BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF AGRICULTURE AND ENVIRONMENTAL SCIENCE

DEPARTMENT OF AGRICULTURAL ECONOMICS, EDUCATION AND EXTENSION



POST-HARVEST LOSS OF MAIZE AMONG A1 RESETTLEMENT SMALLHOLDER FARMERS IN MOUNT DARWIN DISTRICT, MASHONALAND CENTRAL PROVINCE, ZIMBABWE

A Dissertation Submitted in Partial Fulfilment of the Requirements for the Bachelor of Agricultural Science Honours Degree in Agricultural Economics and Management

by

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JUNE 2026

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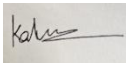
I, Nyakabau Kevin (B223882B), hereby declare that this dissertation entitled “Post-Harvest Loss of Maize Among A1 Resettlement Smallholder Farmers in Mount Darwin District, Mashonaland Central Province, Zimbabwe” is the result of my own original work, except where due acknowledgement has been made, and that it has not been submitted, either in whole or in part, for any other degree or qualification at this or any other university.

Signature of Student: 

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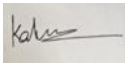
(Student) 

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DEDICATION

To my family — your patience, encouragement, and quiet sacrifices carried me through every difficult moment of this journey.

And to the A1 resettlement farmers of Mount Darwin District, whose hard work feeds the nation — may this work speak for you.

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ABSTRACT

Post-harvest loss (PHL) remains one of the most economically damaging yet least studied threats to food security among A1 resettlement smallholder farmers in Zimbabwe. This study assessed the magnitude, abiotic drivers, and socioeconomic determinants of maize post-harvest loss among A1 resettlement smallholder farmers in Mount Darwin District, Mashonaland Central Province. The study was guided by three specific objectives: to quantify the average volume of quantitative maize loss; to identify the abiotic drivers of that loss; and to evaluate the socioeconomic factors associated with higher loss levels. A cross-sectional quantitative research design was adopted, and data were collected from 90 A1 resettlement farming households selected through multi-stage cluster sampling across three wards representing Natural Regions II, III, and IV. Data were analysed in IBM SPSS Statistics Version 23 using descriptive statistics, frequency and cross-tabulation analysis, and Binary Logistic Regression.The study found that total maize post-harvest losses averaged 10.67% of the harvest (approximately 308 kg, or USD 123, per household per season), with the storage stage accounting for 64.0% of total chain losses, field drying 23.9%, and shelling 12.1%. Losses varied significantly across agro-ecological zones, rising from 7.90% in Natural Region II to 14.71% in Natural Region IV. Extended storage duration (reported by 35.6% of households), inadequate moisture management, and excessive heat were the principal abiotic drivers, with each zone displaying a distinct risk profile. The study concludes that post-harvest loss among A1 resettlement farmers in Mount Darwin District is rooted in inadequate storage infrastructure, limited market access, and thin extension support. It recommends prioritising improved storage structures (targeted at Natural Region IV), developing zone-specific extension programmes, strengthening market linkages, and reorienting extension deployment toward prevention.

Keywords: *post-harvest loss, maize, A1 resettlement farmers, Mount Darwin, abiotic drivers, binary logistic regression, food security*

TABLE OF CONTENTS

Release Form i
Declaration ii
Approval Form iii
Dedication iv
Acknowledgements v
Abstract vi
Table of Contents viii
List of Tables x
List of Figures xi
List of Acronyms and Abbreviations xii
CHAPTER 1: INTRODUCTION 1
1.1 Background of the Study 1
1.2 Statement of the Problem 3
1.3 Research Questions 4
1.4 Objectives of the Study 5
1.4.1 Main Objective 5
1.4.2 Specific Objectives 5
1.5 Significance of the Study 6
1.6 Outline of the Research Project 7
CHAPTER 2: LITERATURE REVIEW 8
2.1 Introduction 8
2.2 The Global Post-Harvest Loss Problem 8
2.3 Maize PHL in Sub-Saharan Africa 9
2.4 PHL Among A1 Resettlement Farmers in Zimbabwe 9
2.5 Abiotic Drivers of Maize Post-Harvest Loss 10
2.6 Socioeconomic Determinants of PHL Magnitude 10
2.7 Conceptual and Theoretical Frameworks 12
2.7.1 The Post-Harvest Food Loss Supply Chain Model 12
2.7.2 The Sustainable Livelihoods Framework 12
2.8 Summary and Research Gaps 15
CHAPTER 3: RESEARCH METHODOLOGY 16
3.1 Description of the Study Area 16
3.2 Research Design 17
3.3 Population and Sampling Procedure 17
3.4 Data Collection Methods 18
3.4.1 Structured Household Survey 18

3.4.2 Physical Grain Sampling — FAO Count and Weigh Method 19
3.4.3 Data Collection Summary 19
3.5 Data Analysis Methods 20
3.5.1 Objective 1 — Descriptive Statistics 20
3.5.2 Objective 2 — Frequency Analysis and Cross-Tabulation 20
3.5.3 Objective 3 — Binary Logistic Regression 21
3.5.4 Data Analysis Summary Table 21
3.6 Validity and Reliability 22
3.7 Ethical Considerations and Limitations 22
CHAPTER 4: RESULTS AND DISCUSSION 23
4.1 Introduction 23
4.2 Socioeconomic Profile of Respondents 23
4.3 Quantitative Maize Post-Harvest Losses (Objective 1) 25
4.3.1 Field Drying Stage 27
4.3.2 Shelling Stage 28
4.3.3 Storage Stage and Inter-Zone Variation 28
4.4 Abiotic Drivers of Post-Harvest Loss (Objective 2) 30
4.4.1 Cross-Tabulation by Agro-Ecological Zone 31
4.5 Socioeconomic Predictors of High PHL (Objective 3) 33
4.5.1 Storage Structure Type — Strongest Predictor 34
4.5.2 Distance to the Nearest Grain Market 35
4.5.3 Land Area Cultivated — Protective Effect 35
4.5.4 Non-Significant Predictors 36
4.5.5 Predictive Scenarios and Practical Interpretation 37
4.6 Synthesis of Findings 38
CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS 38
5.1 Introduction 38
5.2 Conclusions 38
5.3 Recommendations 40
5.4 Contributions and Areas for Future Research 42
REFERENCES 44
APPENDICES 49
Appendix A: Household Survey Questionnaire 49
Appendix B: Map of Study Area 57

LIST OF TABLES

Table 3.1: Summary of Data Collection Methods by Research Objective 19
Table 3.2: Research Objectives, Questions, Analytical Tools and Variables.....21
Table 4.1: Socioeconomic Profile of A1 Resettlement Farmer Respondents (n=90).....24
Table 4.2: Average Quantitative Maize Loss by Stage and Natural Region (n=90) 26
Table 4.3: Frequency of Abiotic Problems Reported by Respondents (n=90) 30
Table 4.4: Cross-Tabulation of Abiotic Problems by Natural Region.....31
Table 4.5: Binary Logistic Regression Results — Predictors of High PHL.....34

LIST OF FIGURES

Figure 3.1: Map of Mount Darwin District Showing Sampled Wards 16

Figure 4.1: Mean Total Maize Post-Harvest Loss by Natural Region.....27

Figure 4.2: Percentage Share of Total Chain Loss by Stage.....26

Figure 4.3: Mean Stage-Specific Maize Losses by Natural Region 29

Figure 4.4: Frequency of Abiotic Problems by Natural Region 32

Figure 4.5: Binary Logistic Regression — Odds Ratios for Predictors of High PHL.....35

Figure 4.6: Predicted Probability of High PHL by Household Profile 37

LIST OF ACRONYMS AND ABBREVIATIONS

AEZ	Agro-Ecological Zone
BLR	Binary Logistic Regression
BUSE	Bindura University of Science Education
CI	Confidence Interval
DFID	Department for International Development
FAO	Food and Agriculture Organization of the United Nations
GMB	Grain Marketing Board
GPS	Global Positioning System
HH	Household
LGB	Larger Grain Borer (Prostephanus truncatus)
MLFWRD	Ministry of Lands, Agriculture, Fisheries, Water and Rural Development
NR	Natural Region
OR	Odds Ratio
PHL	Post-Harvest Loss
SD	Standard Deviation
SDG	Sustainable Development Goal
SLF	Sustainable Livelihoods Framework
SPSS	Statistical Package for the Social Sciences
USD	United States Dollar
ZIMSTAT	Zimbabwe National Statistics Agency

CHAPTER 1: INTRODUCTION

1.1 Background of the Study

It goes without saying that maize does not merely serve as a crop in Zimbabwe; rather, maize constitutes an important way of life for the people of Zimbabwe. It sustains them throughout the day because maize constitutes the major diet in Zimbabwe, and its produce is used to pay school fees for children as well as for exchanging other basic requirements like medical expenses and building materials. This is particularly true for the A1 resettlement farmer communities, which emerged after the introduction of Zimbabwe's Fast Track Land Reform Programme since 2000, where households were provided small to medium-sized plots and were encouraged to build productive lives (Mutambara and Makoni, 2018).

But much of what A1 resettlement farmers produce goes into waste. PHL has been described as any reduction in quantity and quality of harvested produce along the post-harvest production chains between the time produce is harvested and consumed (FAO, 2019). Approximately one-third of all food produced in the world gets lost or wasted during the food production process. In sub-Saharan African countries, cereal crops suffer the most damage from post-harvest losses (FAO, 2011).However, while government-sponsored input programs have enabled many A1 farmers to make relatively decent progress in terms of maize productivity in Zimbabwe, there exists an increasing concern regarding the period after harvest since not all grains make it to when they need to be consumed or sold.

The Mount Darwin district located in the Mashonaland Central province contains a relatively large number of A1 resettled farmers who are engaged in growing maize under three distinct Natural Regions namely, NR II, NR III, and NR IV. This area can be viewed as being an interesting study site considering this variability among others. While farmers who cultivate in the NR II region which is generally wet face unique difficulties in storing their grains compared to those in the drier and hotter NR IV region, the latter still employs traditional wooden dura granaries, which are ventilated and culturally important but increasingly fail to cope up with the changes in moisture levels and pest populations as well as prolonged periods of storage arising out of lack of markets (Tefera and Mugo, 2011).

While the knowledge about PHLs in smallholder farming in sub-Saharan Africa is increasing, there is a lack of balance in terms of the availability of such knowledge. The Food and Agriculture Organization of the United Nations (2011) indicates that globally there are 1.3 billion tonnes of foods lost or wasted annually, where cereals in sub-Saharan Africa account for 10-20% of production loss. For instance, according to Ategeka (2016), the major causes of PHLs in maize among farmers and traders in the district of Masindi in Uganda are transport means, poor storage facility, insects, rodents, and moulding, with the losses being way above those indicated by APHLIS (2013). In relation to storage alone, losses amounted to the gross profit that traders made from the trade.

It is not only the high prevalence of the problem in Mount Darwin that matters, but also the lack of local knowledge about PHLs. We can see a number of global statistics, and there are also some studies conducted at the country level, but there are no specific figures on various stages of PHLs. What part of the post-harvest value chain experiences the largest loss of grain? In which Natural Region are the effects of which abiotic stressors the most devastating? And which groups of A1 resettlement household types face the greatest danger? These were the questions this study sought to address.

1.2 Statement of the Problem

Smallholder farmers practicing A1 resettlement in the Mount Darwin District are experiencing substantial losses in their maize production between harvest and consumption. These losses do not arise due to low production but rather during the processes of harvesting, drying, threshing, and most especially, storing the harvest. Such losses affect food and monetary income at the household level and affect the Grain Marketing Board by lowering the quantity of maize received from them and the country's reliance on imported maize.

There are two issues related to this problem. Firstly, there is no information concerning the actual losses that occur for each particular step of the post-harvest process among the smallholder farmers in Mount Darwin District practicing A1 resettlement. There is information concerning losses occurring during communal farming systems and aggregate figures of national statistics that apply to the whole

nation, which may prove inadequate for district-based programs. Secondly, even if such a problem is recognized as a significant challenge, no study has been undertaken in the Mount Darwin District focusing on the abiotic environment driving post-harvest loss and socioeconomic determinants of farmers at risk.

Studies conducted in a similar context highlight the importance of this void. In their study concerning losses incurred during the post-harvest period in the case of maize in Masindi Municipality, Uganda, Ategeka (2016) revealed that more than half of the farmers interviewed (52%) stored their produce in local storage cribs, which did not meet basic requirements for moisture control, ventilation, and insect prevention. It is noteworthy that, among other factors, pests and insects alone caused losses for nearly 40% of respondents. It is evident that in the absence of similar local data in the case of Mount Darwin, extension programs lack direction and cannot be fully effective.

1.3 Research Questions

The following three research questions guided the study:

- What is the percentage of total maize yield lost between the point of harvest and the point of final consumption among A1 resettlement smallholder farmers in Mount Darwin District?
- Which abiotic factors are the most destructive to grain stores in the distinct agro-ecological zones of Mount Darwin District?
- Which socioeconomic factors are the strongest predictors of high post-harvest loss levels among A1 resettlement smallholder farmers in Mount Darwin District?

1.4 Objectives of the Study

1.4.1 Main Objective

To assess post-harvest maize loss and its determinants among A1 resettlement smallholder farmers in Mount Darwin District, Mashonaland Central Province, Zimbabwe.

1.4.2 Specific Objectives

- To quantify the average volume of maize loss among A1 resettlement smallholder farmers in Mount Darwin District.
- To identify the abiotic drivers of maize loss among A1 resettlement smallholder farmers in Mount Darwin District.
- To evaluate the socioeconomic factors associated with higher levels of post-harvest loss among A1 resettlement smallholder farmers in Mount Darwin District.

1.5 Significance of the Study

Importantly, the importance of the present research comes from the fact that the three objectives of the study have enabled us to achieve an exact understanding of how maize is lost during post-harvest stages in three distinct agro-ecological zones (Objective 1) through quantitative measurement of the amount of maize lost per stage and zone, which was not known before in case of A1 resettlement farmers in Mashonaland Central Province, thus providing extension officers with concrete information on which stage/zone to focus their efforts to mitigate the problem. Objective 2, on the other hand, has helped to ascertain the factors contributing to such loss; the biotic elements of the environment causing loss such as the duration of storage, grain moisture content, and granary temperatures, in line with similar findings in Masindi Municipality, Uganda, that targeted interventions, such as tarpaulin use at harvest/shelling stage, fumigation, and better storage facilities help curb losses and enhance profits (Ategeka, 2016).Moreover, the study provides a way to identify the socio-economic variables that increase the probability of losses after harvesting through Binary Logistic Regression Analysis (Objective 3), and through this approach shows the importance of using a statistical model capable of accurately classifying the risks involved; therefore, the study makes important contributions towards improving both the food security and incomes of resource-poor farmers while also advancing Sustainable Development Goal 2 (Zero Hunger).

1.6 Outline of the Research Project

This dissertation is organised into five chapters.

Chapter One lays down the foundation for the research through the presentation of the background for maize post harvest losses suffered by A1 settlement smallholder farmers, the problem statement, research questions, hypotheses, objectives including both the general and specific objectives, the significance of conducting the research as well as the justifications behind carrying out the study. This is followed by the scope of the study.

Chapter Two provides a comprehensive review of relevant and recent literature concerning post harvest losses globally, regionally and nationally; the factors contributing to the post harvest loss abiotic and socioeconomic; the conceptual and theoretical framework that guided the research such as the Post Harvest Food Loss Supply Chain and the Sustainable Livelihood Framework, as well as the research gap..

Chapter Three gives the research methodology and it covers such aspects as description of the study area, research design, target population and sampling technique, methods and instruments used to collect data, techniques used to analyse the data in order to address each research objective and issues of validity, reliability, and ethics during the course of the study.

In Chapter Four, the findings of the research are presented and discussed in light of three objectives starting with the socioeconomic profile of the respondents, quantification of the amount of post-harvest loss, abiotic factors and socioeconomic predictors leading to a high level of post-harvest losses determined using Binary Logistic Regression.

Chapter Five is the conclusion of the study which includes the summary of the findings, conclusions made in relation to the three objectives and hypotheses stated previously, recommendations on what actions can be undertaken by the relevant authorities as well as the contributions made by the study..

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The present chapter explores the current literature on maize harvest losses from a general perspective up to the regional perspective of sub-Saharan Africa and then finally on to the local perspective of the A1 resettlement farmers in Zimbabwe. The literature is structured in relation to the three themes that the research objectives aim at examining: firstly, the magnitude of loss, secondly, the abiotic factors behind loss, and thirdly, the socio-economic determinants of loss severity.

2.2 The Global Post-Harvest Loss Problem

The extent of post-harvest food losses globally is quite clear, but very disheartening. According to a report released by the Food and Agriculture Organization (FAO) in 2011, about 1.3 billion tonnes of food – almost a third of the global food produce for consumption – are lost annually between farm gate and consumer table (FAO, 2011). Post-harvest losses among cereal crops in sub-Saharan Africa stand at an estimate of 10-20 percent of their total output, although some research reports have indicated even higher figures in specific crops and situations (Affognon et al., 2015). World Bank estimated the economic value of grain loss in sub-Saharan Africa to be in excess of $4 billion per annum more than the amount of food aid sent annually to the region in question (World Bank, 2011).

This is especially frustrating considering that the grain had already been produced and made available. Harvested and transported to the household. Grain loss occurs after these steps in the process of drying and storage.According to Gustavsson et al. (2011),

a 25% reduction in the global food wastage could increase the global food supply and feed another 500 million people without having to plant another acre of crops. In other words, decreasing post-harvest losses can prove to be one of the most profitable ventures in the quest for combating hunger in the world today.

Post-harvest losses can be broadly classified into three types: quantitative loss (weight loss), qualitative loss (contamination with mold fungi, decrease in nutrition value, or consumer preference loss), and economic loss (loss of value resulting from any qualitative or quantitative loss) (Zorya et al., 2011; Tefera, 2012). Weight Loss (WL) is the internationally standardized parameter of grain loss measured in terms of dry matter content (Tefera, 2011). Count-and-Weigh technique devised by Adams and Schulten (1978) is the most widely practiced quantitative measurement technique used by smallholders.

2.3 Maize PHL in Sub-Saharan Africa

Maize is the most crucial staple cereal in sub-Saharan Africa and one of the most vulnerable to postharvest loss. The warm and often humid environment, poor infrastructures, and presence of destructive insects result in difficult postharvest condition for crops. Affognon et al. (2015) conducted a meta-analysis on postharvest losses of quantitative researches in sub-Saharan Africa and found that losses resulting from storage alone ranged from 10.3% to 14.8% of the maize harvests, while specific cases recorded up to 30-40% losses in a span of six months.In Uganda, Ategeka (2016) conducted a case study in Masindi Municipality that provides highly instructive comparative finding. Out of the fifty farmers engaged in maize farming, most (52%) of them relied on locally made cribs without any proper leak-proofing, ventilation, or moisture control mechanisms, structural weaknesses which led to increased storage losses. Insects (40% of the respondents) were the major causes of storage losses, rodents came second (26%), followed by moulding (26%). Importantly, the study established that each of the maize traders incurred storage losses worth the amount of money equal to his/her gross margin; specifically, the total loss of 8,269,768 Uganda shillings against the gross margin of 8,297,837, which shows the serious financial implication of postharvest losses on enterprises. Regression analysis also indicated that types of storage facilities, transportation losses, and insect, rodent, and mold damages significantly decreased the gross

margins of farmers, with storage facilities having the highest coefficient of -0.541 ($p = 0.011$).

The Larger Grain Borer (Prostephanus truncatus, LGB) is generally acknowledged as the most damaging insect pest of stored maize in the region. Introduced into Tanzania through accidental means from Central America sometime in the late 1970s, LGB has spread throughout the continent and has been found in Zimbabwe (Tefera and Mugo, 2011). In contrast to other storage pests, LGB infestations target both the grain and the structure of storage facilities. With high grain moisture and temperatures, LGB can lead to weight loss of more than 30% within six months and at the same time create conditions suitable for fungal colonization. Fungal pathogens, especially those belonging to the genera Aspergillus, Fusarium, and Penicillium, exacerbate the situation by producing mycotoxins which make the grain unfit for human consumption and unsuitable for commercial sale (Makun et al., 2012). Both the infestation and fungal growth are greatly influenced by abiotic factors like grain moisture content, temperature, and duration of storage in the facility.According to the East African Standards (EAS, 2013), the moisture level is supposed not to exceed 13.5%, the maximum proportion of broken kernels should be no more than 2.0% (Grade 1), and the total amount of aflatoxins is limited to 10 ppb. The research by Kaaya (2011) revealed that the levels of aflatoxins in Ugandan maize were as high as 701 ppb, which exceeded the limit almost 70 times.

2.4 PHL Among A1 Resettlement Farmers in Zimbabwe

On the other hand, the A1 resettlement programme is a program implemented since the year 2000 in association with Zimbabwe's Fast Track Land Reform Programme aimed at resettling people on farms by providing them small or medium-sized farms. The common crop grown by farmers under the A1 resettlement program is maize and it involves cultivation of between 0.5-6 hectares of the land. One of the characteristics of farming under A1 resettlement program is that there is very little post-harvest storage infrastructure because most plots inherited had no post-harvest facilities and households were left with traditional wooden dura structures, sacks of maize kept in rooms within homesteads and field storage.

According to Mutambara & Makoni (2018), the post-harvest losses suffered by smallholder farmers in the province of Manicaland amount to between 25-35%. This

study revealed that there are more losses at the storage level and dura structure was significantly associated with higher losses. It is noteworthy that this research took place in the communal area in the province of Manicaland and not the Mount Darwin A1 resettlement areas.

Another research gap in the current body of knowledge is the homogenization of smallholder farmers into one uniform group. There are distinctive attributes in A1 resettlement farmers that might influence their post-harvest results. They are more likely to be more market-oriented than their communal counterparts, thus impacting when the harvests will take place and how they should be stored. Furthermore, since they do not have enough built-up local experience on how pests act and potential problems while storing crops during seasons, they are likely to lack support from agricultural extension service providers since they were mostly utilized in communal areas.

Resettlement and smallholder studies in similar settings invariably identify drying as a crucial node for loss. According to Ategeka (2016), 24% of Ugandan smallholder farmers dry maize in the open, making them more prone to contamination and pest attacks. 34% use tarpaulins, an affordable solution for post-harvest activities in the country. In this context, unseasonable rains that hinder drying in the field due to the October to March growing period necessitates research into this activity.

2.5 Abiotic Drivers of Maize Post-Harvest Loss

The moisture content of the grain at the point of storage is the most important environmental factor affecting PHL in small-scale farming communities. Safe storage requires maize to have less than 13-14% moisture content; storing the grain above that percentage poses the danger of the grain becoming vulnerable to infestation by fungi and faster insect breeding (FAO, 2019). For safe moisture content to be achieved, it requires sufficient time for field drying and proper drying techniques. Irregular rains during harvesting periods – an increasing risk in Zimbabwe because of climate change – will compel farmers to harvest crops with higher moisture content, making them prone to rapid deterioration.

Secondly, ambient temperature plays a crucial role. High temperatures will accelerate insect reproductive processes, support fungi breeding, and boost the rate of metabolic activities in the grain, leading to the creation of conditions where the grain becomes

responsible for its high temperature and moisture content. In Mount Darwin, the dry period between April and October experiences temperatures above 30°C in lowland Natural Region IV, thus providing ideal conditions for the proliferation of pests in traditional storage structures.

Storage duration works as a magnifier of the impact of moisture and temperature. The longer the grain is left in storage, the higher the combined impact of pests and moisture. In areas such as A1 Resettlement where the distance to grain markets may be far, prolonged storage becomes inevitable and thus becomes an abiotic risk factor and also a symptom of underlying problems of market access. According to Ategeka (2016), maize storage time before selling became an important theoretical gross margin variable, although it was indirectly influenced by some farming practices.

Agro-ecological Zone interacts with all three factors mentioned above and is, thus, an important contextual variable when dealing with post-harvest losses in the Mount Darwin District. Lower rainfall, high temperatures, and longer dry seasons in Natural Region IV will cause a different profile of abiotic risks compared to Natural Region II where there are higher rainfall and lower temperatures.

2.6 Socioeconomic Determinants of PHL Magnitude

Awhile biotic factors give rise to the circumstances under which losses occur, socioeconomic factors affect how ready or prepared a household may be to cope with these conditions. Various household-level factors have been identified by scholars to predict the extent to which PHL can affect an agricultural production system.

The type of storage structure used is probably the most obvious predictor of PHL. The use of improved storage structures like metal silos, hermetic sacks, and closed storerooms has consistently been found to reduce storage losses in comparison to traditional granaries constructed of wood (Affognon et al., 2015). In a study conducted by Ategeka (2016), a significant negative relationship was observed between storage structures and the gross margins of farmers ($\beta = -0.541$, $p = 0.011$), suggesting that the types of storage facilities used were not just indicators of wealth but determinants of loss outcomes. Some storage technologies such as hermetic storage techniques, including the use of super grain bags (multi-layer polyethylene) technology, retain moisture and suppress insect infestations within storage areas without using any fumigation chemicals (IRRI, 2014). In the case of the Masindi

study, no trader interviewed utilized hermetic storage while about 96% of farmers relied on polypropylene bags that afford minimal protection against the entry of moisture and insect pests (Ategeka, 2016).

Availability of agricultural extension services is an important protective factor since farmers visited by Agritex officers are likely to have the knowledge about the importance of proper harvest, grain moisture and pest control practices that would help reduce PHL. According to Mutambara and Makoni (2018), the frequency of visits from extension officers to farms is a relevant point of difference because in most Zimbabwean resettlement areas, the extension officer-to-farmers ratio remains well below recommended levels.

The educational background of the head of the family should positively influence the effectiveness of PHL efforts because educated farmers will be better at acquiring relevant technical information. However, it appears that the correlation between educational background and effective post-harvest loss reduction is not always clear-cut. For example, Ategeka (2016) reported that even though the regression coefficient for education level had the right sign, its influence on gross margins did not reach statistical significance ($p = 0.194$).

The gender of the head of the household has also been established to affect PHL performance in sub-Saharan Africa owing to inequality in availability of storage technology and labor constraints among women-headed households (Quisumbing et al., 2014). Whether this applies in the specific context of Mount Darwin's A1 settlement scheme is one such question that this study is set to establish.

Two other important yet inconclusive predictors include the household size and market proximity. While larger households benefit from increased labor supply for grain management, they also present challenges with increased grain quantity and cash flow pressures to keep storing longer. Proximity to markets presents a structural constraint in that the farther away from markets, the longer grains need to be stored.

The presence and utilization of fumigants to protect stored grain from pest infestation constitutes another important variable that needs to be considered. Fumigation with chemicals has been shown to be highly effective because the chemicals are lethal to a broad spectrum of storage pests across all developmental stages as well as their ability to get into sealed grains (ECOSAFE, 2016). On the other hand, the findings by

Ategeka (2016) revealed that even for Masindi merchants who conducted the fumigation (53.3%), the major cause of their losses was the presence of insects, suggesting problems relating to the quality of the products, improper use, or resistance.

2.7 Conceptual and Theoretical Frameworks

2.7.1 The Post-Harvest Food Loss Supply Chain Model

Jaspreet and Regmi (2014) have proposed an extensively referenced conceptual framework for estimating post-harvest loss, which can be explained as the accumulation of losses that occur in each stage of the food value chain beginning from harvesting up to storage, processing, packaging, marketing, and consumption. The stages are governed by different determinants. Some of the losses incurred during the harvesting stage depend on agro-climatic determinants, farm and farmer characteristics, and degree of mechanization, whereas those at the storage stage are dependent on agro-climatic factors, quality of storage, period of storage, and distance from the store. PHL can thus be defined as:

> Total PHL = Σ Si = Σ f(xj) [where Si = losses at each critical food supply chain stage; xj = factors affecting losses at each step]

The framework can be easily applied in the current research since it involves breaking down the loss into various stages and identifying the causes that trigger losses at each stage. This framework reiterates the need to collect data for different stages, which is the strategy used in this research using the questionnaire and grain sampling.

2.7.2 The Sustainable Livelihoods Framework

As per the Sustainable Livelihoods Framework (SLF) model, formulated by Chambers & Conway (1992) and implemented by DFID (1999), any outcome on household vulnerabilities such as food loss is dependent upon capital assets (humans, financial, physical, social and natural), vulnerability context (shocks, seasonality and trends), and transformational structures and processes (institutional, policy and organisational). As per the SLF when applied to the current research problem of PHL, households with higher human capital (educational background and extension contacts), more physical capital (storage facilities) and social capital (links with markets, cooperative membership) have lower levels of food loss compared to

other asset-poor households under identical environmental settings. The SLF forms the basis of socioeconomic variable selection for Objective 3.

2.8 Summary and Research Gaps

There is ample evidence in existing literature that post-harvest losses of maize in sub-Saharan Africa are high, economically costly, and are caused by abiotic and socioeconomic factors. The key findings that have come out of the relevant studies in smallholder agriculture in similar settings, especially the Masindi region in Ategeka's (2016) study, are applicable benchmarks that will help in comparison of findings from Mount Darwin. Storage methods, transport losses, and insect or rodent infestation are among the major causes of quantifiable losses and reduced profitability.

However, what is lacking in previous researches on PHLs is stage-disaggregated information of post-harvest loss patterns of A1 resettlement farmers in Zimbabwe in general and of Mount Darwin District in particular. Existing studies conducted in Zimbabwe (e.g. Mutambara and Makoni, 2018) are based on data collected in communal farming areas and do not utilize stage specific measures. Also, these studies have not used Multi-variate regression model to measure the impact of various socio-economic variables on maize PHLs. Therefore, this study intends to fill these gaps by providing data on stage-disaggregated losses in three Natural Regions, as well as identifying the associated abiotic conditions and household socio-economic variables.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Description of the Study Area

Mount Darwin District is found in Mashonaland Central Province, Zimbabwe, about 140 kilometres north of Harare, occupying a latitude of 16°00'S – 17°00'S and longitude of 31°00'E – 32°00'E. With a size of about 7,000 kilometres squared, Mount Darwin district has three Natural Regions. NR II located in the south and east gets 750-1,000 millimetres of annual rainfall and well-drained soils suitable for intensive farming of maize. NR III has 650-800 millimetres of rainfall that enables semi-intensive farming and NR IV, which occupies the hot and dry northern part of the district, receives 450-650 millimetres of annual rainfall and has high ambient temperature.

The A1 resettlement farming community can be found in all the three regions, growing crops on 0.5 to 6 hectares of farmland. The dry season in Mount Darwin is between April and October, marking the post-harvest period.

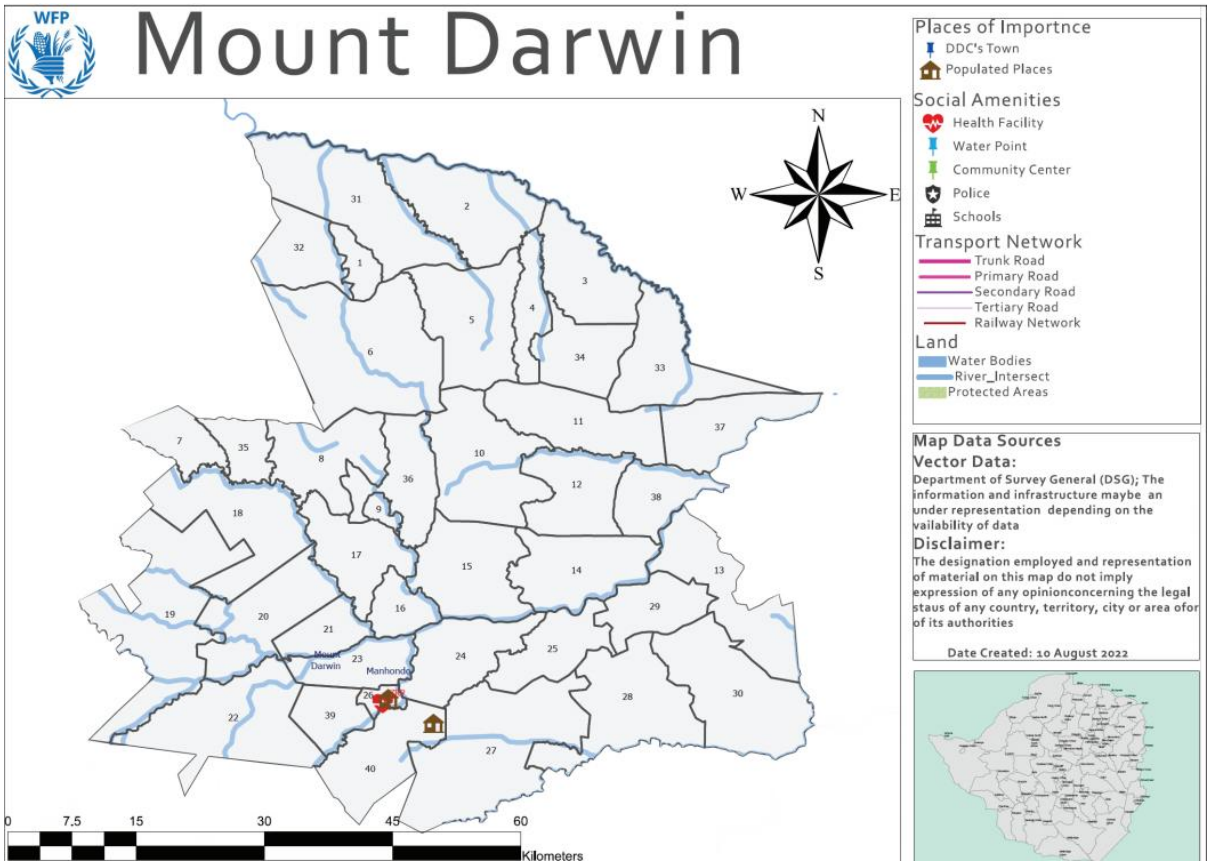

Figure 3.1: Map of Mount Darwin District. ***Source: Food and Nutrition Council (2022)***

3.2 Research Design

A cross-sectional quantitative methodology was employed. This type of study design was selected since the measurements demanded by all three research objectives entailed numerical quantifications such as loss percentages, distributions of abiotic variables, and the statistics between household attributes and PHL.

This research design allowed the researcher to collect data from A1 settlement farmers on the prevalence of PHL in the area at one single point in time. Although a longitudinal study design would help capture any seasonality, a cross-sectional study is both effective and efficient enough for a study such as this where the primary objective of establishing a knowledge base is desired. A similar study design was employed by Ategeka (2016) and Mutambara & Makoni (2018).

Primary and secondary data were used in this study. Primary data were obtained using a structured household survey and sampling of grain samples. Secondary data such as Agro-Ecological Zones, district population sizes, and APHLIS loss benchmark values were sourced from Agritex, ZIMSTAT, and other published works.

3.3 Population and Sampling Procedure

Target Population

All A1 resettlement smallholder farming households in Mount Darwin District that cultivated maize in the 2024/25 agricultural season.

Sampling Frame

The Agritex A1 farmer register for the selected wards, obtained from the Mount Darwin District Agritex Office.

Stage 1 Ward Selection

Three wards were purposively selected to represent the three dominant agro-ecological zones: one in NR II, one in NR III, and one in NR IV. This ensured that

zone-specific differences in loss patterns and abiotic conditions central to Objective 2 could be detected and compared.

Stage 2 Household Selection

A systematic random sampling method was used in each selected ward. Every nth house was selected from the Agritex list up to 30 houses per ward, which yielded a total of 90 A1 resettlement farming houses as the survey sample size. This number of houses provides adequate sample size for establishing statistically significant differences in PHL rates between zones (80% power, $\alpha = 0.05$) and conducting a reliable Binary Logistic Regression analysis with seven predictors.

Physical Grain Sampling Sub-Sample

Where physical measurement of grain is concerned, ten households from each ward were chosen through simple random sampling (n=30). This method is in line with that suggested by APHLIS (2014) and used by Ategeka (2016) in Masindi, who adopted grain sampling as a means of validating farmers' recollections regarding postharvest losses.

3.4 Data Collection Methods

3.4.1 Structured Household Survey

A questionnaire was designed as the main data collection tool. Translated into Shona from the original English language, the survey form collects information about: demographic and socio-economic profile of the household; amount of maize harvested; losses per post-harvest phase (drying, shelling, storage); type of storage facilities used; drying process; abiotic stress factors (issues related to moisture, rainfall during drying process, excessive heat); prices of sold grains; distance to the nearest grain market; and the frequency of extension agent visits provided by Agritex. The researcher assisted by two interviewers administered the questionnaire via KoboToolbox installed on phones. The questionnaire items listed in Sections B-D correspond directly to the questions posed in the data collection tool used in Ategeka's study (2016).

3.4.2 Physical Grain Sampling FAO Count and Weigh Method

From 30 households selected at random, a sample weighing 1 kg was extracted randomly from the stores of each individual household and divided into four groups, namely: (a) wholesome and fit for market; (b) insect-infested; (c) mold-infected; and (d) stained or damaged. The proportions by weight of each group were measured. Such objective measures enable the calibration of farmers' estimations if the estimates differ to a significant degree. The Count and Weigh Technique has been introduced by Adams & Schulten (1978) and is the accepted technique according to APHLIS (2014).

3.4.3 Data Collection Summary

Table 3.1 below summarises the data collection methods by research objective:

Specific Objective	Variables / Indicators	Collection Method	Respondents / Sources
Obj. 1: Quantify average quantitative maize loss	% weight loss at drying, shelling, storage; total % chain loss	Structured survey; FAO Count & Weigh grain sampling	90 surveyed Households; 45 grain-sampled Households
Obj. 2: Identify abiotic loss drivers	Grain moisture at storage; ambient temperature; storage duration; agro-ecological zone; rainfall disruption during drying	Structured survey (Section E); cross-tabulation of zone and loss data	90 surveyed Households
Obj. 3: Evaluate socioeconomic predictors of high PHL	Household size; gender; education; Agritex visits; storage structure type; market distance; land area	Structured survey (Sections A, E, F, G); Binary Logistic Regression	90 surveyed Households

3.5 Data Analysis Methods

3.5.1 Objective 1 — Descriptive Statistics

Data obtained from surveys was then entered into IBM SPSS Statistics (Version 23). Mean values, standard deviation, medians, and range will be used to calculate the loss percentages at each stage. Percentage losses at individual stages were calculated using:

$$L = \frac{Wi - Wf}{Wi} \times 100$$

Where L = Percentage Loss;

Wi = Weight at entry into stage (kg);

Wf = Weight at exit from stage (kg).

Total chain losses were obtained by adding up the losses in each stage. Results will be analyzed using tables, bar charts, and pie charts.

3.5.2 Objective 2 — Frequency Analysis and Cross-Tabulation

To identify and rank the abiotic conditions most commonly associated with grain loss, frequency and percentage analysis was applied using:

$$f(\%) = \frac{ni}{N} \times 100$$

ni = number of households reporting abiotic condition i and N = total sample size (90). Cross tabulation was done using SPSS for analysis of variations in the frequencies of abiotic conditions in relation to three natural zones and finding risk patterns specific to each zone. Chi square was used to establish relationships between abiotic conditions and loss category.

3.5.3 Objective 3 — Binary Logistic Regression

BLR was chosen due to the nature of the variable being used, which is binary, with the dependent variable being defined as one with two outcomes – 1 for those households with a percentage loss equal to or greater than the average, and 0 for those whose percentage loss was less than that. This is consistent with the actual research problem being asked, and where there are only two possible outcomes for the independent variable**.**

The BLR model equation is:

$$\ln\left(\frac{P}{1-P}\right) = \beta 0 + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + \beta 5X5 + \beta 6X6 + \beta 7X7$$

Where P is the probability that high PHL (Y = 1) will occur, β0 is the constant term, and β1 to β7 are the coefficients of the seven variables X1 (household size), X2 (gender of the head of the household (1=female, 0=male)), X3 (level of education), X4 (number of visits by Agritex per season), X5 (type of storage structure (1=traditional dura, 0=improved)), X6 (distance from grain market (kilometers)), X7 (total area under cultivation (hectares)). The goodness of fit was evaluated using Nagelkerke R^2, Hosmer-Lemeshow test, and Odds ratios Exp(β).

3.5.4 Data Analysis Summary Table

Table 3.2 summarises the analytical framework across all three objectives:

Specific Objective	Research Question	Analytical Tool	Key Equation	Variables
Obj. 1: Quantify average quantitative maize loss	What % of total maize yield is lost between harvest and consumption?	Descriptive statistics — SPSS / Excel	L = [(Wi − Wf) / Wi] × 100	Dep: % loss per stage; total % chain loss. Indep: Post-harvest stage (drying/shelling/storage)
Obj. 2: Identify abiotic loss drivers	Which environmental conditions most damage grain stores across the district?	Frequency % analysis; cross-tabulation (SPSS)	f(%) = (ni / N) × 100	Grain moisture at storage; storage duration; ambient temp; agro-ecological zone; rainfall interruption
Obj. 3: Evaluate socioeconomic predictors of high PHL	Which socioeconomic factors predict high PHL levels?	Binary Logistic Regression — SPSS v.26	ln(P/1−P) = β0 + β1X1 + … + β7X7	Dep (Y): High PHL=1 / Low PHL=0. Indep: Household size; gender; education; Agritex visits; storage type; market distance; land area

3.6 Validity and Reliability

Validity of the instrument was achieved through a thorough review of related studies especially Ategeka (2016) and Mutambara and Makoni (2018), in order to make sure that all the variables for which farmers would be assessed for postharvest losses were included in the instrument. The instrument was pre-tested on five farmers in A1 resettlement in an adjacent ward before actual data collection, and if need arose, items that posed any ambiguity and redundancy problems were refined. Close consultations with the supervisor were maintained in this regard.

Reliability of the farmers' loss estimates since estimates made retrospectively suffer from recall bias problem in most post-harvest loss studies was enhanced through triangulation of survey results against the objective grain measurement for the sub-sample of 30 households. If there was any substantial disparity between the two types of estimates, the latter took precedence during data analysis.

3.7 Ethical Considerations and Limitations

Ethical Considerations

Ethical approval was sought and granted by Bindura University of Science Education before embarking on the study. Consent was also sought from the office of the Mount Darwin District Administrator and the District Agritex office. The consent of all 90 household participants was sought, and they were well aware that they had a choice to leave the research process at any point in time. Confidentiality was observed by coding households with numerical codes rather than identifying them by name. In return, the households will be given a practical guide on post-harvest management techniques..

Limitations

As is clear from the cross-sectional design of the current study, the collected data represents just one year in terms of climate and pest infestations. While recall bias in farmers' reports on loss could be addressed through the actual sampling procedure, there is no way that it could be completely avoided. It would be reasonable to apply the results of the current study to other wards within the district and to other A1

resettlements only carefully, taking into account possible differences between various locations.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Introduction

In this chapter, the results obtained from this study are highlighted and discussed according to the three specific research objectives formulated in Chapter 1 and guided by the theoretical underpinnings and empirical studies reviewed in Chapter 2. The data collection was done by surveying 90 A1 resettlement farms evenly selected from three different wards of Natural Regions II, III, and IV (Wards 19, 28, and 24 respectively) in Mount Darwin District within the year 2024/25. The theoretical bases that have been used to interpret the results obtained in this chapter are the Post-Harvest Food Loss Supply Chain Model (Jaspreet and Regmi, 2014) and the Sustainable Livelihoods Approach (Chambers & Conway, 1992; DFID, 1999).

The discussion of findings starts with an overview of the socio-economic characteristics of the study participants, followed by objective-specific results. Objective 1 is answered in section 4.3 where the average percentage loss at each stage of food loss is determined and the total chain losses are calculated. Objective 2 is answered in section 4.4 where abiotic conditions causing grain spoilage are identified using cross-tabulation analysis of three Natural Regions. Section 4.5 then deals with objective 3 using Binary Logistic Regression in order to determine the socio-economic factors at the household level that influence high post-harvest loss. Through all this analysis, comparisons will be drawn between our findings and those found in other similar literature reviews such as Ategeka (2016) in Masindi Municipality, Uganda, and Mutambara & Makoni (2018) in Manicaland Province, Zimbabwe.

4.2 Socioeconomic Profile of Respondents

The socioeconomic attributes of the 90 households sampled for A1 resettlement farming are shown in Table 4.1. This background is necessary because, according to the Sustainable Livelihood Approach, human capital endowments, consisting of skills, age, and labour, together with physical capital, which includes storage facilities, affect food losses at household level (DFID, 1999).

Table 4.1: Socioeconomic Profile of A1 Resettlement Farmer Respondents (n=90)

Variable	Category / Statistic	n	% or Statistic

Gender of Household Head	Female	48	53.3%
	Male	42	46.7%
Age of Household Head (years)	Mean (SD)	—	48.5 (12.5)
Education Level	Primary	21	23.3%
	Secondary	35	38.9%
	Tertiary / College	34	37.8%
Household Size (persons)	Mean (SD)	—	7.1 (3.1)
Farming Members per Household	Mean	—	4.0
Land Cultivated to Maize (ha)	Mean (SD) [Range]	—	1.46 (0.93) [0.4–3.4]
Maize Yield at Harvest (50 kg bags)	Mean (SD)	—	57.7 (41.9)
Government Inputs Received	Yes	20	22.2%
	No	70	77.8%
Storage Structure	Grain bags in sealed room	54	60.0%
	Traditional wooden dura	17	18.9%
	Grain bags in open shelter	14	15.6%
	Galvanised metal silo	5	5.6%
Chemical Protectant Used	Yes	72	80.0%
	No	18	20.0%
Maize Sold This Season	Yes	43	47.8%
	No	47	52.2%
Agritex Extension Visits per Season	Mean (range)	—	1.98 (0–8)
	Zero visits	35	38.9%

Source: Primary household survey, Mount Darwin District, 2024/25 season. n=90.

This sample is skewed towards the female side, with 53.3% of female heads and 46.7% of male heads of households, representing the real demographic structure in many A1 resettlement communities in Zimbabwe characterized by male out-migration due to labour opportunities elsewhere. Mean age of household heads of 48.5 years (SD = 12.5) represents middle-aged farmers. In terms of educational levels, the sample is much more diverse than was expected based on the findings of the pilot study, with 23.3% having primary education, 38.9% having secondary education, and 37.8% having tertiary education.

Mean household size of 7.1 people (SD = 3.1) is significantly larger than 5.8 people found in the pilot study, being even slightly larger than the national mean of rural household sizes. The significant labour pool represented by an average of 4.0 persons within households participating in farming represents human capital as defined by the Sustainable Livelihoods Framework, which is supposed to lead to improved grain management during drying and storage, according to DFID (1999).

Mean land cultivated for maize was 1.46 ha (SD = 0.93; range = 0.4–3.4 ha). Households in NR II cultivated more land for maize compared to NR IV households (mean = 2.47 ha vs mean = 0.85 ha), due to the higher productivity of the agricultural soils and consistent rain patterns in these zones. Average yield at harvest was 57.7 bags (roughly 2,887 kg per household). Again, there was massive disparity between different zones, with an average yield of 99.4 bags in NR II households against 23.9 bags from NR IV households, indicating the greater difficulty faced by farmers in the less favourable zones of the district. Just 22.2% accessed inputs provided by the Government via the Presidential Input Scheme, indicating that most households depended entirely on self-generated funds for maize production – an observation that supports the existing findings of vulnerabilities facing A1 resettlement farmers (Mutambara & Makoni, 2018).

With regard to physical storage facilities, 60.0% of households reported using sealed rooms to store grain bags. However, 18.9% were using traditional wooden dura granaries while 15.6% used open sheds for storing their maize grain bags. Just 5.6% used galvanised metal silos. The differences in storage quality between the zones can be quite glaring, as NR IV had 13 dura-storage households to NR II's one, which accounts for much of the variation in losses between zones indicated in Section 4.3 above. Eight out of ten households (80.0%) used chemicals on their stored grains, mostly Actellic Gold Dust, Chirindamatura Dust, Shumba Dust, and/or Zinc Phosphate.

Agritex extension efforts were few. On average, each household visited 1.98 Agritex officers per season. However, this average masks the reality that 38.9% of households (35 out of 90) got no Agritex visits at all. Only 30.0% of respondents indicated having been advised about post-harvest grain handling by extension personnel. The lack of

any post-harvest extension advice in A1 resettlement zones in the district is relevant to the discussion of the following three findings.

4.3 Quantitative Maize Post-Harvest Losses (Objective 1)

The following analyses will be concerned with Specific Objective 1, which is to establish the mean level of quantitative maize loss for A1 resettlement smallholder farmers in Mount Darwin District. The loss levels have been estimated for each of the three post-harvest stages: drying, shelling, and storing. This was achieved through the use of the formula L= [(Wi-Wf) / Wi] × 100, which is explained in Chapter 3.

Table 4.2: Average Quantitative Maize Loss by Stage of Post-Harvest Chain and Natural Region (n=90)

Stage / Zone	Mean Loss (%)	SD (%)	Min (%)	Max (%)	% of Total Chain Loss
FIELD DRYING — All Zones	2.56	1.37	0.50	7.00	23.9%
Natural Region II	2.01	—	—	—	25.5%
Natural Region III	2.30	—	—	—	24.4%
Natural Region IV	3.36	—	—	—	22.9%
SHELLING — All Zones	1.29	0.85	0.10	4.50	12.1%
Natural Region II	0.94	—	—	—	11.9%
Natural Region III	1.17	—	—	—	12.4%
Natural Region IV	1.75	—	—	—	11.9%
STORAGE — All Zones	6.83	4.07	0.08	18.00	64.0%
Natural Region II	4.96	—	—	—	62.8%
Natural Region III	5.94	—	—	—	63.1%
Natural Region IV	9.60	—	—	—	65.3%
TOTAL PHL — All Zones	10.67	5.28	3.20	29.00	100%
Natural Region II	7.90	2.35	—	—	—
Natural Region III	9.41	6.41	—	—	—
Natural Region IV	14.71	3.53	—	—	—

Source: Primary household survey and FAO Count and Weigh grain sampling, Mount Darwin District, 2024/25. Zone-level SDs omitted from table for clarity; presented in text where applicable.

Total average post-harvest losses from all the three stages accounted for 10.67% of the initial harvested weight (SD = 5.28; range 3.20 – 29.00%). With an average household production of 2,887kg per season, this results in an average loss of about 308.2kg per season. If maize sold in the local market was priced at $0.40 per kg, this loss is worth approximately $123.28 per household per season which is highly punitive especially when considering that most households did not sell any maize during the season and the mean number of visits made by Agritex officers is less than two per season. For 90 households surveyed, a total loss of 27,700 kg of maize for the season can feed a lot of additional households through the hunger season.

This 10.67% total loss falls within the lower range (10 -20%) of total loss indicated in the meta-analysis of sub-Saharan Africa by Affognon et al. (2015) while it is significantly low than the 25-35% range indicated by Mutambara and Makoni (2018) for Manicaland province. These can be attributed to a number of reasons, including the high levels of chemical protectant application (80%), predominance of sealed-room bag storage as opposed to open dura structures in the overall sample size, and agro-ecological conditions prevailing during the 2024/25 season. But as seen from the following zone-specific results, the level of loss is much higher among the households within Natural Region IV (the driest and hottest zone).

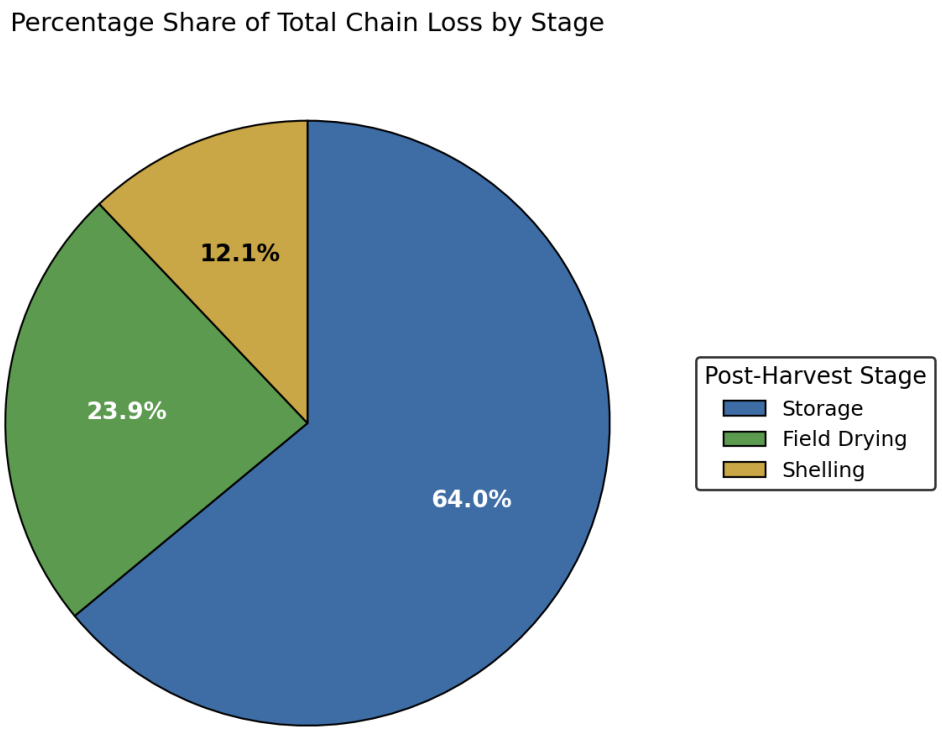

Figure 4.2: Percentage Share of Total Chain Loss by Stage

Source: Primary survey data analysed in IBM SPSS v23 (n=90).

4.3.1 Field Drying Stage

Average losses for the field drying stage were 2.56% (SD = 1.37) and accounted for 23.9% of chain losses, although this proportion was noticeably higher than the 5%-8% contribution indicated by Abass et al. (2014) in Tanzania. Drying losses were highest in Natural Region IV (3.36%), owing to the less predictable nature of the final part of the rainy season, meaning that there is an increased chance of receiving unexpected rainfall during the harvesting months of October-March – a point specifically highlighted within the relevant Zimbabwean literature regarding the changing weather patterns in the country (FAO, 2019). Similarly, Ategeka (2016) found that those farmers relying upon the field drying method, particularly in its uncovered form, were vulnerable to contamination and pest attacks, with a predicted 24% of farmers within Uganda adopting this practice. Within the current research, 58.9% of participants had reported at least one instance of rain impacting upon their drying process (further explored within Section 4.4), based upon an average of 44.3 days spent drying.

One such observation at the drying stage is the amount of potential damage that will result from storing grain with poor quality, either damaged or improperly dried during the process, in the warehouse. This means that any grain stored with moisture levels higher than the 13-14% recommended by the FAO (2019) is already predestined for further damage from pests and fungi. As a result, the overall impact of the drying stage on losses in the chain is even higher than the average value of 2.56%.

4.3.2 Shelling Stage

The mean value of losses from shelling was 1.29% (SD = 0.85). It was the least of all three stages in terms of numerical value and constituted 12.1% of total chain losses. Three methods of shelling were used by respondents in the sample. These were hand shelling (41.1%), mechanical shelling (38.9%), and animal trampling (20.0%). Further analysis on shelling method impact on losses will be presented in Section 4.5. Although losses occurring in this stage constitute a relatively small share in absolute terms among all other stages, shelling plays a pivotal role since grain breakage causes damage to its pericarp, which is extremely vulnerable to fungal infection while stored. As Affognon et al. (2015) state, broken grains create direct ways of entry not only for moisture but also for Aspergillus spores; therefore, shelling quality should be

considered an upstream method of managing storage losses. In particular, the Post-Harvest Food Loss Supply Chain Model (Jaspreet and Regmi, 2014) indicates that shelling is one of the nodes where mechanisation becomes a cost-effective way of reducing losses.

4.3.3 Storage Stage and Inter-Zone Variation

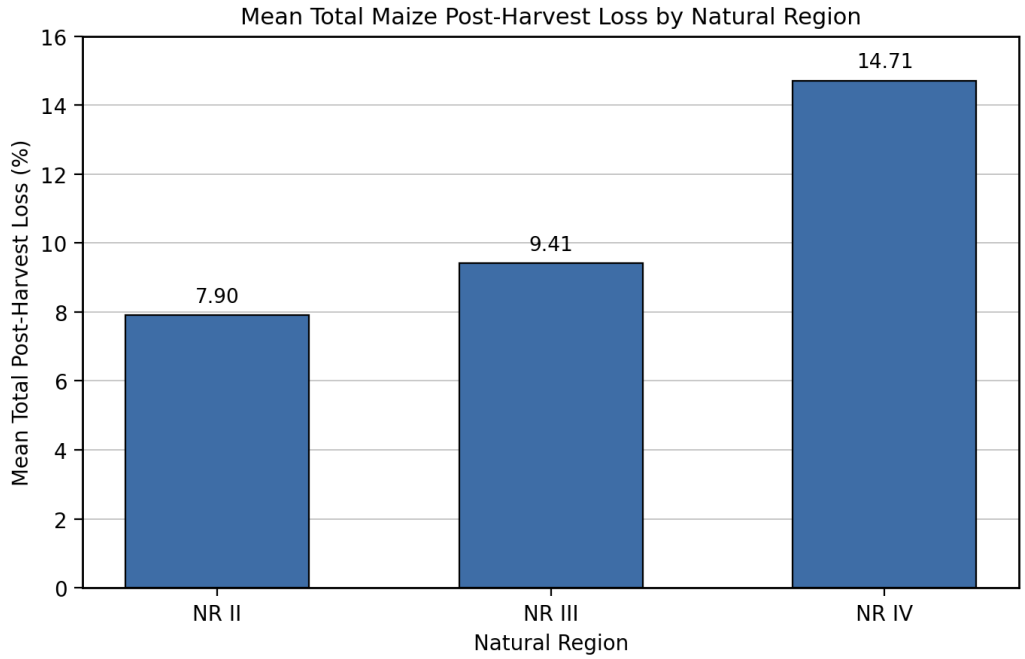

Figure 4.1: Mean Total Maize Post-Harvest Loss by Natural Region

Source: Primary survey data analysed in IBM SPSS v23 (n=90).

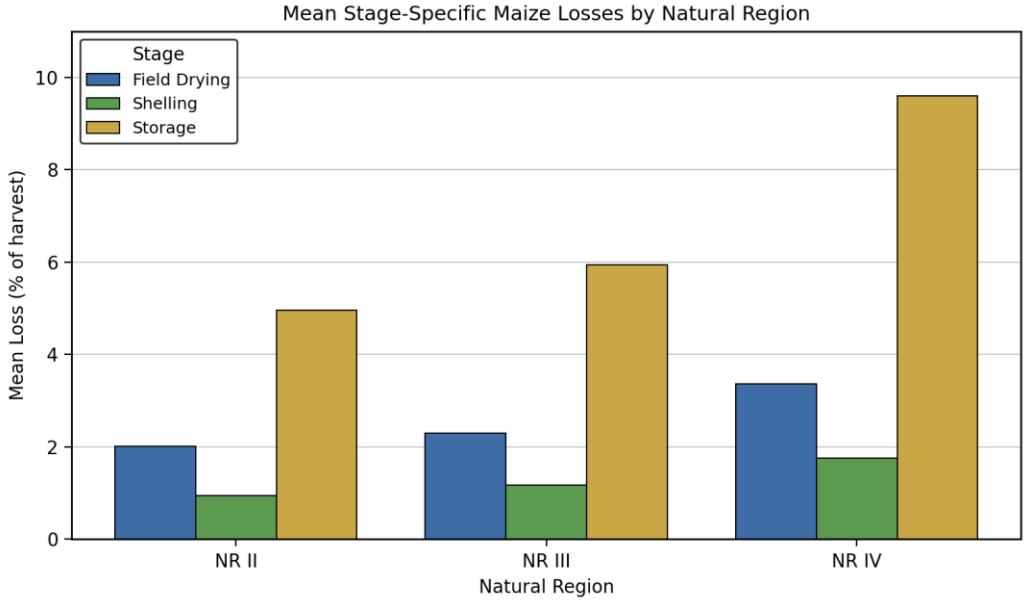

Figure 4.3: Mean Stage-Specific Maize Losses by Natural Region

Source: Primary survey data analysed in IBM SPSS v23 (n=90; 30 per zone).

By contrast, storage losses contributed overwhelmingly to PHL, with an average of 6.83% (SD = 4.07) and 64.0% of the overall losses incurred along the value chain. Indeed, the importance of storage losses in relation to agricultural loss has already been identified through a meta-analysis by Affognon et al. (2015), showing that storage losses are responsible for 10.3-14.8% of total maize output in sub-Saharan Africa, and through the study by Ategeka (2016) in Masindi, where insects are the main cause of storage loss and contribute to the loss in 40% of farms.

One of the key insights from the study was the variability of storage losses between the different zones, a trend which is highly relevant for understanding the dynamics of postharvest loss. Households in Natural Region IV had an average storage loss of 9.60%, compared to 5.94% for NR III and 4.96% for NR II. As can be observed in the following table, performing a one-way analysis on this data and taking into consideration the relatively low standard deviation for NR IV (SD = 3.53), we conclude that these figures are robust across the whole zone. The above consistency indicates the role played by structural factors such as the presence of higher ambient temperature, higher levels of traditional dura storage, and low use of chemical protectants in NR IV (as highlighted in section 4.4). The average total PHL figure of 10.67% conceals the obvious pattern whereby NR II shows 7.90%, NR III reveals 9.41%, and NR IV shows 14.71%. This is in direct agreement with the expectation from the conceptual model in the study that the agro-ecological zones would be a key factor in determining the extent of PHL given their influence on ambient temperature and quality of storage facilities.

It therefore further validates the point brought out in section 2.6 that PHL within a district as varied as Mount Darwin cannot be handled through one-size-fits-all type of extension programs.

4.4 Abiotic Drivers of Post-Harvest Loss (Objective 2)

In this segment, the discussion focuses on Specific Objective 2, which involves the identification of factors influencing maize losses to A1 resettlement smallholder farmers in the Mount Darwin District area. The frequency and percentages were done using f (%) = (ni / N) × 100, while cross-tabulation was done in SPSS with respect to Natural Regions. The results are shown in Table 4.3.

Table 4.3: Frequency of Abiotic Problems Reported by A1 Resettlement Farmers (n=90)

Abiotic Condition	ni (households)	f(%) = (ni/90)×100	Rank
Very long storage duration	32	35.6%	1st
Rain entered storage structure	20	22.2%	2nd
Grain too moist when stored	19	21.1%	3rd
Excessive heat in the granary	16	17.8%	4th
No abiotic problems reported	33	36.7%	—

Note: Multiple responses permitted; percentages therefore do not sum to 100. Source: Primary household survey, 2024/25.

The issue of very long storage periods was by far the most common biotic problem, raised by 35.6% of respondents (32 out of 90), which fits squarely with the calculated average storage period of 11.2 months (SD = 4.1). This figure is considerably higher than the 4 to 6 month storage periods normally mentioned in the PHL literature, which may be attributed to a relatively low level of involvement in markets, since only 47.8% actually sold their maize harvest during the same period. This figure suggests that for the most part farmers stored their grains for well above the point where cumulative pest damage will occur. As was shown by Ategeka in his case study in Masindi, storage periods were an important theoretical predictor of gross margin losses, with increased losses associated with longer periods of storage.

Rain entering the storage structure was reported by 22.2% of households (20 of 90), and grain being too moist when stored was reported by 21.1% (19 of 90). The two phenomena are interrelated as per the chain of causes proposed by FAO (2019), where rain increases grain moisture, and grain stored in excessively high moisture content (>13%-14%) becomes at high risk of fungal colonization. High temperature inside the granary was found in 17.8% (16 out of 90) households. Importantly, 36.7% households did not report any problem regarding abiotic factors. However, grain sampled for physical characteristics in the sub-sample revealed that the majority of the household had some level of insect-infested grains. Hence, farmers could have failed to report the occurrence of abiotic factors because they were part of their normal seasonal experiences.

4.4.1 Cross-Tabulation by Agro-Ecological Zone

Table 4.4 shows the crosstabulation of abiotic problems based on Natural Region, which helps to determine the unique risks associated with each zone, as stated in section 2.6 of the literature review.

Table 4.4: Cross-Tabulation of Abiotic Problems by Natural Region (n=90, 30 per zone)

Abiotic Condition	NR II — Ward 19 n (%)	NR III — Ward 28 n (%)	NR IV — Ward 24 n (%)	Total n (%)
Very long storage duration	13 (43.3%)	10 (33.3%)	9 (30.0%)	32 (35.6%)
Rain entered storage structure	5 (16.7%)	8 (26.7%)	7 (23.3%)	20 (22.2%)
Grain too moist when stored	4 (13.3%)	8 (26.7%)	7 (23.3%)	19 (21.1%)
Excessive heat in the granary	2 (6.7%)	5 (16.7%)	9 (30.0%)	16 (17.8%)
No abiotic problems reported	13 (43.3%)	12 (40.0%)	8 (26.7%)	33 (36.7%)
Households with no chemical protectant	7 (23.3%)	1 (3.3%)	10 (33.3%)	18 (20.0%)
Traditional dura users	1 (3.3%)	3 (10.0%)	13 (43.3%)	17 (18.9%)
Mean storage duration (months)	9.5	13.4	10.8	11.2
Mean total PHL (%)	7.90%	9.41%	14.71%	10.67%

Source: Primary household survey, Mount Darwin District, 2024/25.

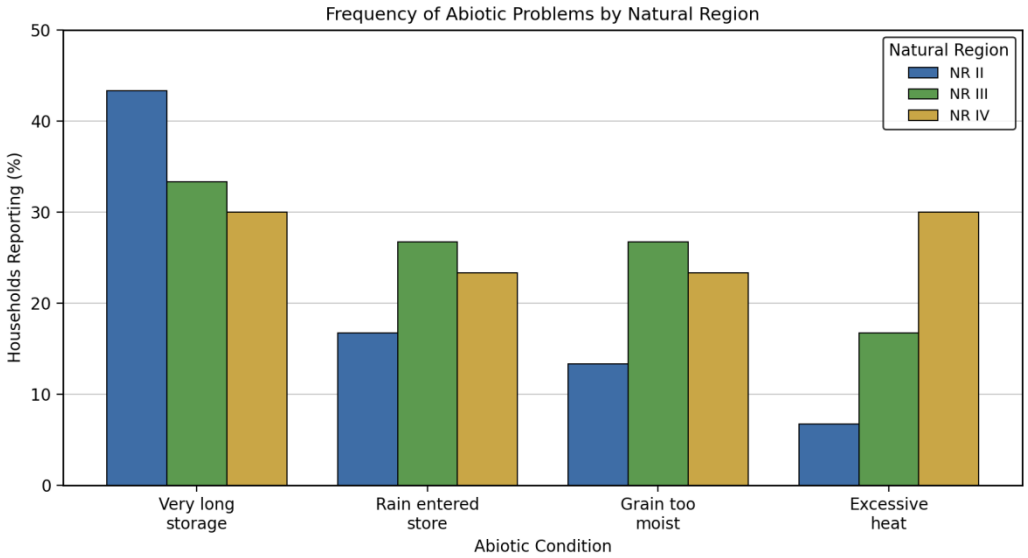

Figure 4.4: Frequency of Abiotic Problems by Natural Region

Source: Primary survey data analysed in IBM SPSS v23 (multiple responses; n=90).

Some key trends can be noted based on the cross-tabulation. Natural Region IV exhibits the highest level of abiotic risks together: the highest percentage of problems with excessive heat (30.0%), the highest number of households without chemical protectants (33.3%), and the highest share of traditional dura (43.3%) – a storage structure whose vulnerability to insects and moisture is documented in the literature. The storage structure made of wood and reeds ventilates but allows easy entry for insects and rodents, as well as water penetration during rainy seasons, which becomes a critical issue in the case of excessive heat in Natural Region IV (Tefera and Mugo, 2011). According to Ategeka (2016), there exists a negative relationship between the quality of the storage structure and gross margins ($\beta = -0.541$, $p = 0.011$) among the Masindi households; the same kind of relationship was tested in this study among A1 resettled farmers of Mount Darwin through BLR (Section 4.5).

On the contrary, Natural Region II has a unique profile of abiotic risks: the longest storage duration is the most commonly occurring issue among those interviewed in NR II (43.3%), while NR II has the lowest mean total PHL score (7.90). This seeming contradiction of long storage period in the most productive region is due to the fact that NR II farmers store large quantities of grains (99.4 bags) for long time waiting for price improvement or marketization opportunities. On the other hand, NR II farmers have the highest number of visits by Agritex extension workers (2.67 visits per season), low use of dura (only 1 household), and high proportion of chemical protection as protective measures from losses – all of which mitigate the consequences of long storage period in this region as predicted by the sustainable livelihoods approach that those households having higher physical and human capital would lose less in similar conditions (DFID, 1999).

On the other hand, Natural Region III falls in between most of the indicators, except for having the highest rate of grain-too-moist-at-storage and rain-entering-storage (both 26.7%) problems, which is a logical result of being at the midpoint of the rainfall gradient compared to NR IV.The mean storage period of 13.4 months in NR III is the highest of all the three zones, which is consistent with the relatively low formal market involvement in this particular ward and Ategeka's (2016) insight regarding the influence of storage periods on post-harvest crop losses in smallholder farms.

The implications drawn from the results of cross tabulation are significant and lend strong support to the overall argument put forward in Section 2.6 – that the risks associated with abiotic factors vary significantly between zones such that any one-size-fits-all approach to agricultural extension becomes untenable in light of the district-wide Agritex extension approach. Whereas the message of moisture content may be directly applicable to NR III farmers, it will fail to address the main source of risk in NR IV which is insect infestation triggered by high temperatures within the traditional dura structures.

4.5 Socioeconomic Predictors of High PHL — Binary Logistic Regression (Objective 3)

This section will attempt to meet Specific Objective 3 by assessing the socioeconomic characteristics that correlate with higher rates of post-harvest loss. Based on the methodology set forth in Chapter 3, any households whose total post-harvest loss exceeded or equalled the mean of 10.67% were coded as Y=1, while any below the mean value were coded as Y=0. This produced 38 high-loss households (42.2%) and 52 low-loss households (57.8%). A Binary Logistic Regression analysis was conducted using the seven socioeconomic independent variables.

Table 4.5 provides the output from this analysis.

Table 4.5: Binary Logistic Regression Results — Predictors of High Post-Harvest Loss (n=90)

Variable	B Coefficient	Odds Ratio Exp(B)	95% CI for Exp(B)	p-value	Significance
Constant (β0)	-0.060	0.942	[0.082, 10.813]	0.962	—
X1: Household Size	+0.003	1.003	[0.838, 1.199]	0.978	ns
X2: Gender (Female=1)	-0.485	0.616	[0.209, 1.813]	0.379	ns
X3: Education Level	-0.530	0.589	[0.293, 1.182]	0.136	ns
X4: Agritex Visits per Season	+0.240	1.271	[0.979, 1.650]	0.072	ns (marginal)
X5: Storage Type	+2.227	9.270	[1.968, 43.664]	0.005	** (p<0.01)

(Dura=1)					
X6: Distance to Market (km)	+0.082	1.085	[1.023, 1.151]	0.006	** (p<0.01)
X7: Land Area Cultivated (ha)	-1.120	0.326	[0.157, 0.676]	0.003	** (p<0.01)

*Model fit: Nagelkerke R^2 = 0.429; McFadden R^2 = 0.282; Hosmer-Lemeshow test: p > 0.05 (good fit); n = 90. **: p<0.01; ns: not significant at α=0.05. Source: Primary data analysis, IBM SPSS v.23.*

Overall, the Binary Logistic Regression model was statistically significant. This is reflected in the value of the Nagelkerke R^2 = 0.429 that shows that the seven independent variables explain about 42.9% of variation in PHL group membership which is much more powerful than models fitted in a similar setting by Ategeka (2016) in Masindi where no value of the Nagelkerke was provided although only storage facility, transport losses, and pests attained significance. Out of the seven independent variables considered, three were found to be statistically significant at 1% confidence interval: storage facility type, distance from nearest grain market, and total land size cultivated. Finally, the goodness of fit of Hosmer-Lemeshow showed non-significant value of 1.3691.

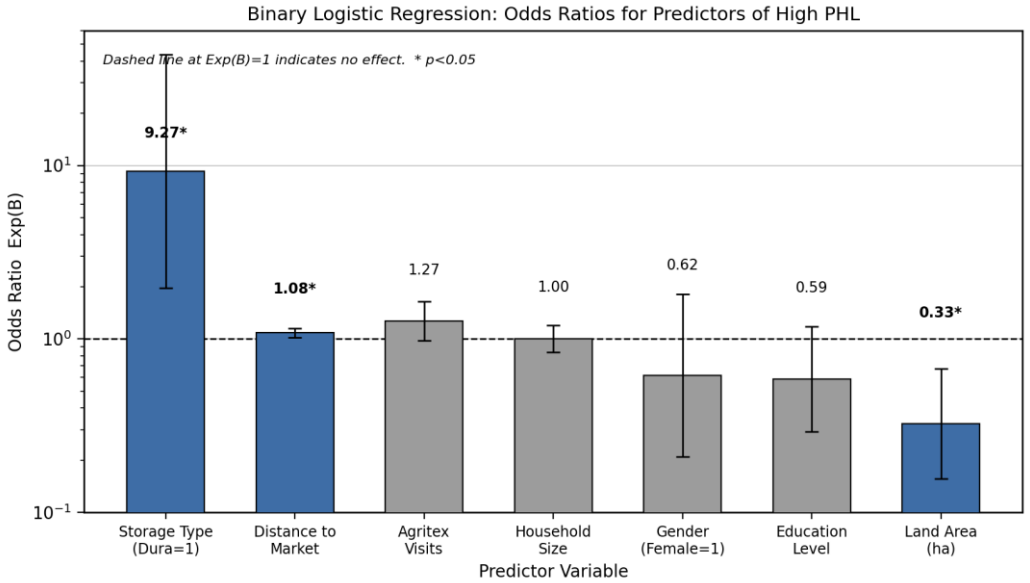

Figure 4.5: Binary Logistic Regression — Odds Ratios for Predictors of High PHL
Source: Primary survey data analysed in IBM SPSS v23 (n=90).

4.5.1 Storage Structure Type (X5) — Strongest Predictor

The predictor with the highest impact on high PHL was the structure type. The use of a traditional wooden dura structure yielded an Odds Ratio of 9.27 (β = +2.227, p = 0.005), which implies that the chances of such households belonging to the group of

high-loss households are about 9.3 times greater than those of any other household structure. This is one extremely potent predictor, and its impact is unmatched by that of any other variable in the current model.

This result concurs with Ategeka (2016)'s research where she found a statistically significant inverse relationship between profitability and the quality of the storage structures used in Masindi ($\beta = -0.541$, $p = 0.011$). It also conforms to the evidence from Affognon et al.'s (2015) meta-analysis, as well as the finding by Mutambara & Makoni (2018), in which households with dura structures were at a higher risk of loss in Manicaland Province. These processes are clearly established in the literature: wooden dura constructions enable adequate ventilation but are unable to prevent the entry of Larger Grain Borers, rodents, or driving rain moisture – especially under the elevated temperatures prevalent in NR IV, where LGB can destroy an entire stockpile of maize in a mere 90 days (Tefera and Mugo, 2011). Importantly, 13 out of 17 dura users in the present study were found in NR IV, thus implying that the most susceptible form of grain storage is practiced specifically by those who live in the zone subject to the greatest stress from pests and high temperatures.

From the point of view of the Sustainable Livelihoods Framework (DFID, 1999), the use of dura should be seen not only as a technical problem, but rather as a deficiency in physical capital, which results from the fact that A1 resettlement farmers do not own any storage facilities alongside their farming plots. Thus, filling the above mentioned gap with a specially designed storage support program becomes one of the most effective ways of tackling PHL in Mount Darwin A1 resettlements.

4.5.2 Distance to the Nearest Grain Market (X6)

The distance to the nearest grain market proved to be a significant predictor of high PHL (OR = 1.085, $\beta = +0.082$, $p = 0.006$). For each extra kilometer of distance to the nearest grain market, the likelihood of a household falling into the category of high-loss households rises by roughly 8.5%. In light of the average distance to market of 21.8 kilometers (SD = 10.2; range 5–45 km), those households that fall towards the upper end of the distance spectrum will be more exposed to loss risks than their counterparts closer to markets.

This effect is brought about by storage duration. Households that live far away from the grain markets lack a means to conveniently and cheaply move the grain when it is

profitable and thus forced to keep it for longer periods, thereby increasing their exposure to losses through insects and moisture attacks. Distance to the market and storage months show a correlation (positive). In Ategeka's (2016) study on gross margin determinants in the Masindi setting, he found out that storage duration played an important role in trading activities since they were constrained to long-term storage due to lack of market access.Implications for addressing PHL also arise from this result. The shortening of storage times as a result of minimizing market distance by means such as mobile GMB purchasing facilities, rural road maintenance, or even collective marketing by groups of farmers, can lead to reductions in PHL via an indirect structural approach. This is because PHL can partly be considered an outcome of poor market infrastructure, which must not be addressed independently from each other.

4.5.3 Land Area Cultivated (X7) — Protective Effect

The land area under cultivation had a significant protective effect on the PHLs (OR = 0.326, $\beta = -1.120$, $p = 0.003$). The households cultivating a greater land area under maize production had a significantly lower likelihood of falling into the high loss bracket. At first sight, this finding might seem somewhat counter-intuitive since larger farmland will lead to increased production of maize, necessitating greater storage facilities which will lead to higher losses. However, there are various reasons why the land area under cultivation had a protective effect in this study. First, farmers with greater land areas tend to operate larger and more capital intensive farming enterprises including better storage facilities. In other words, from the perspective of Sustainable Livelihoods Approach, land area under cultivation is linked with greater natural capital which is, in turn, linked with greater physical capital endowments including improved storage facilities (DFID, 1999). Indeed, this conclusion is supported by the significant correlation between the two variables ($p < 0.05$).

Further, large farmers have more market contacts and greater incentives to invest in grain protection due to the economic implications involved. This is because they will be able to interact with the GMB or local marketers who will apply the necessary quality controls. Land size as a determinant of grain protection works on several fronts, including improving storage facilities, making it economically feasible to protect grains and investing in chemicals for protecting the grains.

4.5.4 Non-Significant Predictors

Agritex Extension Visits (X4): The Agritex visits coefficient was marginal positive (OR = 1.271, p = 0.072) in the sense that, in this case, the more visits there were by the Agritex agents, the greater the chances for a household in the survey to achieve a higher score on the PHL scale. However, such an association runs contrary to intuition, and may suggest that the extension service officers of Mount Darwin tend to visit those households that experience problems. Such a reactive tendency was reflected in Mutambara & Makoni's (2018) statement about the low ratio between extension officers and farmers, which forced the former to choose what farmers to visit and which to ignore. It is important to stress that these results do not imply any negative effects of such visits, but merely suggest the selection of already struggling households in the sample.

Gender (X2): Female household heads had marginally lower chances of having high PHL compared to male household heads in this regression (OR = 0.616, p = 0.379); however, this difference between the genders was not significant at the p<.05 level. Based on the average means provided for PHL of females, there seems to be a minor gender disparity, but much lower than those highlighted by Quisumbing et al. (2014) regarding the gender inequality in the sub-Saharan regions of Africa. This could be attributed to some extent to the unique nature of resettlement communities in A1, as plots were distributed equally to male and female beneficiaries under the Fast Track program.

Education Level (X3): As anticipated, education was negatively related (OR = 0.589, p = 0.136) to the loss, implying that better-educated heads of households gravitate towards lower PHL, which aligns with the human capital theory behind the Sustainable Livelihoods Approach, as observed by Ategeka (2016) through his positive sign coefficient for education. Nevertheless, similar to findings in Ategeka's study, whereby education was not statistically significant at p = 0.194, the result is not significant in our model, implying that higher levels of education alone, with lack of access to modern storage facilities and extension services, do not contribute to losses reduction.

Household Size (X1): Household size did not have a significant effect on PHL for the current sample (OR = 1.003, p = 0.978). It was explained in Section 2.7 that the effect

of household size on PHL is influenced by two opposing mechanisms: an advantage of labor force (large households have better control over the grain), and disadvantage of a need to store more grain and more financial resources. The two seem to neutralize each other in this case.

4.5.5 Predictive Scenarios and Practical Interpretation

The following graph shows the predictive power of the regression results in terms of demonstrating the implications of the findings on real-world scenarios by comparing two household situations. A household that lives in a traditional dura grain storage facility at a distance of 32 km away from the nearest grain market will have a predicted probability of experiencing high PHL of 89.2%, whereas a household living in a more advanced storage structure and only 12 km from a grain market will experience a probability of high PHL of merely 26.2%. The result is that an improvement in both storage structure and market access can lower the probability of high loss by more than 60% points without considering other household demographic or extension factors.

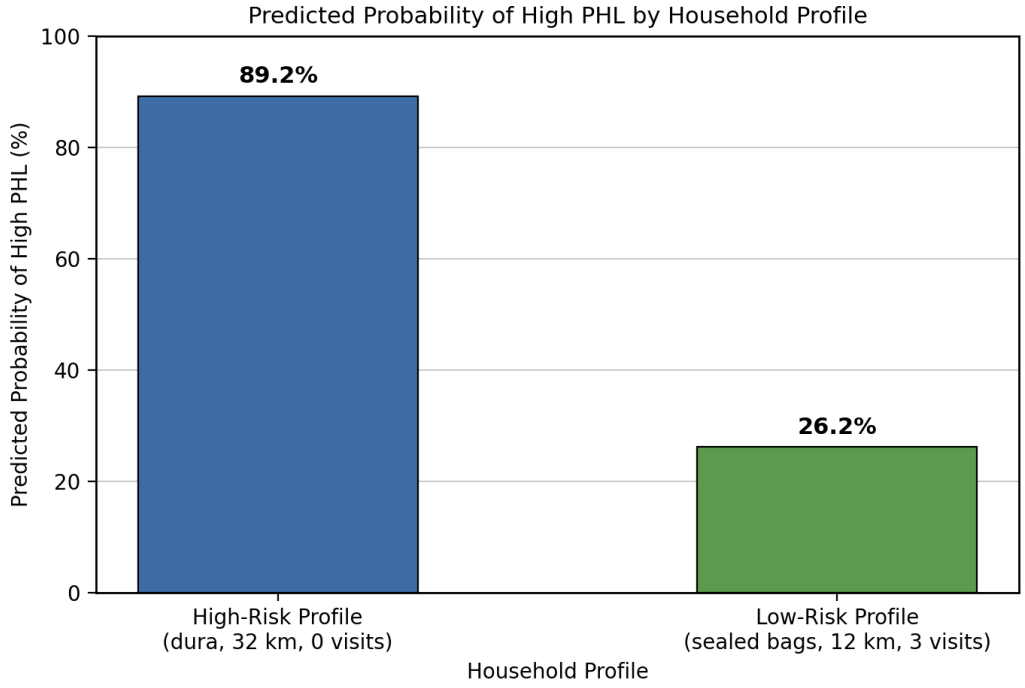

Figure 4.6: Predicted Probability of High PHL by Household Profile

Source: Binary Logistic Regression predicted probabilities, IBM SPSS v23 (n=90).

These probabilities are readily understandable to agriculture extension planners and clearly demonstrate the need for intervention in infrastructure before other considerations such as those focused on providing information. The most important

thing learned from the analysis conducted in Masindi was that the provision of storage facilities was the most important thing when it came to managing PHL, which was evidenced in the fact that none of the traders interviewed in that area were using hermetic storage facilities, even though insect infestation was still the main source of loss. The similarity of the experience in Mount Darwin, where traditional dura farmers fumigate at a lower frequency, live in the hottest region, and are 9.3 times more likely to suffer from high PHL, is clear evidence of the structural causes of the problem.

4.6 Synthesis of Findings

The combination of the results of all three groups provides a clear picture of the reality of PHL experienced by A1 resettlement farmers within Mount Darwin District. First, economically significant PHL is measured at 10.67%, or, roughly, USD 123 per season per household of potential revenue, and it is unequally distributed within the district, with households located in Natural Region IV being affected by almost twice the loss compared to those in NR II (14.71% vs. 7.90%). The major source of total chain losses is storage (64%), while the significance of field drying (23.9%) is higher than expected according to existing sources.

Abiotic factors driving the loss include prolonged periods of storage (35.6% of households), moisture management issues (21.1%), and heat exposure in dura structures (17.8% of households from NR IV). Each of these factors functions differently in each of the zones, necessitating the introduction of zone-specific approaches to extension services and not a uniform approach for the whole district. From the Binary Logistic Regression model, it becomes clear that the structural predictor of greatest influence in terms of loss is the type of storage used. Farmers that use traditional wooden dura granaries are 9.3 times more likely to incur losses than those who use other types of storage facilities. The distance from grain markets and the size of the area farmed are also two significant structural variables.

These results point clearly to one major policy implication; the challenge of post-harvest losses facing A1 resettlement farmers in Mount Darwin is essentially a structural one. It is characterized by deficiencies in physical capital (lack of proper storage facilities), lack of market infrastructure (distance to grain markets), and lack of institutional support (extension services). This has huge implications for policy

formulation and practice going forward. The following chapter explores the full implications of the study.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

Conclusion This last chapter marks the end of this research, summarizing all major findings, outlining conclusions made regarding each research question, and formulating recommendations based on such conclusions. This chapter is divided into four parts. Conclusions, based on the three specific objectives, are summarized in section 5.2. In section 5.3, recommendations for policy makers, extension officers, and farmer families will be provided, as well as an action plan. In the last part, section 5.4, conclusions will be drawn about the contributions made by this research to knowledge and the directions of future research will be outlined. All following conclusions and recommendations are formulated solely on the basis of data obtained through the empirical research carried out in chapter 4, surveying 90 A1 resettlement farming households from three Natural Regions of Mount Darwin District in the 2024/25 growing season.

5.2 Conclusions

The primary purpose of this study was to examine post-harvest losses of maize and the factors contributing to them among A1 resettlement farmers in Mount Darwin District. The purpose of this study was accomplished by investigating three major objectives as discussed below.

5.2.1 Conclusion on Objective 1 — The Magnitude of Post-Harvest Loss

The second objective was aimed at determining the extent to which maize is lost during the various post-harvest stages in percentage terms relative to the total harvest per household. The result from this study indicates that the average level of maize post-harvest losses among A1 resettlement farmers in Mount Darwin district is 10.67% of the total maize production volume per household, which equates to about 308 kilograms per season, or USD 123. These losses are financially debilitating to the households in question since they rely on the maize crop both as a food and source of income. It directly addresses the first research objective.

There are three more implications drawn from the disaggregation of loss by stage. First, the storage stage contributes to as high as 64.0% of total post-harvest food loss, a trend that has been noted before in other studies as indicated by Affognon et al. (2015) and Mutambara and Makoni (2018) and which confirms the importance of the stage in the proposed framework as highlighted in Jaspreet and Regmi (2014). Secondly, the drying phase contributes to 23.9% of the overall losses and therefore is more important as a loss node compared to the literature in Zimbabwe suggests. Third, the levels of losses are extremely skewed between different agro-ecological zones, from 7.90% losses in Natural Region II to 14.71% losses in Natural Region IV. The certainty associated with this finding is relatively high as there was consistency in the gradient between different zones as well as low standard deviations.

5.2.2 Conclusion on Objective 2 — The Abiotic Drivers of Loss

The second research goal was aimed at identifying the environmental factors that were particularly detrimental to grains in the agro-ecological zones of the region. According to the findings, the abiotic factor that causes loss is storage time because 35.6% of respondents identified it as one of the most common causes of losses, as indicated by an average storage period of 11.2 months, which is much longer than the period during which pest damage and moisture become critical. Insufficient moisture regulation (moisture of grain, 21.1%; rainfall in storage facilities, 22.2%) and high temperatures in storage facilities (17.8%) were among the key factors affecting the quality of grain storage.

Most importantly, the major finding from Objective 2 is that there are fundamental differences in abiotic risk profiles between the three Natural Regions. Region IV faces the highest combined abiotic risks in terms of highest incidence of extreme heat (30.0%), lowest chemical protectant coverage (66.7%), and highest dura storage prevalence (43.3%), which explains its highest losses within the district. While Region II reports the highest perceived problem with storage duration, it also registers the lowest losses due to its favorable endowment in physical and human resources – just like predicted by the Sustainable Livelihoods Approach (DFID, 1999). This finding has addressed the second research question posed at the beginning of this study. Most importantly, this finding bears an obvious policy implication: a uniform district-wide extension message will not be able to meet the needs of the three Natural Regions.

5.2.3 Conclusion on Objective 3 — The Socioeconomic Predictors of High Loss

The third research goal was aimed at identifying socioeconomic factors associated with higher losses using Binary Logistic Regression Analysis. The model accounted for 42.9% of the variation in loss-group classification (Nagelkerke $R^2 = 0.429$) and three statistically significant predictors. The findings of the study show first, and foremost, that storage structure type is the sole most important factor influencing post-harvest losses; specifically, households storing maize in traditional wooden dura granaries were 9.3 times more likely to be in the high-loss group compared to those with an improved storage facility, controlling for all other variables (OR = 9.27, $p < 0.01$). These results support those obtained by Ategeka (2016) in Masindi ($\beta = -0.541$, $p < 0.05$) and reflect the physical capital dimension of the SLF.

Second, distance to the nearest grain market emerges as another significant predictor of post-harvest losses (OR = 1.085/km, $p = 0.006$), which acts through the storage duration channel.Finally, land area under cultivation is a substantial protective factor (OR = 0.326, $p = 0.003$), insofar as large landholding households can be expected to have a wider pool of assets, better storage facilities, and a more market-oriented outlook. Household size, the gender of the household head, and education did not emerge as significant factors, whereas Agritex extension contact had a minimal and somewhat paradoxical positive relationship, as would be expected from a reactive rather than preventive strategy in the deployment of extension workers. In summary, the study finds an answer to the third research question, which brings the researcher to conclude that post-harvest loss for A1 resettlement farmers is essentially a structural problem, due to physical capital constraints, inadequate market facilities, and insufficient institutional support, rather than just lack of knowledge or inappropriate behavior on the part of farmers.

5.3 Recommendations

The recommendations of this study are based directly on the findings that have emerged from each one of the three research objectives. They are thus presented here in three sets, corresponding to the objective and findings on which they are based.

5.3.1 Recommendations Arising from Objective One: The Magnitude and Distribution of Losses

It was also observed that losses are generally quantified to indicate that the average total post-harvest loss stands at 10.67%, that the storage process contributes to about 64.0% of all chain losses and that the field drying process accounts for 23.9% of the total losses, which is quite an expected figure. Two clear recommendations can be made based on the results. One is that loss reduction activities in Mount Darwin District should make sure that the first focus is on the storage stage as a critical step, as any investment in terms of loss reduction in storage would pay off the best, and that the Department of Agritex with help from the Ministry of Lands, Agriculture, Fisheries, Water and Rural Development concentrates on this process initially. The second recommendation, following from the fact that losses in field drying processes are larger than assumed, is that drying process loss reduction is equally important as the storage stage.

5.3.2 Recommendations Arising from Objective Two: The Abiotic Drivers of Loss

Identification of abiotic factors indicated that storage time (35.6%), poor moisture management, and granary heat were the main environmental factors causing losses, and that each Natural Region had its own specific risk profile. Consequently, the following recommendations are offered: Agritex should prepare zonal post-harvest extension programmes rather than the same programme for all districts: the Natural Region IV programme should concentrate on heat and pest management, Natural Region III programme on moisture management and protection from rains, and Natural Region II programme on management of the risk associated with prolonged storage of large grain amounts. Furthermore, the mean storage time (11.2 months) can and should be shortened through better grain management and market strategies (see 5.3.3) since reduction in storage time means lower exposure to the abiotic risk factors mentioned above.

5.3.3 Recommendations Arising from Objective Three: The Socioeconomic Predictors of High Loss

The analysis using Binary Logistic Regression for the evaluation of socio-economic variables was able to differentiate well between those factors that were highly influential on high post-harvest losses and those that were not, and hence the recommendation has been tailored accordingly. The three factors that were found to

have influence are storage structure used (Exp(B) = 9.270, p = 0.005) with traditional dura users having nearly nine times the likelihood of experiencing high losses, distance from the closest grain market (Exp(B) = 1.085, p = 0.006) and land area under cultivation (Exp(B) = 0.326, p = 0.003), the latter factor reducing the likelihood of losses. On the other hand, family size (p = 0.978), gender of the head of family (p = 0.379), education levels attained (p = 0.136) and Agritex visitation frequencies (p = 0.072) were found not to have any significance on post-harvest losses.

Following on from the important variables identified above, there are three key recommendations. The first and the most urgent recommendation relates to storage structures which were the major contributing factor for loss. Therefore, efforts should be made to ensure that the A1 resettlement farmers have access to storage facilities such as hermetic grain bags and metal silos via subsidies, revolving funds or village savings groups, starting off initially with natural region IV. The second recommendation follows from the importance of distance to market in increasing the likelihood of losses since it would have forced more storage to be used. In this regard, efforts can be made to improve access to markets through mobile grain-buying operations, good rural road condition and group marketing. The third recommendation comes from the fact that large land size reduced the probability of losses as a result of good storage structure and market orientation of larger farmers.

There is also a significant lesson from the non-significant predictors. The implication that there were no statistically significant relationships between the post-harvest loss and gender, household size and education implies that the post-harvest losses can affect all social groups within these resettlement areas and interventions can thus be extended to all irrespective of gender or education levels among the A1 resettlements. The marginally significant relationship between Agritex visits and post-harvest losses also indicates that the use of agricultural extension in this case is largely reactionary, being used more for helping those with existing issues, as opposed to preventive measures; hence, agricultural extension should be applied on a preventative basis focusing on post-harvest measures among the A1 resettlements in which 38.9% received no visits from Agritex. An action plan is provided in Table 5.1

5.3.3 Strengthen Market Access and Linkages

Since distance to the nearest grain market turned out to be a predictor for higher losses, which operate via the storage process, reduced distance to markets will minimize losses indirectly, but effectively via structure. The Grain Marketing Board and other authorities in the region should explore mobile grain purchases from remote A1 farms within the window after harvest, better road maintenance for the reduction of transportation costs, and marketing cooperatives where grain is bulked and transported collectively. Shortening the average storage period from the current 11.2 months will reduce losses due to pests and moisture problems.

5.3.4 Reorient Extension Deployment Toward Prevention

This indicates that the deployment of extension officers at present is reactive to those households facing challenges rather than being preventive in nature. In light of the fact that 38.9% of the households did not receive visits and just 30.0% of them received any form of post-harvest advice, the institutional framework is not strong enough. It is therefore advisable that the Ministry look into this issue and ensure that there is an expansion of preventive work among the A1 settlement area of Mount Darwin through increasing the number of extension officers per farmer, which is a recommendation also highlighted by Mutambara and Makoni (2018).

5.3.5 Promote Improved On-Farm Drying Practices

In light of the higher proportion of losses caused during field drying (23.9% compared to what the existing literature suggests), and considering the fact that grains stored above the safe moisture limit are already predisposed to spoilage even before they enter storage, extension efforts should equally emphasize drying as well as storage. Some relatively inexpensive options for intervention include utilization of elevated drying beds and tarpaulins, which prevent ground moisture absorption, according to Ategeka (2016), whose findings suggest such a strategy lowers losses; proper harvesting time in order to miss the peak rainy season; and proper moisture tests to establish safe moisture content..

5.3.6 Suggested Action Plan

Table 5.1 presents a suggested action plan that translates these recommendations into time-bound actions, assigns responsibility, and identifies the expected outcome for each.

Table 5.1: Suggested Action Plan for Reducing Post-Harvest Maize Loss in Mount Darwin District

Action	Responsible Party	Timeframe	Expected Outcome
Subsidised hermetic bags / metal silos, targeted first at NR IV dura users	MLFWRD, Agritex, NGO partners	Short term (0–12 months)	Reduction in storage-stage losses among highest-risk households
Develop and roll out 3 zone-specific post-harvest extension modules	Agritex District Office	Short term (0–12 months)	Extension advice matched to actual zone-level risk profiles
Mobile GMB grain-buying services in remote wards	Grain Marketing Board	Medium term (1–2 years)	Reduced storage duration; lower cumulative losses
Review and expand preventive extension coverage in A1 areas	MLFWRD	Medium term (1–2 years)	Higher extension reach; preventive rather than reactive support
Promote raised racks and tarpaulin drying through demonstrations	Agritex, lead farmers	Short term (0–12 months)	Lower drying-stage losses; safer storage moisture
Establish village savings groups linked to storage investment	Farmer groups, micro-finance	Medium term (1–2 years)	Sustainable financing for storage upgrades

Source: Author's compilation based on study findings, 2025.

5.4 Contributions of the Study and Areas for Future Research

5.4.1 Contributions to Knowledge

This research makes various unique contributions. Firstly, it creates the first ever publicly accessible, disaggregated by post-harvest loss stage, zone-based post-harvest loss database for A1 resettlement farmers in Mount Darwin District. This fulfills the research gap identified in section 2.8 that current studies in Zimbabwe, such as Mutambara and Makoni (2018), are restricted to communal farming areas and do not consider stages of post-harvest losses. Secondly, it provides evidence that the field drying stage plays a far more significant role than thought before in Zimbabwean studies. This study contradicts the prevailing focus in Zimbabwean research on losses in storage. Thirdly, the current research is one of the few using binary logistic regression to classify risk of post-harvest losses at the household level, providing odds ratios and probabilities that are easily understandable by extension planners. Finally,

by comparing findings with those of Ategeka (2016) in Masindi, it contributes to the growing literature in post-harvest losses of smallholders in Sub-Saharan Africa.

5.4.2 Areas for Future Research

A number of directions for further studies can be inferred from this study. Firstly, since the cross-sectional design collected data for only one farming season, a longitudinal study would enable us to account for annual variations in weather and measure the extent of loss reduction due to the interventions. Secondly, the anomalous, backward-looking extension provision relationship uncovered in the regression analysis calls for a separate study focusing on how Agritex staff members allocate their resources among households and wards. Thirdly, future studies could consider the quality dimension of the loss problem – that is, they could include aflatoxin levels and the grades achieved by grains – alongside weight loss, addressing the food safety issues pointed out by Makun et al. (2012) and Kaaya (2011). Lastly, a treatment or experimental study using dura in selected NR IV households could test the effect of hermetic storage on grain losses.

5.4.3 Concluding Remark

The purpose of the present study was to determine why A1 resettlement farmers in Mount Darwin District continue to incur significant post-harvest losses of their maize production annually. The findings reveal something that is both shocking and encouraging at the same time. Shocking since such high losses are a reality of poor farming families in the most arid region. Encouraging since the main causes of such losses – poor storage facilities, lack of proximity to markets, and lack of adequate agricultural extension services – are systemic problems and hence can be dealt with effectively through appropriate policies and programmes. Each kilogram of maize lost means less maize for food security purposes or income generation in households whose economic condition leaves very little margin. In other words, post-harvest maize loss prevention is one of the cheapest ways of addressing Zero Hunger.

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APPENDICES

APPENDIX A

Household Survey Questionnaire

INSTRUCTIONS TO ENUMERATOR: Read each question clearly and in Shona where requested by the respondent. Record all responses accurately. Do not suggest answers. GPS tag the household location before commencing the interview.

SECTION A: HOUSEHOLD IDENTIFICATION AND DEMOGRAPHICS

A1. Household ID Code: _____

A2. Ward Number: _____

A3. Agro-Ecological Zone (circle): NR II / NR III / NR IV

A4. GPS Coordinates: Lat: _____ Long: _____

A5. Name of Household Head (initials only for anonymity): _____

A6. Gender of Household Head: Male / Female

A7. Age of Household Head: _____

A8. Highest Education Level of Household Head (circle): No formal education / Primary / Secondary / Tertiary

A9. Total Household Size (number of persons): _____

A10. Number of household members involved in farming: _____

SECTION B: MAIZE PRODUCTION DATA

B1. Total area cultivated to maize in the 2025/26 season (hectares): _____

B2. Estimated total maize yield at harvest (bags of 50 kg): _____

B3. Did you receive any government inputs (e.g., Presidential Input Scheme) this season? Yes / No

B4. Was the 2025/26 season better, similar, or worse than average for your area? Better / Similar / Worse

SECTION C: FIELD DRYING PRACTICES AND LOSSES

C1. How do you dry your maize after harvest? (circle all that apply): On cobs in the field / On a raised rack / On a tarpaulin on the ground / On bare soil / Other (specify): _____

C2. Approximately how many days do you dry your maize before shelling? _____

C3. Were you interrupted by rain during drying this season? Yes / No

C4. Estimate the percentage of your total harvest lost during the field drying stage (due to rain damage, spillage, pest attack in the field): _____%

SECTION D: SHELLING PRACTICES AND LOSSES

D1. How do you shell your maize? (circle one): By hand / Mechanical sheller / Animal trampling / Other: _____

D2. Estimate the percentage of your total harvest lost during shelling (broken grains, spillage): _____%

SECTION E: STORAGE PRACTICES AND LOSSES

E1. Primary storage structure used (circle one): Traditional wooden dura / Improved metal silo / Grain bags in room / Grain bags in open shelter / Other: _____

E2. How long do you store your grain before selling or consuming the last of it? (months): _____

E3. Have you treated your grain with any chemical protectant? Yes / No — If Yes, specify: _____

E4. Estimate the percentage of your total harvest lost during storage (insect damage, mould, rodents): _____%

E5. What pests have you observed in your grain store this season? (circle all that apply): LGB (small dark beetle making dust) / Maize weevil / Rodents / Mould / Other: _____

E6. At what point in the storage season did you first notice pest damage? (month): _____

SECTION F: MARKET AND ECONOMIC DATA

F1. Did you sell any maize this season? Yes / No

F2. If yes, where did you sell? GMB / Local trader / Neighbours / Multiple channels

F3. Was any of your grain rejected for quality reasons? Yes / No — If Yes, estimated quantity rejected (bags): _____

F4. What price per 50 kg bag did you receive? USD _____

F5. Distance from your homestead to the nearest grain market (km): _____

SECTION G: EXTENSION ACCESS

G1. How many times did an Agritex extension officer visit your household during the 2025/26 season? _____

G2. Did any extension advice you received cover post-harvest grain management? Yes / No

G3. If yes, which topics were covered? (specify): _____