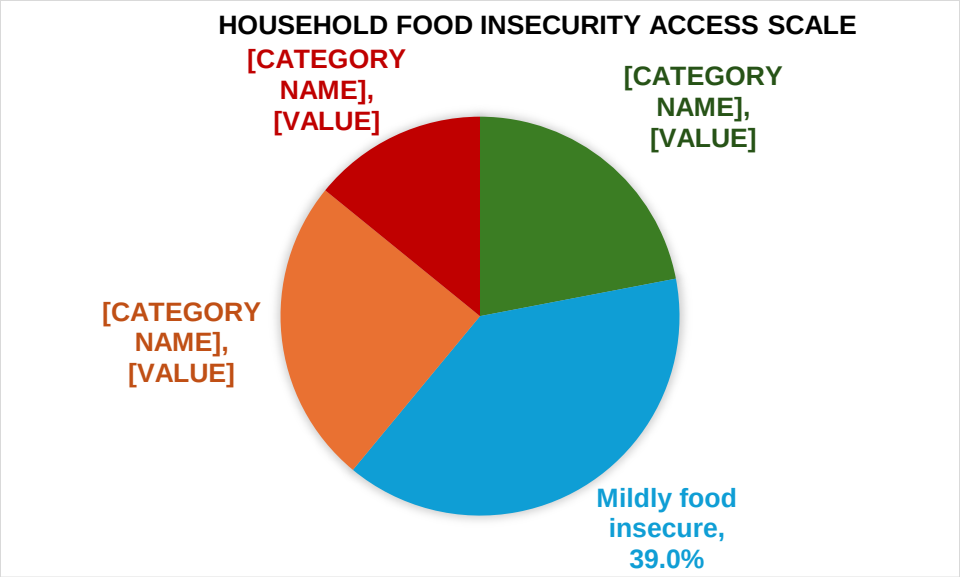


Figure 8: *Household food insecurity status based on HFIAS classification*

5.3.2 Descriptive Statistics: Dietary Diversity (HDDS)

The mean Household Dietary Diversity Score (HDDS) of 6 (≈ 6.40) (SD=2.13) indicates that, on average, rural households in Mutare District consumed foods from approximately six out of twelve different food groups within the 24-hour reference period, suggesting moderate dietary diversity among households in the study area. The results show considerable variation in dietary diversity, indicating disparities in food consumption patterns.

Table 2: *Percentage of Household Consuming Different Food Groups (24-hour Recall)*

Food Group	Number of Households	Percentage (%)
Cereals	382	100.0
Roots and Tubers	228	59.7
Vegetables	363	95.0
Fruits	176	46.1
Meat, Offal, and Poultry	188	49.2
Eggs	154	40.3

Food Group	Number of Households	Percentage (%)
Fish and Seafood	104	27.2
Pulses/Legumes	293	76.7
Milk and Milk Products	119	31.2
Oils, Fats, and Butter	226	59.2
Sugar, Sweets, and Honey	147	38.5
Condiments, Spices, Miscellaneous	64	16.8

The results show that cereals (100%) and vegetables (95%) were the most common food groups taken, showing the predominance of staple-based diets. The legumes were also consumed by many individuals (76.7%), acting as sources of protein. On the other hand, the intake of animal-source foods, including meat (49.2%), eggs (40.3%), fish (27.2%), and milk (31.2%), was quite low, showing carbohydrate-based diets without adequate intake of high-quality protein and important micronutrients. Fruit consumption was also modest (46.1%). Therefore, the results show that while there is consumption of various food groups, the diets are characterized by consumption of staples, where nutrient-dense foods are lacking, hence poor dietary diversity. 55.8% of the selected households (Figure 5) have a high HDDS. Nonetheless, their diets continue to be characterized by a few types of staple foods with poor intake of nutrient-dense foods, including animal-source foods, fruits and seafood. It is clear that while such diets are not characterized by deprivation, they are still at risk of developing micronutrient deficiencies and food shortages seasonally.

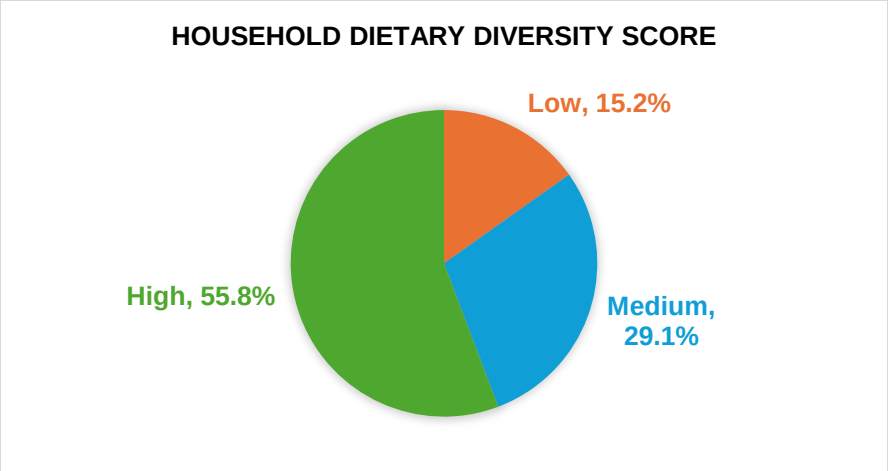


Figure 9: *Distribution of household dietary diversity (HDDS) among surveyed households*

Food-insecure households did not have much access to varied kinds of foods because of lower crop diversification practices and economic challenges, as well. The research findings are consistent with previous literature, which claims that food insecurity restricts households' access to diverse foods as it lowers their purchasing capacity (Langer et al., 2024; Ukonu et al., 2024). For instance, one study conducted in South-eastern Nigeria reported that most households consumed starchy foods instead of protein-rich foods, which means that food insecurity has a direct effect on the dietary composition (FAO, 2018; Ukonu et al., 2024).

The moderate HDDS mean (6) is consistent with multiple linear regression results obtained in the study, according to which the level of dietary diversity positively influences the probability of achieving medium-high and high levels of crop diversification. Therefore, there is a two-way relationship between the variables in question: crop diversification positively influences the household's access to diverse kinds of foods; conversely, increased dietary diversity encourages households to use diverse cropping systems (Bellon et al., 2020; Sibhatu et al., 2015).

5.3.3 Regression Results: Impact of Crop Diversification on Food Security

Model 1: Multinomial Logistic Regression (HFIAS)

Crop diversification, as measured by HI, was established to have an effect on HFIAS. The coefficient for HI is statistically significant at the 5% level and exhibits a positive effect on HFIAS of the household. Since crop diversification intensity is high, it follows that the diversity in food crops consumed within the household will also be high, hence explaining the positive

relationship. Thus, crop diversification enhances food consumption in rural Mutare. The multinomial logistic regression analysis shows that crop diversification has an effect on the food security status of the household. The HI was positive and statistically highly significant for all the levels of food insecurity ($p < 0.001$). It means that the households with higher crop concentration are more likely to suffer mild, moderate, or severe food insecurity compared to food-secure households.

Increased crop diversification reduced the probability of being food insecure. This finding supports the study's hypothesis that crop diversification has a positive contribution to food security among rural households in Mutare. Crop diversification improves food availability and reduces risk on any one particular crop. Such results have been observed in Zimbabwe and other parts of sub-Saharan Africa, whereas crop diversification leads to increased food consumption, income stability, and nutritional benefits (Mango et al., 2014; Makate et al., 2016; Adjimoti & Kwadzo, 2018). The Household Food Insecurity Access Scale (hfias_cat) has a negative and significant association with food security ($p < 0.001$). This implies that as food insecurity rises among households, food security falls because households experiencing food insecurity cannot diversify their crops due to liquidity and risk constraints. Similar findings have been found in Malawi and Zimbabwe, where food insecurity access scores were high since food availability and consumption were unstable (Mango et al., 2018; Nyathi & Ndlovu, 2022).

Table 3: *Multinomial Logistic Regression (MLR) Estimates for Factors Influencing Household Food Insecurity (HFIAS)*

	Mildly Food Insecure				**Moderately Food Insecure**				**Severely Food Insecure**			
Variable	**Estimate (β)**	**Std. Error**	**p-value**	**Exp(β)**	**Estimate (β)**	**Std. Error**	**p-value**	**Exp(β)**	**Estimate (β)**	**Std. Error**	**p-value**	**Exp(β)**
Crop Diversification (HI)	30.308***	4.735	0.000	1.45E+13	46.488***	5.223	0.000	1.55E+20	53.871***	5.447	0.000	2.49E+23
Land Size	-0.043	0.056	0.448	0.958	-0.081	0.077	0.291	0.922	-0.074	0.096	0.438	0.928
Household Labour Availability	0.045	0.052	0.390	1.046	0.073	0.070	0.297	1.076	0.066	0.086	0.443	1.069
Gender (Female=0)	-0.111	0.370	0.764	0.895	0.587	0.492	0.233	1.798	0.609	0.601	0.311	1.839
Education (No)	-0.141	0.619	0.820	0.869	0.149	0.759	0.844	1.161	0.031	0.916	0.973	1.031
Education (Primary)	-0.437	0.388	0.259	0.646	-1.289	0.525	0.014	0.276	-0.858	0.655	0.190	0.424
Farmer Group Membership	-0.337	0.420	0.423	0.714	-0.219	0.531	0.680	0.803	0.246	0.636	0.699	1.279
Irrigation Access	-0.220	0.343	0.521	0.803	-0.007	0.455	0.987	0.993	-0.476	0.563	0.398	0.621

Variable	Mildly Food Insecure				Moderately Food Insecure				Severely Food Insecure			
	Estimate (β)	**Std. Error**	**p-value**	**Exp(β)**	**Estimate (β)**	**Std. Error**	**p-value**	**Exp(β)**	**Estimate (β)**	**Std. Error**	**p-value**	**Exp(β)**
Extension Access	0.387	0.403	0.337	1.472	0.601	0.512	0.241	1.823	0.041	0.636	0.949	1.042

Notes: N=382, Reference category: **Food Secure**. Pseudo-R^2 Nagelkerke = 0.701, χ^2 = 402.769, ***df*** = 27, $p < 0.001$, *Significant at $p < 0.05$.

Reference categories: Education (Secondary+) = 2, Gender (Male), Irrigation (Yes), Extension (Yes), Farmer group (Yes).

The more crops a household cultivates, the less food insecurity it suffers. In the case of Mutare District, this means that greater crop diversification leads to less intensity of food shortages and less reliance on harsh survival measures. Households with a large number of crops in a particular growing period have a smaller probability of using such practices as not having meals or selling their productive assets, as crop diversification increases production and income, as well as the availability of food. Such a relationship was confirmed by several empirical studies showing that there is a positive correlation between crop diversity and food security (Lin, 2011; Njeru, 2013; Makate et al., 2016).

In the case of a varied climate of Mutare District, such an approach also helps to reduce risks associated with droughts and floods. In case the small-scale farmers continue to expand the growing area of traditional crops like maize and tobacco instead of more resilient crops, the consequences of drought and floods may become more negative for food security (Holden & Lunduka, 2010). Increased diversification of crops enables farmers to avoid the maize poverty trap, where poor weather conditions prevent maize from attaining full maturity. The study also identified education as one of the significant factors determining food security. It is worth noting that individuals with primary education ($\beta = -1.28$, $p = 0.014$) had higher odds of not being moderately food-insecure compared to the reference category. Individuals with higher education are better prepared to deal with food insecurity.

Food-insecure households with a head having secondary education had significantly lower odds of being moderately food insecure compared to food-secure households. Households with a head having secondary education have higher chances of having better food security and higher food consumption levels compared to food-insecure households with uneducated household heads. An educated head has the capability to interpret extension advice and efficiently diversify the

cropping system while undertaking off-farm activities to supplement their income. Higher education improves access to information, which enhances decision making among farmers for improved management and increased food availability year-round. Several empirical studies have shown a positive correlation between the education level of the household head and household food security. (Makombe et al., 2010; Idrisa et al., 2008).

Variables such as land size, labour availability in households, gender of households' heads, being members of farmer groups, access to irrigation, and access to extension were found to have no statistically significant association with household food security. While there was a tendency of a slightly greater possibility of moderate food insecurity among female-headed households ($\beta = 0.58$), the effect was not statistically significant ($p = 0.233$). This is consistent with your findings in Chapter 4 that gender is not a key determinant of food security, but resources are. Highly diversified farms are more likely to be food secure than a huge monoculture farm.

Model Fitting Information criteria were used to evaluate the fitness of the whole model. Addition of the independent variables improved the goodness-of-fit of the model compared to the base model (intercept only) ($\chi^2 = 402.769$, df = 27, $p < 0.001$) (see Table 2 below). A marked reduction in the -2 Log Likelihood (-2LL) from 1009.315 to 606.546 shows that the chosen predictors significantly discriminate between the various household food insecurity categories in Mutare district. The pseudo-R-squared values show good explanatory power of the multinomial logistic regression model. The Nagelkerke R^2 of 0.701 indicates that the independent variables account for about 70.1% of the variance in household food insecurity status. The findings indicate that the independent socioeconomic and agricultural factors, such as crop diversification, considered in the model, make up an important part of the explanation of differences in household food security among the smallholder farmers in the district of Mutare.

Model 2: Multiple Linear Regression (HDDS)

From the multiple linear regression analysis, it is clear that crop diversification is one of the major determinants of household dietary diversity. The Herfindahl Index had a negative sign and was very significant ($\beta = -9.953$, $p < 0.01$), meaning that more crop diversification contributes greatly to dietary diversity among rural households. This finding gives support to the theoretical basis of the study in that diversified cropping systems contribute to greater food availability,

dietary diversity, and reduced food insecurity among the smallholder farmers. More consumption of different food groups means more food security. Diverse farming practices have also been associated with increased dietary diversity and better nutritional status in previous studies conducted in Zimbabwe and Malawi (Rubhara et al., 2020; Ngoma et al., 2023). The standardized coefficient also shows that crop diversification is the most important factor in the model. On the contrary, other socio-economic factors, including gender, education, and land size, among others, were not statistically significant.

Table 4: *Multiple Linear Regression for Factors Influencing Household Dietary Diversity (HDDS)*

Variables	**Coefficient (β)**	**Std. Error**	**β**	**t-value**	**p-value**
Constant	11.084***	0.457	—	24.276	0.000
Crop Diversification (HI)	-9.953*	0.561	-0.729	-17.757	0.000
Gender	-0.138	0.162	-0.032	-0.856	0.392
Education	-0.141	0.122	-0.045	-1.159	0.247
Farmer Group Membership	-0.222	0.178	-0.049	-1.248	0.213
Irrigation Access	-0.107	0.156	-0.025	-0.689	0.491
Extension Access	0.047	0.170	0.010	0.276	0.782
Land Size	0.003	0.026	0.005	0.123	0.902
Household Labour Size	-0.009	0.024	-0.014	-0.387	0.699

Notes: N= 382, Dependent variable is HDDS Total Score (0-12). R = 0.711; R^2 = 0.505; Adjusted R^2 = 0.495; Std. Error = 1.512 F-statistic = 47.609, ***Significant at $p < 0.001$.

The fact that 50.5% of the variability in household food security has been accounted for by the regression model (R^2 = 0.505) indicates that the model is highly explanatory and valid for cross-sectional household data, as is common with agricultural livelihood literature studies in developing country settings. The validity of the model is further indicated by the adjusted R^2 value of 0.495 for the number of explanatory variables used. The model itself is highly

statistically significant ($F = 47.609$; $p < 0.001$). This implies that the independent variables affect household food security as a whole. It can be concluded that crop diversification may help improve the nutritional status of the small-scale farmers. The standardized residual plot against predicted values (Figure 9) shows that the residuals are scattered randomly with no pattern or structural shape. This implies that the homoscedasticity assumption holds. While clustering has occurred slightly because of the discrete nature of the HDDS variable, there is no heteroscedasticity problem or model misspecification.

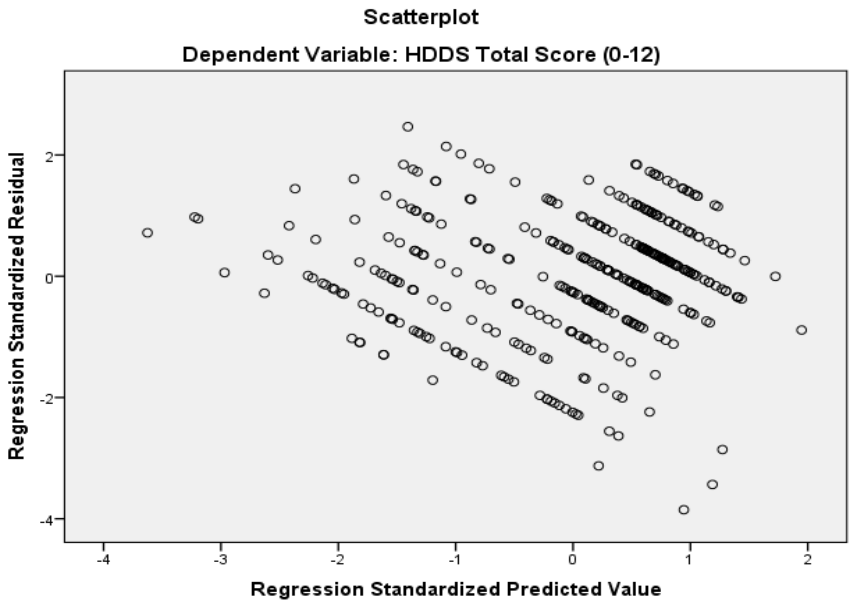


Figure 10: *Standardized Residual plot for HDDS Regression model*

5.3.4 Qualitative Findings

Whereas quantitative data provided statistical relations between crop diversification and food security variables, qualitative data offered an explanation of those relations in terms of the why and the how, thus adding value to the analysis through interpretation. The qualitative aspect of this study enhances the quantitative findings in terms of giving a context-specific insight into the lived experiences, perceptions, and decisions of smallholder farmers from Mutare District. It emerged from FGDs and KIIs that the farmers regard crop diversification as one of the key ways of adapting to climate change, food shortages, and income uncertainty. Farmers stressed that crop diversification enhanced their food availability and reduced their dependency on markets during droughts.

5.4 Discussion

The results show that crop diversification is an important contributor to household food security in Mutare District because it enhances food availability, diet diversity, and food security against climatic shocks. The findings are in line with other studies that have been done in the Manicaland region and southern Africa in general, which indicate crop diversification as an important adaptation strategy among smallholder farmers (Makate et al., 2016; Mango et al., 2018). Households with diverse crop systems have higher diet diversity and lower food insecurity.

The above results support the findings of studies from Sub-Saharan Africa, which have indicated that diversification increases resilience to climatic shocks, promotes stability of income, and improves nutrition outcomes. Pseudo R-square (Nagelkerke = 0.705) shows high explanatory ability and is consistent with the linear regression analysis ($R^2 = 0.505$). The above results imply that diversified crops, along with productive inputs, help enhance food security, thus increasing resilience and food security outcomes. A standard error of 0.457 (see Table 3) shows that household heterogeneity in the decision to diversify is sufficiently explained by food security status, size of land, level of education, and access to institutions. Nevertheless, the above error also indicates the existence of some unobserved variables like climatic variability, market price changes, and farmer preferences, which can affect the diversification decision-making process. Monocropping of maize in Mutare district supplies the needed caloric intake (sadza), but it does not ensure enough micronutrients. In case of rainfall shocks, households with mono-crops suffer from the extreme decrease in HDDS scores.

These findings provide strong empirical evidence on the extent to which crop diversification increases the level of food security among rural households in Mutare District. The positive and highly significant coefficient of crop diversification shows that households growing varied types of crops have higher levels of food security compared to those that grow few types of crops. The results thus confirm the theory that crop diversification leads to food security by increasing the availability of food and reducing vulnerabilities. These findings are consistent with previous findings from Zimbabwe and other parts of sub-Saharan Africa, whereby crop diversification has been positively related to increased food consumption and income stability (Makate et al., 2016; Mango et al., 2018; Waha et al., 2018).

The positive association between dietary diversity and food security reveals the nutritional advantages that come with crop diversification. Growing diverse crops allows households to obtain different food groups, thereby improving diet quality. This finding is consistent with previous findings where agricultural diversification improves household dietary diversity and nutrition (Adjimoti & Kwadzo, 2018; Ngoma et al., 2023). Positive correlation between diversification and food security is linked to legumes, small grains, and horticulture products, improving the quality of diet and spreading the risk of production. Negative correlation between food insecurity access (hfias_cat) and food security is consistent with theoretical predictions and thus proves the validity of the food security indicators used in this study. Those households that have experienced frequent problems related to shortage and anxiety in relation to food availability are significantly less food-secure than others, as was found previously in other studies conducted in southern Africa (Mango et al., 2018).

5.5 Conclusion

In this chapter, the aim was to estimate the dual effect of crop diversification on the volume of food access and the quality of diet among a sample of smallholder farmers from Mutare District. It turned out that there is strong empirical evidence in support of the hypothesis that moving away from the traditional practice of growing only maize and towards the diversification of crops plays an important role in ensuring household food security. The descriptive analysis showed a high food insecurity rate (78%) among people whose diets consisted mainly of cereals and vegetables but lacked fruits and protein. The Multinomial Logistic Regression model showed that crop concentration (high Herfindahl Index) greatly raises the probability of being in the 'Severely Food Insecure' classification. On the other hand, Multiple Linear Regression results proved that crop diversification is the main predictor of better diet quality, accounting for about 50.5% of HDDS variation ($R^2 = 0.505$).

Among the main lessons learned from the analysis is the fact that while socioeconomic determinants such as education level create a certain basis of resilience, they cannot be a substitute for agricultural diversification. Determinants like land size and gender were insignificant in the model, meaning that diversification intensity, not the farm size per se, is the key driver of food security in Manicaland Province. Overall, crop diversification can be considered both a pathway to balanced nutrition and a resilience tool that helps to overcome the

"maize poverty trap" and protects from climatic instability. The above results form the empirical basis for policy recommendations stated below in Chapter 6.

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CHAPTER SIX: Summary, Conclusion, and Recommendations

6.1 Introduction

This final chapter consolidates the core findings, overarching conclusions, and practical policy directives emerging from this research, which explored how agricultural diversification influences household nutritional security across rural communities within Mutare District, Manicaland Province, Zimbabwe. The research was designed to evaluate the effects of diversified cropping systems on food security through examining whether diversified cropping systems increase food availability, dietary diversity, and resilience to shocks, and the effect of socioeconomic and institutional characteristics on food security outcomes.

The findings from empirical evidence gathered from Sub-Saharan Africa show that agricultural diversification plays a considerable part in household food security. Diversified cropping systems contribute positively towards food availability, dietary diversity, and resilience to climate change and shocks. Nonetheless, the research has found that crop diversification is not sufficient in itself for ensuring that optimal food security outcomes are attained. There are socio-economic determinants, such as level of education, land endowment and security, gender relations, membership in farmers' associations, and availability of extension and credit services.

This chapter summarizes the key findings of the research, concludes the discussion, and provides policy recommendations in order to enhance the livelihoods of rural people. The recommendations highlight the importance of a holistic approach that integrates crop diversification with gender-oriented policies, institutions, education, good land governance, and financing agriculture. By situating the results within the broader literature and regional development agendas, this chapter serves as a platform for translating research findings into practical steps to enhance food security in Mutare district and other rural settings.

6.2 Research summary

The current research examined the role of crop diversification in enhancing household food security of small-scale farmers in Mutare district, Zimbabwe. This research was prompted by the existing food insecurity problem, characterized by climate change, overdependence on maize cultivation, and lack of alternative food sources in the region. The main aim was to determine whether increasing crop diversity has any impact on improving both the quantity and quality of

food consumed by the small-scale farmers in question. The research adopted a cross-sectional study design and collected the primary data from 382 households through questionnaires, focus group discussions, and interviews. Food security was evaluated through two indicators, HFIAS, measuring the psychological and physiological state of food access over a period of 30 days, and HDDS, measuring the nutritional diversity in a 24- hours timeframe. The study gave a detailed description of the district's food security situation analyze dietary diversity. The Herfindahl Index was used to quantify crop diversification, but other socioeconomic variables like land size, education, gender, and service access were added as control factors. Descriptive Statistics (Ordinal and Multinomial), Logistic Regression, and Multiple Linear Regression models were employed for data analysis.

From the descriptive statistics, only 22% of the households were food secure, whereas 78% faced food insecurity in different magnitudes. There was moderate dietary diversity with HDDS of about 6.4 food groups. But there was dominance in staple foods and a very small proportion of protein-rich and micronutrient-rich foods like meat, dairy products, fish, and fruits in the diets. The statistical analysis revealed that diversification has a strong explanatory capacity on food security levels, even when controlled for other socioeconomic variables like land size and education. And econometrics revealed that crop diversification positively impacts food security levels.

Families with little diversification (high Herfindahl Index) were likely to end up in the category of severe food insecurity, while those that were diversified had better food security and dietary diversity. The HDDS model revealed that the most powerful factor influencing household dietary diversity is crop diversification, which explains a great deal of variance in dietary diversity among households. In general, this research proved empirically that crop diversification is an effective way to ensure food security, improve dietary quality, and increase the resilience of rural farming families.

6.3 Research Conclusion

The evidence presented in this study proves that crop diversification is not only an agronomic measure but also a key element of food security and climate resilience of households in the Mutare District. This hypothesis was verified: the higher the degree of crop diversification, the less severe food insecurity is, and the greater the dietary quality. It is clear from the results that

food insecurity is still a big problem in the study area, where a significant number of families face insufficient and poor-quality food intake. One notable finding from the data is the "maize-poverty trap," where the households whose sole objective in agriculture is to produce cereals for bulk calories end up being the most susceptible to seasonal effects and deficiencies in micronutrients. It is noted that crop diversification contributes to the nutritional security of households by increasing dietary diversity. This way, the households will have improved their diets and minimized the risks of having deficiencies in their diets. By incorporating crops such as legumes, fruits, and vegetables, households can improve the quality of their diets and reduce the risk of micronutrient deficiencies.

The findings suggest that current institutional support, such as extension services and irrigation, while present, must be more intentionally aligned with diversification strategies to maximize their impact. Diversified cropping systems improve food availability, dietary diversity, and resilience, while socio-economic factors such as education, land access, and social capital further shape food security outcomes. Promoting crop diversification alongside supportive socio-economic and institutional interventions can significantly enhance food security and rural livelihoods in the study area. The findings emphasize that crop diversification is not only a production strategy but also a critical pathway for enhancing resilience, nutrition, and overall household welfare. The diversified agriculture increases the food availability, dietary diversity, and resilience, together with the socio-economic factors such as education, land, and social capital affecting food security outcomes.

In the context of sustainable agriculture, these results provide a clear mandate for a shift in extension messaging. In order for the rural families in Manicaland province to progress from being "mildly food insecure" to being "food secure," the emphasis must shift from producing high yields of a single staple crop to optimizing the biodiversity of the entire farm system. This is important to ensure reliable access to different food groups and hence improvement in the nutritional status of the rural population.

In summary, crop diversification among smallholder farmers could be an efficient means of improving food security and ensuring food nutrition security in rural areas of Zimbabwe. Strengthening policies that support diversified agriculture will be essential for achieving long-term food and nutrition security, particularly in the face of increasing climate variability.

6.4 Policy implications and recommendations

Based on the study findings, the following policy recommendations are proposed:

6.4.1 Promote Crop Diversification

Crop diversification, in particular, promotion of legumes, small grains, and underutilized and drought-tolerant crops, should be an important component of agricultural development programs. The mean HDDS from the policy angle indicates that although diversification of crops is necessary for a good dietary diversity, it is not enough, as other measures like agriculture for nutrition, extension services that focus on crops high in nutrients, development of irrigation systems, and market access need to be put in place to ensure better dietary results.

6.4.2 Strengthen Farmer Organizations

It would be important for government and development partners to empower farmer groups through training, inputs, and markets to strengthen collective action. Agricultural development actors (NGOs, the government, development partners, Academia, and technical institutions) can play an instrumental role in forming rural farmers' groups, especially those composed of women, so that they can work for themselves as agents of change in farming and food security. The Land Administration Project in Ghana was designed to formulate a gender strategy for solving the issues related to land administration issues affecting women and men by collecting gender-sensitive data and engaging women and men in the design, implementation, monitoring, and evaluation of LAP. There are five thrusts of this gender strategy in LAP: public education, capacity building, institutional processes, advocacy, and collaboration and networking.

6.4.3 Enhance Gender-Sensitive Interventions and Agricultural Policies

Supports must be offered to female-headed households by providing them with better access to land, credit, extension services, and labor-saving technologies. Enacting laws that would help provide an equitable distribution and ownership of land for women, recognizing their contribution towards livestock production. Developing a policy that favors women considering their double marginalization and dominance in crop production. Creating a ‘gender desk’ in government offices that would help put the policy into action.

6.4.4 Invest in Education and Capacity Building

It is important to invest in training programs for farmers and adults as a way of improving the decision-making process and diversification of farming systems. Conducting specific training programs targeting women on livestock management, market access, and finance. It is also important to make sure that women have access to technical information and training on crop production, livestock management, sustainable agriculture, and climate change, thus making them more efficient in food security. Empowering rural communities and women with information will result in better food systems, as evidenced by the Capacity Building Program in Ethiopia (FAO, 2013b). Training of women farmers in different areas of farm management, including planting practices, crop rotation, storage facilities, costing and pricing, machinery maintenance, labor management, and marketing of produce, enhances the food chain.

6.4.5 Enhance Land Access and Tenure Security

Land tenure security policies should be encouraged in order to create an environment for investment in diverse and sustainable agriculture. Develop clear legal and policy provisions that will protect the land rights of women, as is done in Tanzania through its Land Act (FAO, 2012b). Example two: In Kenya, the Young Widows Advancement Program carried out action research financed by the International Land Coalition with the aim of assisting young widows residing in Nairobi but married in Nyanza province. The initiative helps the widows to avoid being dispossessed of the property and regain any lost land rights following widowhood. According to the Kenyan Succession Act of 1981, women can inherit property as dependents of their late husbands (GROOTS Kenya, 2011). Also, gender sensitive land redistribution should be considered, as is done in Zambia's Land Reform Program. Create a functional market for land so that there will be buying and selling of land, as in Ghana's Land Market Program, and create a land registration program to ensure secure land tenure and enable land transactions, as in Kenya's Land Registration Program.

6.4.6 Agricultural Finance

Make agricultural finance and insurance available to ensure funds for investment into the land, as in Uganda's Agricultural Finance Program. Provide inputs and farm equipment and machinery to women farmers not only because they need it for increased production, but also for increased security of tenure. While there is a need for an improved legal framework, research has revealed

that security of tenure depends upon other non-traditional elements in the fluid and dynamic circumstances in Zimbabwe at present.

6.5 Areas for further research

Regenerative agriculture (RA) focuses on soil health improvement, restoration of biodiversity, and ecosystem functions through nature-based farming methods. Cover cropping, diversified crop rotations and reduced tillage practices are some of the ways in which regenerative agriculture works for building up soil quality and moisture. RA is beneficial in terms of sustainability and resilience of farming systems and provides ecosystem services as well as farm productivity.

Also, many RA techniques enhance soil carbon sequestration, providing an additional benefit to the climate mitigation effort. Farmers who implement regenerative agriculture practices often observe decreased input costs, increased yields, and soil quality, as well as contributions to sustainable economics and the environment in the long run. (McLennon et al., 2021; Schreefel et al., 2020; Khangura et al., 2023; Schulte et al., 2022; Ranganathan et al., 2020). RA is increasingly recognized as a revolutionary way to tackle ecological and social problems by means of restoration, improvements in soil structure and biodiversity, and direct fight against climate change using practices that go beyond standard sustainability (Sher et al., 2024).

Plant breeding has enabled the development of crop varieties with resistance to climate shocks, pests, diseases, and stress. Breeding techniques, including both classic and modern breeding techniques, such as marker-assisted breeding and genome editing, were applied to develop drought-resistant, heat-resistant, and overall stress-tolerant varieties, allowing farmers to mitigate climate risks in their production and increase revenues. Field tests and adoption studies have found that those varieties yield more crops in unfavourable conditions compared to the local check variety, but performance may vary for different crops and environments (Hafeez et al., 2023).

Though breeding is a potent adaptive mechanism, its efficacy will depend on the existence of functioning seed systems, availability of improved seeds to farmers, effective extension support, and regulation and market structures; all these elements may hamper adoption and delayed impact (Prasanna et al., 2021). Further research should incorporate varietal improvement along

with strategies to ensure better seed delivery systems, farmer training, and farm-level trials to guarantee that resilient cultivars deliver tangible benefits to farmers. Better-yielding varieties of small grains, legumes, fruits, and vegetables can be developed through breeding to increase food diversity and yield (food security).

Digital and biotechnologies are rapidly converging and transforming Climate Smart Agriculture practices and increasing the resilience of the food system. High-resolution remote sensing with the use of hyperspectral and thermal imagery complemented by machine learning analytics can provide field-level intelligence on soil health, moisture status, and crop stress, allowing for more informed decisions about crop diversification and intervention (Konfo et al., 2024). On the other hand, blockchain and traceability solutions will contribute to greater supply chain transparency and added value of diversified production in terms of origin and quality. Robotics, automation, and immersive tools (virtual/augmented reality) offer new ways to scale precision management and farmer training, while additive manufacturing (3D printing) supports rapid prototyping of low-cost farm tools and spare parts.

The emergence of biotechnologies, such as bioinformatics and genome editing, especially in the CRISPR approach, is rapidly enhancing the breeding of varieties resistant to local stress factors (such as heat, drought, and pests), which would enable crop adaptation to local conditions and decrease the need for inputs (Nakamae & Bono, 2022). Thus, all these innovations will help achieve more accurate crop-to-environment fit; however, their efficiency requires affordable access to relevant data and analytics, functional seed and input delivery, a clear regulatory framework, and farmer approval. Integrated research that will include remote-sensing confirmation, field testing of gene-edited varieties, and socioeconomic studies of their adoption will be key to achieving positive results (Konfo et al., 2024; Nakamae & Bono, 2022).

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5.7 Appendices

Appendix A: Household Survey Questionnaire

Includes all structured questions grouped by section.

Title: Crop diversification and Its Contribution to Food security among Rural Households in Mutare District, Manicaland Province, Zimbabwe.

Estimated Time: 30–40 minutes **Enumerator Name**: _____ **Date**: _____

Ward: _____Village: _____ **Household ID**: _____

Section A: Demographics

1. Gender of household head: ☐ Male ☐ Female
2. Education level of household head: ☐ None ☐ Primary ☐ Secondary or Tertiary
3. Membership of household head in a Farmer Group: ☐ Yes ☐ No
4. Access to irrigation: ☐ Yes ☐ No
5. Access to extension services: ☐ Yes ☐ No
6. Land size(owned/leased): _____ ha
7. Household labour availability: _____ persons

Section B: Crop Productions and Diversification

(Used to compute Herfindahl Index)

List all crops grown in the last agricultural season

Crop Type	Yes	No	Specify
Cereals (Maize, Sorghum, Wheat, etc.)			
Roots and Tubers			
Vegetables			
Fruits			
Pulses/Legumes			
Other crops (specify)			

Do you practice crop rotation or intercropping? ☐ Crop rotation ☐ Intercropping ☐ Both ☐ None

Section C: Household Dietary Diversity (HDDS) (24-Hour Recall)

Did you or anyone in the household drink or eat the following yesterday during the day and at night IN THE HOME:

Food Group	**Examples**	**Yes** (1)	**No** (0)
Cereals	bread, samp, or any other foods made from millet, sorghum, maize, rice, wheat + insert local foods e.g., *sadza*, porridge, pastes, or other locally available staple	☐	☐
Roots and Tubers	pumpkin, carrots, squash, sweet potatoes, potatoes, yams, cassava, or foods made from roots.	☐	☐
Vegetables	pepper, dark green/leafy vegetables (*covo*), cabbage, all kinds of vegetables including wild ones (*guku/mutsine)* + locally available vitamin-A rich leaves such as sweet potato leaves, cassava leaves	☐	☐
Fruits	all kinds of ripe fruits (mango, papayas, guava, orange, other locally available, vitamin A-rich fruits, including wild fruits (like *mazhanje, maonde*)	☐	☐
Meat, Offal, Poultry	beef, pork, lamb, goat, rabbit, wild game, chicken, duck, or other birds, liver, kidney, heart, or other organ meats, or blood-based foods	☐	☐
Eggs	all kinds of eggs, including wild ones	☐	☐
Fish and Seafood	fresh or dried fish, shellfish, or any type of seafood (dried or fresh)	☐	☐
Pulses/Legumes	beans, peas, lentils, nuts, seeds, or foods made from these	☐	☐
Milk and Milk Products	milk, cheese, yogurt, or other milk products	☐	☐
Oils, Fats, Butter	oil, fats, or butter added to food or used for cooking	☐	☐

Sugar, Honey, Sweets	sugar, honey, sweetened soda, or sugary foods such as chocolates, sweets, or candies	☐	☐
Condiments/Spices/Miscellaneous	spices, coffee, tea, alcoholic beverages, or local examples of snacks (*maputi)*	☐	☐

Section D: Household Food Security (HFIAS) (30-Day Recall)

READ TO RESPONDENT:

"For each of the following questions, consider whether this has happened in the past [30 days, month, or 4 weeks using country-specific terminology]. If the answer is yes to a question, please indicate how often this happened."

Instructions for interviewer: Options for soliciting the frequency responses depend on the method defined from preliminary work for questionnaire adaptation. Examples:

a) *exact number or range of times it happened in the past [4 weeks]*
b) *indication that it happened **rarely** (once or twice), **sometimes** (3-10 times), or **often** (more than 10 times) in the past [4 weeks]*.

NO.	QUESTION	Response Options *Assign code according to the following answers:*	CODE
		(0) No = it did not happen in the past [4 weeks] (1) Rarely = once or twice in the past [4 weeks] (2) Sometimes = three to ten times in the past [4 weeks] (3) Often = more than 10 times in the past [4 weeks] *Or locally-defined terms of frequency corresponding to these ranges*	
1	In the past 4 weeks, did you worry that your household would not have enough food?	0 = No (skip to Q2)	….|___|
1a	If yes: *ask respondent* "how often did this happen?"	1 = Rarely (1-2 times) 2 = Sometimes (3-10 times) 3 = Often (more than 10 times)	….|___|
2	In the past 4 weeks, were you or any household member not able to eat the	0 = No (skip to Q3)	….|___|

	kinds of foods you preferred because of a lack of resources?		
2a	If yes: *ask respondent* "how often did this happen?"	1 = Rarely (1-2 times) 2 = Sometimes (3-10 times) 3 = Often (more than 10 times)	….|___|
3	In the past 4 weeks, did you or any household member have to eat a limited variety of foods due to a lack of resources?	0 = No (skip to Q4)	….|___|
3a	If yes: *ask respondent* "how often did this happen?"	1 = Rarely (1-2 times) 2 = Sometimes (3-10 times) 3 = Often (more than 10 times)	….|___|
4	In the past 4 weeks, did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food?	0 = No (skip to Q5)	….|___|
4a	If yes: *ask respondent* "how often did this happen?"	1 = Rarely (1-2 times) 2 = Sometimes (3-10 times) 3 = Often (more than 10 times)	….|___|
5	In the past 4 weeks, did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food?	0 = No (skip to Q6)	….|___|
5a	If yes: *ask respondent* "how often did this happen?"	1 = Rarely (1-2 times) 2 = Sometimes (3-10 times) 3 = Often (more than 10 times)	….|___|
6	In the past 4 weeks, did you or any other household member have to eat fewer meals in a day because there was not enough food?	0 = No (skip to Q7)	….|___|
6a	If yes: *ask respondent* "how often did this happen?"	1 = Rarely (1-2 times) 2 = Sometimes (3-10 times) 3 = Often (more than 10 times)	….|___|

7	In the past 4 weeks, was there ever no food to eat of any kind in your household because of a lack of resources to get food?	0 = No (skip to Q8)	….|___|
7a	If yes: *ask respondent* "how often did this happen?"	1 = Rarely (1-2 times) 2 = Sometimes (3-10 times) 3 = Often (more than 10 times)	….|___|
8	In the past 4 weeks, did you or any household member go to sleep at night hungry because there was not enough food?	0 = No (skip to Q9)	….|___|
8a	If yes: *ask respondent* "how often did this happen?"	1 = Rarely (1-2 times) 2 = Sometimes (3-10 times) 3 = Often (more than 10 times)	….|___|
9	In the past 4 weeks, did you or any household member go a whole day and night without eating anything because there was not enough food?	0 = No (Questionnaire is finished)	….|___|
9a	If yes: *ask respondent* "how often did this happen?"	1 = Rarely (1-2 times) 2 = Sometimes (3-10 times) 3 = Often (more than 10 times)	….|___|

Appendix B: SPSS (Regression) Case Processing Summary

Variable	Coding	Marginal Percentage	N
crop_div_cat	Low	10.7%	41
	Medium	54.7%	209
	High	34.6%	132
hfias_cat	Food secure	22.0%	84
	Mildly food insecure	39.0%	149
	Moderately food insecure	24.9%	95
	Severely food insecure	14.1%	54
hdds_cat	Low	15.2%	58
	Medium	29.1%	111
	High	55.8%	213
ward	Mutanda	14.4%	55
	Gombakomba	17.0%	65

	Chishakwe	17.0%	65
	Buwerimwe	13.9%	53
	Vumba	16.8%	64
	Dora B	20.9%	80
educ_cat	no formal education	13.6%	52
	primary education	48.7%	186
	secondary or higher	37.7%	144
gender_cat	Female	57.1%	218
	Male	42.9%	164
farmer_group	Non-member	31.7%	121
	Member	68.3%	261
extension_access	No	33.8%	129
	Yes	66.2%	253
irrigation_access	No	53.7%	205
	Yes	46.3%	177
Total		100.0%	382