AN ASSESSMENT OF SMALL GRAIN POST-HARVEST MANAGEMENT PRACTICES IN WARD 22 OF BUHERA DISTRICT

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A DISSERTATION SUBMITTED TO THE DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES IN PARTIAL FULFILMENT OF BACHELOR OF SCIENCE HONOURS DEGREE IN GEOGRAPHY AND ENVIRONMENTAL STUDIES

OCTOBER 2017

DECLARATION

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DEDICATION

This dissertation is lovingly dedicated to my mother, Mrs Esina Gwarimbwa for all her guidance, sacrifices and support she gave me since my tender age up to now. Without her, this academic journey would be impossible.

ACKNOWLEDGEMENTS

I wish to warmly express my deepest appreciation to Almighty God for his grace and protection throughout my academic journey. I also want to express my great honour to Dr W. Kusena, my project Supervisor for her constructive criticism, comments and professional guidance which resulted in the accomplishment of this work. I also want to give a lot of thanks to the Ward 22 Councillor and community members for their participation in this research. I would like to acknowledge the Ward 22 Extension officer, GMB Depot Manager, Project Evaluation and Monitoring Manager of World Vision for their participation in this study. Lastly, I owe my sincere gratitude to all my family members and friends with special mention and appreciation to Lydia Kundeseyo, Bradwin Zinyoni and Tadzidza Takundwa for being source of inspiration to me.

LIST OF ACRONYMS

AGRITEX	Agricultural Technical and Extension services
APHLIS	African Post-Harvest Losses Information System
CIMMYT	International Maize and Wheat Improvement Center
FAO	Food and Agricultural Organisation
GMB	Grain Marketing Board
ICRISAT	International Crops Research Institute for the Semi- Arid Tropics
LGB	Large Grain Borer
NGO	Non-Governmental Organisation
PHL	Post-Harvest Loss
PHM	Post-Harvest Management
PHP	Post-Harvest Profiles
SDC	Swiss Agency for Development and Cooperation
SPSS	Statistical Package for Social Sciences
SSA	Sub Saharan Africa
WFLO	World Food Logistics Organization
ZimVac	Zimbabwe Vulnerability Assessment

ABSTRACT

The research was carried out to assess small grain Post-Harvest Management practices in ward 22 of Buhera district. A case study research design was used and the research employed both quantitative and qualitative research approaches. Two stage of multistage sampling technique was used. For the first stage, primary sample units (villages) were drawn randomly from all the villages in Ward 22 and for the secondary sample units, stratified random sampling was used to select households for questionnaires. Purposive sampling was employed to select key informants from World Vision, AGRITEX, GMB and the Ward Councillor. A combination of questionnaires, interviews, measurements and observation were used to collect data from the field. Data collected from the field was analysed using Statistical Package for Social Sciences (SPSS) and Microsoft excel. Results of this study showed that indigenous Post-Harvest Management practicessuch as use of chaff, *Mutikiti* leaves and crushed barks, dung and ashes at storage stage,bare ground, *ruware*, and stalksat drying stage and beating and cattle trampling at threshing stage are currently being used in Ward 22 of Buhera district. It was also shown that these indigenous technologies are susceptible to pests, termites, moulds and incomplete threshing. The results revealed a worrying lack of modern day Post-Harvest Management technologies which have proved to be a solution towards Post-Harvest Loss reductions. The findings established that lack of required resources such as cattle, scorch-carts, labour, and money are the major constraints hindering adoption of modern day technologies. Results revealed that food is being eliminated from food supply chain through decay, germination, scattering and damage. It was also revealed that, pertaining to level of Post-Harvest Loss, there was an underestimation of loss from self-reported loss estimations. However, findings of this research found that there is a strong correlation between household head type and level of loss. The researcher recommends that there is a need for the NGOs and the government to initiate exotic post-harvest technologies aimed at equipping the farmers both with sophisticated tools and equipment and modern day knowledge through awareness creation and training. There is also a need for continual quantification of on-farm loss which can be compared to costs of adopting improved post-harvest practices.

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CHAPTER ONE: INTRODUCTION

1.1 Background to the study

Global population is escalating at a very high rate, with many researchers in unison that the rapid population rise will further add to global food security concerns and increased demand of mouths to feed. With the perceived food insecurity, Hodges (2010) posits that globally, about 850 million people are undernourished. This forced the international community to come up with sundry measures in response to the 1966 International Covenant of Economic, Social and Cultural Rights Article 11 (1 and 2) (World Bank, 2014). The State Parties of the declaration agreed to revive agrarian systems and trade policies. This raised and intensified issues of management of food stocks, improvements on agriculture production, distribution, land use and population control as basic requirements at all levels. However, globally, some continents are food insecure, within the continent some countries are food insecure, within the countries some districts are food insecure, within the district some villages are food insecure and within villages some households are food insecure.

World Food Logistics Organisation (WFLO) (2010) argued that for decades, most countries have concentrated on the improvement in agriculture production, population control, increase in distribution of food through globalization and land use planning. However, Post-Harvest Loss, a crucial issue is yet to be given the same attention. For example, 95% of the research investments in the past 30 years were reported to have focused on increasing productivity and only 5% directed towards reducing losses (Kader, 2005 and WFLO, 2010). Rugumamu (2011) noted that Post-Harvest Management (PHM) is a set of logical handling procedures in an intricate sequence of interconnected field and homestead operations undertaken by farmers.

Post-Harvest Loss (PHL) is defined as quantitative and qualitative loss of food which was available for the purposes of consumption but not consumed due to many reason. Hodges, Buzby and Bennett (2011) alluded that PHL is a measurable quantitative and qualitative loss of food starting at assemblage period up to its consumption. According to Gustavsson, Cederberg, Sonesson, van Otterdijk, and Meybeck(2011), Food and Agriculture Organisation predicts that about 1.3 billion tonnes of food are wasted or lost per yearworldwide. Reduction in these losses would increase the amount of food available for human consumption and

enhance global food security.World Bank (2011) revealed that food loss reductions by 1% can result in a US$40 million gain.

According to FAO (2013), food worth US$4 billion per year is lost which is equivalent to an amount that can feed 48 million people in Sub Saharan Africa (SSA). This worsens food insecurity in developing countries through food unavailability and impaired food utility. This is in contradiction to the targets of Sustainable Development Goals of the United Nations Sustainable Development Summit (2015); Goal 2 which is to End Hunger, Achieve Food Security and Improve Nutrition and Promote Sustainable Agriculture by 2030.

The adoption of drought tolerant crops in SSA has managed to temporarily settle the problem of food insecurity. Moyo (2010) found out that in Southern Africa, small grains are consumed mostly by disadvantaged groups for example the multitude of smallholder farmers in rural areas in countries such as Zimbabwe and Botswana. However, what is not known is their PHM until next season (harvest) (Hodges, 2010).International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) (1996) and Moyo (2010) revealed that due to their ability to withstand stresses of low soil fertility, droughts and high temperatures,small grains have the potential to minimize food insecurity situations for most of the world's poorest countries. However, Taylor (2003) noted that research on small grain PHM technologies is still lagging behind particularly in Africa. Thus, most countries in SSA have shifted back to maize as their primary crop. This means that for the 5% research investments towards PHM, greater percentage is directed to maize and leaving small grains with a relatively minimal attention.

Moyo (2010) argued that the government of Zimbabwe's sustenance measures towards small grain PHM are very low. There is paucity on data for small grain PHL and FAO only estimated losses incurred in maize. FAO (2015) revealed that in Zimbabwe, maize losses ravages at an estimated 100 000 tonnes between assembling and storage stages. However, little attention being given to small grains in Zimbabwe increases the likelihood of losses after harvest.

Small grains can contribute to food availability and utilization, if properly managed after harvesting. According to Mtambanengwe, Mapfumo, Manzeke, Nezomba and Muchuweti (2016), small grains have ripple effects of acting as source of income through selling of home-brewed beer, bran and non-alcoholic beverages (*maheu*). Small grain plays a central role for the sick, the weak and is a crucial source of proteins and has amino acids which are

not found in maize (*ibid*). The aforementioned benefits cannot be accrued if there is no continual research on viable and sustainable small grain PHM practices in rural areas of Zimbabwe. Marambanyika, Kusena and Mtekwa (2014) argued that where possible, low cost indigenous reduction methods should be complimented by exotic technologies to reduce the expenses of post-harvest in poorly marginalised smallholder farmers in Zimbabwe. Thus, this research seeks to explore current PHM practices, associated challenges and the magnitude of loss per post-harvest stage in Ward 22 of Buhera.

1.2 Statement of the problem

Ward 22 of Buhera district lies in natural ecological region IV of Zimbabwe. Unfavourable climatic conditions for growing of large grains have forced this community to shift into small grain production as a strategy to curb food insecurity. The community managed to adopt the growing of drought tolerant crops of which success has been noted. Kuwadza (2017) revealed that small grains have been successfully grown across Zimbabwe, with hectares of sorghum increased by 118%, from 86 000hectares in 2016to 188 430 hectares in 2017, pearl millet registered an increase of 120% from 56 000 hectares in 2016 to 124 088 hectares in 2017, but these commendable attainments could be ruined if the farmers do not engage in viable PHM practices.

However, in Buheradistrict, 61% of the total population was food insecure in 2016 for the period January to March and projections show that an estimated 71% would be food insecure for the same period in 2017(Zimbabwe Vulnerability Assessment (ZimVac), 2016). Unfortunately, this begs a question why food insecurity (food shortages, devoid of safe food, malnutrition, hunger and starvation) still persists in Buhera district despite noted achievements of small grain production in Buhera district.

Kader (2005) argues that 95% research investment is directed towards increasing production and only 5% is focused on reducing PHL. World Bank (2011) revealed that 20% to 40% of cereals are lost in developing countries at post-harvest stages (assembling, drying, transportation, packaging, storage and milling). The area under study is not an exception to these losses. The perception might be that; this community is turning a blind eye to the issue of PHM which later on expose them to structural food shortages. Therefore, this research intends to assess the contribution of PHL on food insecurity in Ward 22 of Buhera district.

1.3 Objectives

1.3.1 General objective

- To assess small grain post-harvest management practices in Ward 22 of Buhera district.

1.3.2 Specific objectives

- To identify practices used at post-harvest stages.
- To assess management challenges associated with post-harvest stages
- To determine the level of loss per post-harvest stage.

Hypotheses

H_0–there is no significant difference in the level of loss from self-reported loss estimations and field measurements between household head types

H_1– there is significant difference in the level of loss from self-reported loss estimations and field measurements between household head types

H_0–there is no strong correlation between household head type and level of loss both from self-reported loss estimations and field measurements.

H_1 – there is strong correlation between household head type and level of loss both from self-reported estimations and field measurements.

1.4 Justification

Paucity on PHL data is still a global challenge. PHM issues are complex and therefore do not have universally recognised measures. This research is going to focus on small grain PHM practices and their impact towards food availability and utilization which are yet to be examined particularly in Zimbabwe. Food insecurity in Zimbabwe is taken from the perspective of production failures, for instance ZimVac (2016) alluded that the government of Zimbabwe declared that 46% of the national population is food insecurity due to El Niño induced drought. Again, Maxwell (1996) brought another dimension where he stressed that, in most cases, food depletion in Zimbabwe means all the food was consumed and therefore, turning a blind eye to food which goes unconsumed due to loss or wastage.

Unfortunately, most of the existing PHL estimations are centred on anecdotal stories with limited data from the field (Aulakh and Regmi, 2013). Other cereals have been well

researched as compared to small grains (Taylor, 2003). Therefore, this research shall focus on the small grain PHM practices in Ward 22 of Buhera with main attention to pearl millet.

The district of Buhera falls into three natural ecological regions and therefore crops grown in this district varies. The variations in crops grown also tend to affect losses at different stages to different crops. Losses may not homogeneously occur but vary due to a variety of factors, the importance of which varies from commodity to commodity, from season to season, and to the enormous variety of circumstances under which commodities are grown, harvested, stored, processed and marketed (Taylor, 2003). This is why this current research seeks to assess small grain PHM practices at local level. It has been noted that whether the food stocks are in abundance or few, there is a need for sustainable and viable management practices. This research is going to establish facts about current PHM practices, challenges faced and amount of loss at each post-harvest stage in Ward 22 of Buhera district.

This research is important to the researcher, institutions and as well as the community under study. To Ward 22's villagers, the findings of this study will be a road map on how best villagers can come up with effective PHM practices. This will aid them to reduce PHL of their available food, maintenance of nutritional quality and as well as attainment of long term food security. Institutions such as World Vision will also benefit from the results of this research. This will aid them in coming up with proper intervention strategies that address existing local problems. The government will also benefit, by working hand in glove with the community in an attempt to minimise PHL. Thus, the partnership will go a long way in reducing food dependency from the government. Instead of the government channelling resources for food aid, resources will be used for rural development. This research will also lure international organisations such as FAO and World Bank to increase their investments in small grain PHM.

1.5 Study Area

Ward 22 is found within Buhera central of ManicalandProvince. The Ward is about 93 kilometres from Mutare town and 74 kilometres from Birchnough Bridge. The main road from Harare to Chipinge linked Chivhu and Birchnough Bridge via Murambinda growth point detours Ward 22. The Ward is about 1 190metres above sea level and is located Southwest of Mutare.

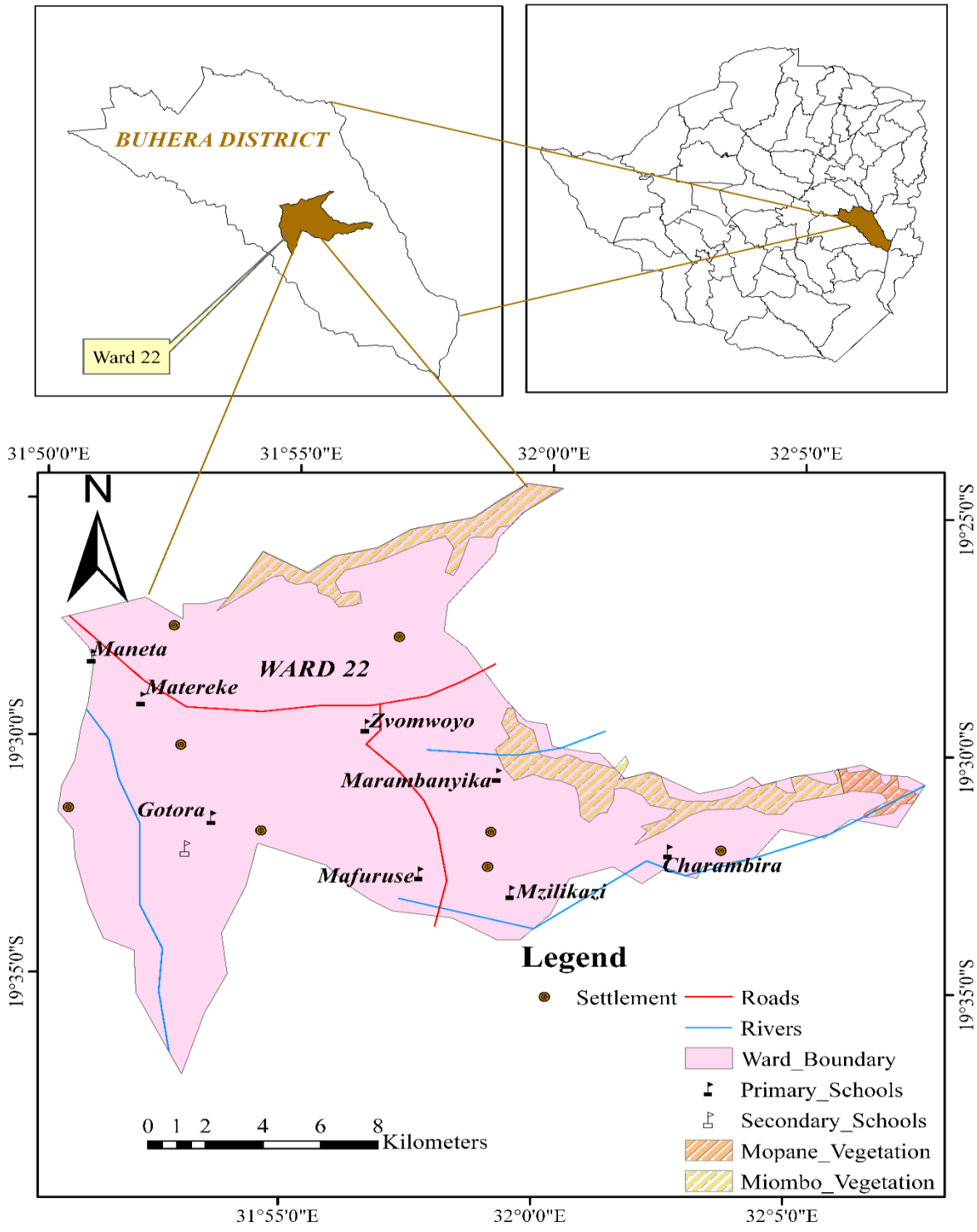


Plate 1.1: Map showing ward 22 of Buhera district.

1.5.1Physical Characteristics

Ward 22 lies into Natural ecological region IV. In terms of rainfall, FAO (2006) revealed that Buhera central receives low, erratic and poorly distributed rainfall of an average of 450-650mm per year. Temperatures are fairly medium to high. Buhera central experiences fairly hot summers with temperature range of 30°C to 40°C and 6°C to 25°C mild winters. According to FAO (2006), the region is prone to frequent dry spells and cyclical droughts and farmers within this region practice small grain production.

Thesoils in this Ward ranges from sandy, partially loam and red. Dominant tree species found in this area composed of Julbernadiaglobiflora (musasa), Treminalia (misusu) and Mopane. In most of Ward 22's villages, small mopane thickets are found. Rivers are scattered within this Ward. These rivers contain a lot of bulrush and offer habitation for qualia birds.

1.5.2 Socio-economic Characteristics

Most of villages in Ward 22 are dominated by the Shona of the Hera ethic group of the *Musiyamwa* totem under chief Nyashanu. The Ward is composed of 47 villages. There are two major business centres serving the whole district including Ward 22. These are Murambinda and Birchnough Bridge Growth points. The roads linking these centres are in a sorry state. Muzokomba, Murwira and Chipongwe clinics serve as Ward 22's health care centres. Both primary and secondary schools are scattered throughout the Ward. However, the whole district does not have tertiary education centres

Christianity is known far and wide in this Ward with mushrooming of the churches such as Johanne Marange, Zion, Zvikomborero, Mugodhi, Zvapupu just to mention a few. Traditional practices are also dominant for example most households have traditional granaries *(hozi)* which they believe to symbolise wealth.

According to ZimStat (2012), Ward 22's population of females constituted of 6567 and their male counterparts are 5858.Average household size for this Ward was at 4.1 in 2012 (*ibid*). About 67% of total population in Buhera practice agriculture for their survival (ZimVac, 2016).Livestock production is also done in Ward 22 of Buhera. Other sources of food to this community are the collection of non-agriculture foods such as both exotic and indigenous fruits. Forests foods such as mopani worms also harvested to supplement their dietary needs.

CHAPTER TWO: LITERATURE REVIEW

2.1 History of Post-Harvest Management.

Before 1970s, innovations in agriculture were anchored on targeting low productivity, adaptation to climate change and food aid and yet an extra factor that exacerbates food insecurity, PHL, was not given similar attention (World Bank, 2011 and World Bank, 2014). It was then in the aftermath of the 1970s' food crisis which for the first time, the international community discussed management issues of harvested food stuffs. Remarkable development investments were spared for PHM after the food crisis of 1970s (World Bank, 2011). Again, World Bank (2014) reiterated that PHM remained a topical concern on the international agenda since the mid-1970s' food crisis.

Thereafter, in 1975, FAO (1981) declared that, "further reduction of post-harvest food losses in developing countries should be undertaken as a matter of priority." In 1976 after the seventh session of the United Nations (UN) General assembly, FAO set a target to reduce PHL by 50% by the year 1985 (Aulakh and Regmi, 2013). In the same year, FAO formulated a special action programme, which identified three major constraints on post-harvest loss prevention in developing countries. They were as follow:

- Lack of information about the amplitude of the losses, the nature of the losses, their causes and the most effective techniques for reducing or preventing them;
- Lack of infrastructure for implementing loss prevention measures;
- Lack of investment in food loss prevention

Conclusions from FAO's report revealed that scales for PHL figures on cereals were not well supported and this inspired individuals, countries and organizations to focus their efforts towards PHM (Aulakh and Regmi, 2013). In 2009, the UN High-Level Task Force for Food Security and Nutrition introduced The Compressive Framework for Action after the unforgettable 2008 food crisis (World Bank, 2011). In 2010, a programme endorsed by World Bank called The Global Agriculture and Food Security was also put in place in an attempt to attend to PHM (*ibid*).

Adam in 1977 proposed loss assessments for cereals and pulses, where samples were taken from the fields and submitted to the laboratory for assessments (Aulakh and Regmi, 2013). The count and weigh method was first initiated in Malawi by Colob for estimating losses incurred in maize and sorghum, where sample weight was compared to the expected weight it would have registered in the absence of loss or damage (Aulakh and Regmi, 2013). In 1998,

Compton and Sherington devised an improved and rapid loss assessments method (visual loss estimation methods which were directly used in the field) to overcome some limitations posed by earlier measurement techniques (Aulakh and Regmi, 2013). Unfortunately, these loss assessments were characterized by anecdotal stories with limited empirical evidence from the field (*ibid*).

However, a recent regeneration of interests on PHL estimates resulted in the development of African Post-Harvest Losses Information System (APHILIS) in 2010 (Hodges, Bernard and Rembold, 2014). APHLIS is backed up by a database and a post-harvest loss calculator which facilitates in the estimation of annual post-harvest losses (by province) for cereals in the Eastern and Southern regions of Africa (*ibid*). The APHLIS was initiated to measure level of loss per post-harvest stage contrary to prior efforts that were anchored on storage losses only (Hodges *et al*. 2014). It also ascertains loss caused by Large Grain Borer (LGB) (*ibid*). The APHLIS does not focuson one country or single crop but on diverse crops which are commonly grown in Eastern and Southern Africa (World Bank, 2011 and World Bank, 2014).

2.2 Post-Harvest Management practices: A global perspective

From a global perspective, FAO (2011) pointed out that about one third of produced food for human consumption is wasted or lost per year. World Bank (2014) revealed that these losses are not uniformly distributed across the globe as some countries suffer more loss than others.

The PHM issues are not taken from same point of view, loss suffered from developed countries are resultant of wastage (avoidable loss) and the opposite is true for developing countries where food losses are a resultant of premature harvesting, poor storage facilities, lack of infrastructure, lack of processing facilities, technological and financial limitations to fund post-harvest stagesrequirements (Parfitt, Barthel, and Macnaughton, 2010 and World Bank, 2014). Therefore, PHLs in high income regions are highest in downstream phases of the food chain which is in contrastto low-income regions where more food is lost and wasted in upstream phases (Kiaya, 2014).

Kiaya (2014) pointed out that PHM for cereals is not yet fully done particularly to small grains such as rice which dominates many parts of Asia. The PHM is being hampered by lack of finance for mechanized PHM, hence,worsening the magnitude of losses (Kiaya, 2014). For instance, South Asia was regarded as the hungriest continent in 2013 (World Bank, 2014). On

the other hand, United States of America and Europe developed more sophisticated post-harvest reduction techniques such as advanced storage facilities, better infrastructure, better transporting facilities and stringent penalties on waste disposal of edible food (Hodges *et al*. 2011 and Aulakh and Regmi, 2013). However, due to growing consumer intolerance of substandard foods or cosmetic defects such as blemishes and misshapen produce, as well as consumer purchases of more food than they consume, large amounts of the food produced is not eaten but discarded, on reasons such as being left on the plate after a meal or the product passing its expiry date (Knight and Davis, 2007 and Hodges *et al*. 2011).

2.3 Post-Harvest Management practices in Africa

PHM challenges in Africa are being aggravated by poor technology, poor infrastructure and lack of investment in PHL reduction (Parfitt*et al*. 2010; Hodges *et al*. 2011 and Kiaya 2014). Hodges *et al*. (2011) found out that most countries in Africa do not have warehouse receipt system which targetsintensificationof efficient movement of harvested food stuffs from the farmers to safe national storage facilities. They further alluded that the adherence to traditional methods and lack ofadoption of sophisticated technologies contribute to elevated losses and high likelihood of food insecurity.

Table 2.1: Selected SSA countries where PHL assessments were done as of 2013

Year	*Country*	*Target crop*	*Method*
1979	Kenya	Maize	Loss assessments
1989	Malawi	Maize and sorghum	Count and weigh
1991	Somalia	Sorghum	Analysis of field samples
1992	Sudan	Sorghum	Count and weigh
1993	Zimbabwe	Maize	Diagnostic surveys
1998	Ghana	Maize	Count and weigh
1998	Togo	Maize	Count and weigh
2006	Eritrea	Sorghum	Analysis of field samples
2010	Eastern and Southern Africa	Cereal crops	APHLIS network and calculator

Source: Aulakh and Regmi (2013)

Efforts in PHM in SSA have been evident in countries such as Kenya, Malawi, Zambia and partly Zimbabwe. The International Maize and Wheat Improvement Center (CIMMYT) funded by the Swiss Agency for Development and Cooperation (SDC) implemented the Effective Grain Storage Management project in Kenya and Malawi from 2008 to 2012 and in Zambia and Zimbabwe from 2012 to 2015 (Chingarande and Kandiwa, 2015). Kimatu (2013) found out that in Kenya, small scale metal silos technology was initiated in 2012 to avert losses at storage; however, storage lossesinMwinji town werevery high particularly because the project was not well supported. In Malawi, Hodges *et al*. (2014) pointed out that super grain bags and small metal silos technology was implemented in 2014 but the initiative targeted maize and rice only.

Kimatu (2013) revealed that the most dominant storage facilities in SSA are the traditional granaries, although there have been shifts from mud cribs to wooden cribs to warehouses to metal silos.However, the shifting rate is at a snail pace particularly in Kenya. The SSA countries have no option to opt for modern day technologies (Aulakh and Regmi, 2013), since success stories in promoting improved on-farm storage technologies have been rare in SSA (World Bank, 2011). World Bank (2014) is in agreement with the aforesaid notion that post-harvest technologies have proved to be financially unsustainable in Tanzania, Uganda and Malawi and losses are occurring at an alarming rate. In 2013; SSA was ranked second on hunger and food insecurityindex (*ibid*).

2.4 Post-Harvest Management practices in Zimbabwe.

Zimbabwe is still facing the fate of food insecurity because much of investments are directed towards improvement of pre-production phase (Chingarande and Kandiwa, 2015). These interventions have not stalled food insecurity because it is insignificant to focus on crop production yet post-harvest loss risks are not addressed and very high (Rugumamu, 2011). Ncizah (2015) argued that in 2002-03, Zimbabwe was the epicenter of the so-called Southern Africa ‘food crisis’, which the World Food Program considered the most severe in decades, with over six million people out of a population of around twelve million declared in urgent need of emergency food aid. To this day, prevalence of food insecurity is still high in the country despite bumper harvests being experienced in some years. Considering these scenarios, then all the endeavors towards eradicating food insecurity may hit a brick wall if PHMs are given little attention (Chingarande and Kandiwa, 2015).

Efforts in PHM in Zimbabwe have been widespread since the year 2012. Chingarande and Kandiwa (2015) pointed out that the CIMMYT funded by the SDC implemented the small-scale metal silos technology in districts such as Makoni and Shamva from 2012 to 2015. However, unaffordability and unavailability of these metal silos in other areas forced the communities to rely on readily available indigenous post-harvest methods. Less effective indigenous methods and techniques such as treating grains using ash, dung and leaves from specific trees, use of traditional granaries, threshing by beating and trampling are the most dominant post-harvest practices used in Zimbabwe (Stahlers*et al.* 2002). Use of indigenous knowledge is predominant in Zimbabwe since, Mvumi, Chigoverah, Chamboko and Mupindu (2017) indicated that training of farmers and Extension officers in PHM is lagging behind. Chingarande and Kandiwa (2015) profound that in some rural areas, thenumber of Extension officers is inadequate affecting information dissemination on post-harvest.

The majority of smallholder farmers in Zimbabwe use indigenous methods on PHM (ZimVac, 2013 and ZimVac, 2014), of which the World Bank (2014) reiterated that adherence to traditional methods is the main driver to PHL and subsequently food insecurity. Indigenous post-harvest reduction methods are widely used in most rural areas of Zimbabwe particularly in Buhera district such asordinary rooms(Marambanyika*et al*. 2014). Modern day post-harvest reduction technologies are failing to cater for all the farmers' produces for example in Shamva district (Chingarande and Kandiwa, 2015). Thus, farmers have to look for other storage facilities options to store the excess. Modern day PHM strategies are as good as novel strategies as they may not be available and also their unsustainably high costs of purchasing them (*ibid*).

2.5 Small grain Post-Harvest Management

Researches on how to minimize PHL are limited particularly on small grains (Hodges *et al*. 2014). The level of loss on small grains in Zimbabwe is not known. Hodges *et al*. (2014) noted that APHLIS only provide detailed losses incurred in maize since the data which was supplied by the network providers was mostly for maize rather than of small grains. It is difficult to ignore small grain PHM such as sorghum and millet since they occupy second and third position of total food production in Zimbabwe and these food crops can contribute to food security particularly to areas where other maize grains are failing (Moyo, 2010). In Zimbabwe, sorghum constitutes 87 000 tonnes per year and pearl millet 54 000 tonnes per year and a merely small percentage of the produce go for safe national storage. The bulk

remains at the source of origin (*ibid*). Hence, potential PHM must be at local level where the bulk of post-harvest activities are being done (Hodges *et al*. 2014). However, in Zimbabwe, nothing is being done to small grain in terms of PHM at local level (Moyo, 2010).

In Buhera district, since the district lies into natural ecological region III, IV and V, the growing of these small grain is overwhelmingly high than of any other crops (Mukundi, 2015). Despite the small grain growth rate particularly pearl millet in Zimbabwe and their relative importance to food security, very little has been done in promoting their PHM (Moyo, 2010).

2.6. Small grain post-harvest practices

2.6.1 Assembling stage

Post-harvest is defined as after separation of food from its medium and site of immediate growth or production. Post-harvest begins when the process of separating food of edible quality from its site of immediate production has been completed. The food need not be removed any great distance from the harvest site, but it must be separated from the medium that produced it by a deliberate human act with the intention of starting it on its way to the table (Hodges, 2010). Thus, assembling refers to the collection of grains just after separation from their immediate site of growth to drying floors*(ibid)*. Practices at assembling stage include the following;

- Use of baskets to collect harvested panicles to the drying points (Chingarande and Kandiwa, 2015).

2.6.2 Drying stage

Aulakh and Regmi (2013) alluded that drying is a food preservation strategy in which moisture will be removed from the food by air drying, wind and sun drying. Platforms that can be used at drying stage include; low cost cribs, unroofed threshing floors and *ruware* (Kiaya, 2014).

2.6.3 Threshing stage

Threshing can be done by modern or traditional methods considering the farm or country's resources (Aulakh and Regmi, 2013). Practices that can be used at threshing stage include;

- Beating using sticks or use of animal power for trampling (Chingarande and Kandiwa, 2015).
- Use of mechanized threshers particularly in developed countries (Kiaya, 2014).

2.6.4 Transportation stage

Transportation of grains can be done either from drying points to threshing floors or from threshing floors to home store or from home store to market (World Bank, 2011and Hodges *et al*. 2014). Practices that can be used at transportation of grains include;

- Use of animal drawn scorch-carts, bicycle, wheel barrows and head load particularly in SSA (World Bank, 2011).
- Women use head loads to ferry their grains to home for example in Tanzania (Rugumamu, 2011).

2.6.5 Storage stage

Post-harvest practices used at storage stage can be in form of storage structures or storage facilities and pest control measures. These include;

- Use of traditional granaries for example in most SSA countries (Rugumamu, 2011).
- Use of ordinary rooms. In the case of Zimbabwe, thisstorage structure is predominantly used in rural areas such as Buhera district (Marambanyika*et al*. 2014). However, for 2014 post-harvest season, use of improved brick granaries was red flagged at 4.1 % in Zimbabwe (ZimVac, 2014).
- Use of metal silos and hermetic bags for example in Kenya (Kimatu, 2013).
- Use of polypropylene sacks, for example in Murehwa district (Mvumi*et al*. 2017).
- Ashes, dung, smoking and eucalyptus leaves are predominantly used in rural areas of Zimbabwe to control pest for example in 2014, 75% of respondents in Manicaland showed that they used these pest control measures (ZimVac, 2014).
- Use of chemicals is predominant in developed countries while in developing countries only few afford to buy the chemicals (World Bank, 2011).

2.6.6 Winnowing Stage

Winnowing can be done following the threshing exercise. It is carried out by blowing away the chaff from the grain and is done to remove stones, debris and chaffs. Sometimes

winnowing can be done when the farmers prepare for milling (Chingarande and Kandiwa, 2015). Winnowing can be done using winnowing trays (Changarande and Kandiwa, 2015).

2.7. Small grain Post-Harvest Management challenges

2.7.1 Assembling stage

Chingarande and Kandiwa (2015) discovered that shortages of labour and equipment also cause challenges at assembling stage. Most smallholder farmers are poor and rely on sharing of resources and if the harvesting exercise occurs concurrently, therefore, it means those without equipment and tools use the little they have or they have to wait for those with such resources to finish harvesting and assembling theirs first, exposing themselves to high losses (*ibid*). Mvumi*et al*. (2017) argued that child headed and female headed households lack access to tools and equipment needed for post-harvest.

Another topical issue at assembling stage is hired labour. For example, Chingarande and Kandiwa (2015) found that hired labour have a wasteful behaviour because their aim is to complete the job and even if there are some grains lost along the way from field to drying platforms, they do not pick and hence contributing to loss. Thus, these losses have a negative bearing to food security by reducing food which would have been available prior to the loss.

2.7.2 Drying stage

Mswazie and Moyo (2017) pointed out that in Zimbabwe; the 2016/17 season did not give the farmers much time to effectively dry their grains. Smallholder farmers in Zimbabwe normally rely on sun drying to ensure that their cropsare sufficiently dry (Chingarande and Kandiwa, 2015). If weather conditions are too cloudy, humid or even wet then the crops will not dry sufficiently and losses will be high (World Bank, 2011;Hodges*et al*. 2014 and World Bank, 2014). Unseasonal rains during drying stage cause the grain to geminate (World Bank, 2014 and Chingarande and Kandiwa, 2015). Insufficient drying of grains owing to rains during drying may lead to grain discoloration and this renders the food unfit for consumption, increasing the rejection rate and the food being thrown away (Hodges *et al*. 2014).

Termites, wandering livestock, birds such as qualia and other vermin pose great threats at drying stage (World Bank, 2011; Kiaya, 2014 and Hodges *et al*. 2014). Birds may either eat or take the grain which would be available for human consumption if that food has not been eliminated from food supply chain (Parfitt *et al*. 2010).

2.7.3 Threshing stage

Chingarande and Kandiwa (2015) profound that the whole PHM is gender based in the sense that practices such as threshing are best performed by males, winnowing by females and transportation by children. Thus, beating of pearl millet and sorghum requires to be done by men considering their physique (*ibid*). Chingarande and Kandiwa (2015) noted that in Shamva district, female headed and child headed families face challenges on threshing their grains. This has adverse impacts on food security since much of the food can be left on the panicles if the practice has been done by females (*ibid*). Threshing done using cattle trampling incur losses through cracking of grains and hence physical elimination of edible food which would have been be available before being lost to cracking (Hodges *et al*. 2014). Damaged grains are highly susceptible to pest attack at storage and this is why most SSA countries incur huge loss at storage (*ibid*). More so, if a harvest is threshed before it is dry enough, this operation will most probably be incomplete.

2.7.4 Transportation stage

Availability of means, status of the means of transport and also status of the roads has greatest impact on PHM. In SSA there are poor transport systems and the bulk of countries in SSA rely on scorch-carts, hand-carts, motorcycles and bicycle (Parfitt *et al*. 2010 and World Bank, 2011). However, for child and female headed households the movement of grains from threshing floors to home store is by head load for example in Tanzania (Rugumamu, 2011).

Resource unavailability is another challenge to most smallholder farmers in rural areas of Zimbabwe. Resource constraints particularly in female and child headed households is of great importance because women may not have the resource such as scorch-carts and cattle which are crucial for transportation of grains (Hodges *et al*. 2014). For example in Zimbabwe, these typical households tend to hire and the owners may restrict the movement or number oftrips. Thus, the user may be forced to overload and elevated losses are incurred along the way (Chingarande and Kandiwa, 2015). Elimination of food intended for human consumption but goes unconsumed lead to food insecurity (Hodges *et al*. 2011).

2.7.5 Storage stage

Pests at storage are the most devastating challenge that exposes the majority of smallholder farmers to food insecurity. In SSA,1 out of every5kilos of grain produced is lost to pests and decay (FAO, 2013). Financial instability also hampers the farmers in purchasing pesticides.

Zimbabwe Food Outlook (2017) reiterated that in Zimbabwe, liquidity challenges compounded by shortages and unsustainably high costs of chemicals hinder the farmers to access the chemicals. In Zimbabwe, challenges of pests in 2014 were at 63% and for Manicalandprovince; it was at 42% and highest in the Midlands province at 82% (ZimVac, 2014).

Rats eat the food or brought foreign matters which lead to contamination or deteriorating of the quality of the food hence reducing the availability and acceptability of the food (Aulakh and Regmi, 2013; Hodges *et al*. 2014 and Chingarande and Kandiwa, 2015). Other pests such as LGB and less grain borer impair the utility of the food and hence contribute to nutritional quality loss (Hodges *et al*. 2014). Lack of improved sacks (hermetic bags) and as well as insecticide application at storage increase loss at storage (Colob, 2002). Hodges *et al.* (2014) pointed out that PHL and food security are intractably linked where the reduction in the food availability and increase in the unacceptability of the food result in the increase in exposure to food insecurity.

Financial instability hinders the farmers to have adequate tools needed for determining level of required moisture in the grains before storage particularly in marginalized smallholder farmers (Wagacha and Muthomi, 2008). If the moisture is as high as 70%, it may cause decay of grains (*ibid*). Although the nutritional value loss is difficult to identify, if the food's utility is reduced, 100% quantity loss is incurred when the whole food stuff is thrown away as in the case of mycotoxins contaminated grains and this results in the reduction of food available (Hodges *et al*. 2014).

In relation to storage facilities, Mvumi*et al*. (2017) found that there is lack of skill on the construction of storage structures among the younger generation particularly child headed households as resembled in Makoni, Hurungwe, Guruve, Gokwe South and Murehwa districts. They also alluded that there are widespread fears of theft at storage and this change the preference of storage facility (ordinary rooms). World Bank (2011) noted that these facilities are not viable in prolonging shelf life of grains. ZimVac (2014) profound that most small grain farmers in Manicalandare at risk of losing their small grain produce due to lack of proper storage facilities for their small grains as only 1% of the surveyed households indicated the use of improved brick granaries.

Procedurally, the use of traditional granaries is almost non-existent as farmers are now prefer ordinary rooms as storage facility (Mvumi*et al*. 2017). The shift was attributed by limited resources such as timber in other parts of the country (*ibid*). In Buhera district, the low cost traditional reduction methods are now being ignored and eroded (Marambanyika*et al*. 2014). Chingarande and Kandiwa (2015) supported this point by arguing that rejection in the use of viable traditional methods such as traditional granaries *(hozi)* is primarily attributed to young household heads since they reported that they grew up with stories that granaries were stables for goblins and other witchcraft items. However, the highly preferred ordinary room storage facility estimated at 75% in Manicaland province is associated with elevated losses (ZimVac, 2014), the grains may catch moisture due to frequent use of water in these rooms and hence they can decay (Chingarande and Kandiwa, 2015). Thus, removing part of food intended for human consumption from the food supply chain threaten food availability, nutrition and income security (World Bank, 2011).

Modern day storage facilities such as metal silos do not have compartments hence they store one crop at a time (Chingarande and Kandiwa, 2015). Modern day storage facilities are unaffordable (World Bank, 2014). Chingarande and Kandiwa (2015) pointed out that a metal silo with holding capacity of I tonne goes for US$174 which is exorbitant for poor smallholder farmers to buy. This is why PHL at storage is still high (World Bank, 2014). Thus, this best explains why food insecurity still persists even in bountiful harvest seasons or years in Zimbabwe (ZimVac, 2014).

2.7.6 Winnowing stage

Chingarande and Kandiwa (2015) pointed out that in Shamva district households headed by females incur less loss at winnowing than their male counterparts. This is because PHM issues are somehow gendered and in the absence of one specified group grain loss are likely to be high (*ibid*). Chingarande and Kandiwa (2015) noted that women farmers reported that during the winnowing stage, grain is also lost particularly when children and men are involved, women perceived men and children as being too impatient to pick on grains that mix with soil. However, females often experience time poverty due to competing demands for their labour(Mvumi*et al.* 2017), while when they attend other issues, the grains may be exposed to free range of chickens (Chingarande and Kandiwa, 2015).

2.8 Determination of level of loss at post-harvest stages

From the existing literature, PHL estimates variations of between 10- 40% are frequently quoted (Sanginga and Borgemeister, 2015). Lipnski, Hanson, Lowmaw, Katinoja, Waite and Searchinger (2013) pointed out that PHL is about 23% for cereals in SSA as opposed to 37% as revealed by FAO (2011). There was also a heated argument on the level of loss in Nigeria and SSA for example; Aulakh and Regmi (2013) noted that figures of the type "about 39% for grain loss in SSA and 45% for pearl millet loss in Namibia" may not portray the perspective of the real situation. Hence, Aulakh and Regmi (2013) nullified these estimates by referring to them as 'anecdotal' with limited empirical evidence from the field and appraised the results presented by the APHLIS.

APHLIS opposing estimates on post-harvest handling and storage in SSA by pointing out that PHL is about 12% to 20% for cereals as compared to FAO 2011's 8% (Hodges *et al*. 2014). In Southern and Eastern African countries small grain PHL of crops such as millet are as follows 3.5%, 2.5%, 2.5% 1.1%, 1% and 4% at assembling, threshing, transportation to store, transport to market, storage and market storage stages respectively. Loss incurred in sorghum at assembling, threshing, transportation to store, transport to market, storage and market storage stages was indicated at 4.9%, 4%, 2.1%, 1%, 2.2% and 4% respectively. However, data on drying and winnowing stages was missing. Post-Harvest Profiles (PHPs) for millet and sorghum at transport are neither measured nor specific (Hodges *et al*. 2014).

PHPs for millet and sorghum are not precise as compared to those of maize. This resembles that there are very few studies undertaken for these two cereals after harvest and there is paucity on data relating to these grains (Hodges *et al*. 2014). Stahlers, Lamboll and Mvumi (2013) pointed out that an explicit picture on the varied post-harvest contemporary systems of cereals crops which are the chief calorie providers are in Southern and Eastern Africa is lacking. Owing to food insecurity in Buhera district, this requires attention to be focused on small grains. Hodges *et al.* (2014) argued that it is therefore worthlessto work with figures that are good estimates at the time and in the situation they are taken but to be aware that at other times and situations the figures will differ.

2.9 Implications of Post-Harvest Loss on food security in Africa

The proportion of food insecure population remains highly unacceptable (FAO, 2010 and FAO, 2012); each year massive quantities of food are wasted or lost (FAO, 2011). World Bank (2011) revealed that in SSA countries such as Ethiopia, Botswana, Mali, Tanzania, Uganda and Zimbabwe just to mention a few; PHL is estimated to exceed 37%. World Bank (2014) further alluded that this begs the question why such significant losses have persisted in the face of continuous undernourishment and hunger, and sluggish yield gains, especially in SSA. Aulakh and Regmi (2013) noted that to achieve goals of food security, food availability and utility should be increased through PHL reductions. Loss reduction would increase the quantity of food available for human consumption (Mundal, 2008 and Trostle, 2010). Assuming, only reduction by 1% in PHL will leads to annual gains of US$40 million (World Bank, 2011). World Bank (2011) further alluded that in another way, annual value loss of about US$ 4 billion can:

- Exceeds total food aid that SSA received for the past 10 years;
- Is equal to cereal annual value imported in SSA, which averages in between US$ 3 to 7 billion over the period of 2000 to 2007;
- Equates to the annual caloric requirements to feed at least 48 million.

Then, World Bank (2011) concluded that improvements in PHM indeed thwart the challenges of food insecurity which many SSA countries are facing. SSA was ranked second to food insecurity and hunger in 2013 (World Bank, 2014). In Zimbabwe the majority of rural dwellers go bed hungry (ZimVac, 2014). It is undoubtedly that reason behind food insecurity is PHL since the country suffers food insecurity despite production failures or bountiful harvests (Ncizah, 2015).

2.10 Research gap

The attention given to small grain PHM both in terms of investment and loss assessment is relatively low as compared to other grains. Level of loss based on self-reported loss estimates from the farmers is still low. Although the APHLIS is regarded as the most reliable software used to determine level of loss, it used a network of data providers who provided data rather than on-farm self-reported loss (World Bank, 2014) and for the data it has, small grain is not specifically presented (Hodges *et al*. 2014). Therefore, this research seeks to fill that gap by obtaining small grain PHL estimates based on self-reported loss estimates from the farmers

and employ field measurements for non-storage loss so as to justify the level of loss obtained from self-reported estimates. Again, this study seeks to fill the gap left by other researchers particularly on small grain PHM by linking the ongoing practices and severity of the challenges on small grain post-harvest management to post-harvest loss levels and subsequent food insecurity.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Research Design

Research design is a blueprint of research which guides the researcher throughout the whole of research study. Thomas (2010) posits that research design is a guiding plan to be followed by the researcher in order to stipulate how all the research study's parts work together in an attempt to answer the research framework or objectives. This research used a case study research design. A case study research design helped the researcher to do an in-depth exploration of the community's practices since the research focused on small grain PHM practices in Ward 22 of Buhera district.

A mixed research approach of both qualitative and quantitative research approach was followed. This allows for synthesis of ideas and ensures complementarity through overcoming uncontrollable biases of one method by compensating that with the alternative method (Bryman, 2008). In this study, a qualitative approach was utilised to gain on-going small grain PHM practices in Buhera district. Qualitative approach was also used to get insights on the challenges faced per post-harvest stage. Thus, a combination of questionnaires, observations, literature review and interviews was used to obtain data pertaining to small grain PHM practices and challenges associated per each stage.

Quantitative approach was also used in this study. Creswell (2009) pointed out that quantitative approach is based on numeric data expression and hence allows for statistical representation of data. Closed questions were used to obtain data related to household characteristics such as age, gender and level of education of the respondents.

3.2 Target population

Discombe (2008) argued that target population is the totality of whole cluster of people or subjects or objects which the researcher seeks to collect data from. The results of this study are generalised basing on the target population because of their common characteristics.

The researcher targeted all households within Ward 22 of Buhera district. Ward 22 of Buhera district has a total of 2 722 households with a diverse of child headed, female headed and male headed households respectively (ZimStat, 2012); therefore, all these households were significant to this research since they intensively grew small grain for the 2016/17 season.

Thus, these households have first-hand information crucial for making conclusions on small grain PHM practices, challenges faced and level of loss per each stage.

In addition, this study also targeted staff from World Vision, Grain Marketing Board (GMB), Ward Councillor and Agricultural Technical and Extension Services (AGRITEX) respectively. These are crucial key stakeholders playing an indispensable role in the PHM system.

3.3 Sample size determination and selection

Sampling is an exercise in which appropriate methods are used to pick some elements from the whole target population such that sample elements of the sample population are identical (Discombe, 2008). However, for the findings of the research to be comprehensive and to generalise the population with limited error margin, the sample size should be at least 10% of the total population (Kanzode, 2004). Two stage of multistage sampling technique was used in this study to select households from Ward 22 for a sample. Two stage sampling technique is used where it is impossible and costly to select all units in the target population (Agresti and Finlay, 2008). Multistage sampling technique ensures selection of sample in stages such that the sample size at each stage gets reduced and then the research study becomes more precise, manageable and allows the researcher to intensively sample primary units (*ibid*). By using two stage sampling technique, primary sample units (villages) were selected from target population (all villages in Ward 22) and then secondary sample units (households) were selected from each primary unit. For this study, simple random sampling was used to select 10 villages out of a total of 47 which is already greater than the 10% of total villages in Ward 22 for primary sample units. Random selection was done so that all villages had equal chance of being selected.

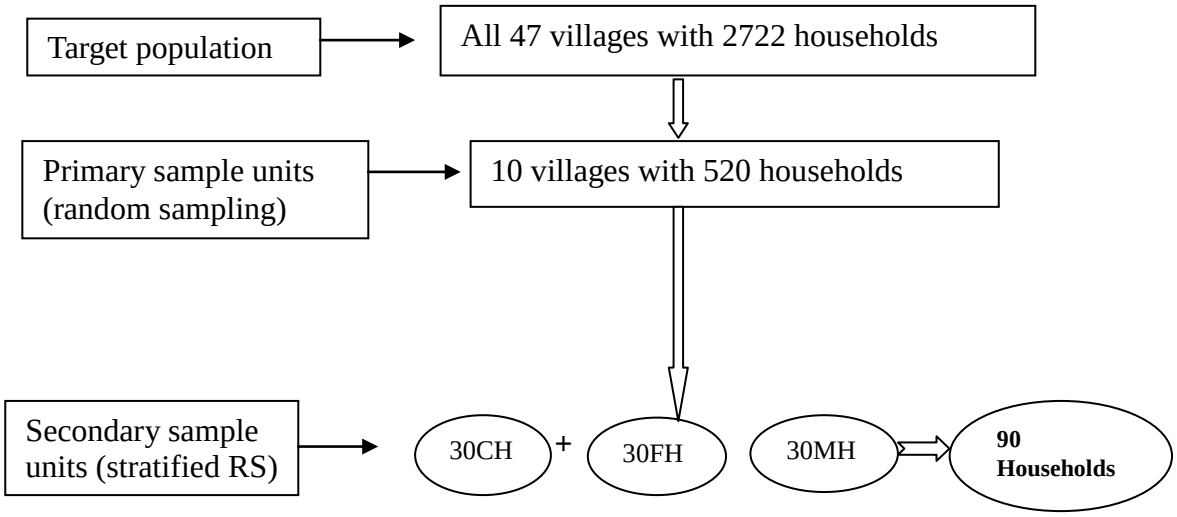
Then, for the second stage, stratified random sampling technique was used to select 90 households for secondary sample units from primary sample units of 10 selected villages with a total of 520 households. Agresti and Finlay (2008) argued that when the primary units are of an unequal size, stratified random sampling technique typically with proportional to size of units is used to select respondents from each unit. Thus, larger primary sample units contributed much to the secondary sample units. Total household units from each primary unit (village) were used to get secondary sample units (households) per each primary unit for questionnaire. This is shown on table 3.1.

Table 3.1: Sample frame

Primary sample units	*Secondary sample calculation*	*Number of respondents per village*
Gotora village	84/520 × 90	15
Zimhete village	69/520× 90	12
Matereke village	66/520× 90	11
Taasure village	56/520× 90	10
Usavi village	27/520× 90	5
Nyararai village	35/520× 90	6
Nhema village	64/520× 90	11
Muchuchu village	30/520× 90	5
Zariro village	40/520× 90	7
Mupfumbi village	49/520× 90	8
		Total = 90 household respondents

Households from primary sample units were divided into strata based on household head. Each stratum had to have equal representation in the secondary sample units. Thus, the researcher distributed questionnaires to 30 child headed households, 30 female headed households and 30 male headed households from all the primary units. This helped ensure the researcher to do comparisons of the results from data collected from the field. Stratified random sampling technique was instrumental in obtaining data from child headed, female headed and male headed households so as to have different views, practices and challenges faced in small grain PHM.

Table 3.2: Two stage sampling technique



Key: CH= Child headed households
FH= Female headed households
MH= Male headed households
RS = Random sampling

Thus; 30 household heads ×3 strata= **90 household respondents**

Purposive sampling was used to select a sample size of 4 key informants which comprises 1 Extension officer of AGRITEX out of 3 in Ward 22, Ward 22 Councillor, 1 Project Evaluation and Monitoring Manager of World Vision Murambinda branch and 1GMB Buhera Depot Manager who participated for the interviews. These respondents; their experience, knowledge and skills relating to PHM practices were of greater importance to the theme of research.

3.4. Research instruments

Different methods of data collection were used. These include; questionnaires, interviews, observations, field measurements and literature review of existing data sources. Questionnaires were distributed to child headed, female headed and male headed households respectively within Ward 22 of Buhera district. Interviews were conducted with various key informants. Observations were done during data gathering process through other data collection methods. Field measurements were employed to justify level of loss obtained from self-reported loss estimates.

3.4.1 Questionnaire for household heads

Questionnaires allow the research to explore frontiers of knowledge that can be locked within human minds (Creswell, 2009). Questionnaires are used to elicit estimates of subject under study from those who have experienced it or them (Hodges *et al*. 2011). Therefore, data pertaining to small grain PHM practices, challenges and level of loss was collected using questionnaires.

Questionnaires were designed and distributed to 90 household head respondents (Appendix 1). The questionnaires composed of both closed and open-ended questions. Open-ended questions allowed respondents to openly air out their views as far as PHM issues are concerned. This helped the researcher to collect socio-economic characteristics, challenges and perceptions towards PHM for surveyed households. Closed questions were vital to the researcher and collected data on household head and size, age, gender and level of education of the respondents. The questionnaire was designed with 21 questions and divided into four sections; A, B, C and D which gathered general information, crops grown, small grain PHM practices per stage, and PHM challenges per stage respectively.

The researcher distributed the questionnaires in person in order to provide assistance or clarity where needed. The questionnaires were designed in English, but the respondents had pleasure to complete the questionnaires in English or Shona that is the local language in Buhera district. In situations where the respondent could not understand English, the researcher had to translate to Shona.

3.4.2 Key Informant interviews

Key informant interviews were opted for in this study in order to compliment data collected using questionnaires and partly due to its ability to capture empirical data both in formal and informal setting (Prabhat and Pandey, 2015). Semi-structured interviews were used in this study with different key stakeholders (Appendix 2-5). Walsh (2001) argues that under semi-structured interviews, the interviewer come up with set of questions in advance which are subject to adjustments during the conservation. Semi-structured interviews are flexible (Bryman, 2008) and this assisted the researcher to query deeper and confronted unknown issues on small grain PHM in relation to the objectives of the study. These include issues on both modern and indigenous post-harvest practices, management challenges faced in post-harvest and the level of loss on small grain post-harvest stages.

The researcher made arrangements in advance with the key informants before the interview day through a mobile phone. This was done to prevent inconveniences. Key informants were visited to their respective workplaces. During interviews, the issue of time was considered and each interview took about 10 to 15 minutes. Responses from the questions were noted down so that no point would be missed and forgotten. Interviews were conducted with 4 key informants that are World Vision Project Evaluation and Monitoring Manager, Ward 22 Councillor, GMB Buhera Depot Manager and Ward 22 Extension officer and their relative importance are summarised in Table 3.3.

Table 3.3: Respondents and reasons for selecting them

Respondent(s)	*Rationale*
Ward 22 Councillor (1)	To find ward's demographic information such as population size, household size and family heads and an overview of PHM practices in Ward 22.
Extension officer of AGRITEX (1)	To obtain information on indigenous and modern post-harvest management practices.
World Vision (1) Murambinda Depot (Project Evaluation and Monitoring Manager)	To get first-hand information on the interventions that they give Ward 22 villagers especially those targeting post-harvest losses and their effectiveness.
GMB (1) Buhera Depot (Depot Manager)	To obtain information pertaining to functionality of national grain reserve, type of silos, transportation of grains from the farmers, shelf life of grains, support given to farmers after harvesting their grains and the crops that are given much attention.

3.4.3 Field Measurements

The shoot area method (researchers' own method) was used to determine loss incurred by the farmers from assembling, drying, transport to threshing floors and threshing stages. A fixed quadrant size of 100 square metres was used to determine number of pearl millet shoots per area and the resultant amount of yield from a selected quadrant. The following tools were

used to determine quadrant size and whole area under pearl millet per those sampled households;

- Measuring tape (50 metres)
- Corner sticks and stickers

Then, quadrants were randomly staggered across the whole farm. Shoots within each quadrant were counted (Qs) and average number of shoots from all the quadrants was obtained and the quadrant which bear the average shoots or which had almost same shoots to the average shoots was selected. The panicles from the selected quadrant was then dried and threshed separately to get sample yield (SY). Then, the area of the whole area under pearl millet cultivation was divided by the area of the quadrant. The yield obtained from a chosen quadrant (SY) was then multiplied by the number of quadrants found within the whole area under pearl millet for that selected household to get Expected yield (EY).

The actual yield (AY)(yield after threshing the total panicles of a selected household)was then subtracted from the expected yield (Chapter 4) to get quantity loss (QL). Then, conversion of quantity loss to percentage gave the researcher percentage loss incurred by that selected household for assembling, drying, transport to threshing floors and threshing stages. Therefore, summation of loss percentages of the selected households based on their household head type gave the researcher the average loss that could have been incurred for the 2017 post-harvest season.

3.4.4Observations

Observations require the researcher to collect data through assessing actors, objects, events, acts and therefore it is non-verbal communication way of collecting data. Both passive and participant observations were used in this research.

The researcher used this data collection tool to collect some of the data which was sensitive to ask the respondents. More so, this tool aided the researcher to ground truth data that was collected from questionnaires and interviews. During different stages of post-harvest, the researcher used observations to observe practices used at post-harvest stages and also to check how the food can be eliminated from food supply chain. Photographs were also captured from different practices used by the households so as to represent visual information. Observations were done to collect non-verbal data pertaining to practices as shown on Table 3.4.

Table 3.4: Post-harvest stages, what, how and why observation was done

What	*How*	*Why*
Drying stage	Random check	To observe methods and platforms used on drying stage.
Threshing stage	Random check	To observe practices used at threshing stage.
Storage stage	Random check	To observe types of storage facilities and their status.
Winnowing stage	Random check	To observe winnowing practices.

3.5 Secondary data collection tools

The researcher also relied on the existing literature from the books, research papers, dissertations and data available on the internet. Existing information was of greater importance to researcher to have know-how of the area under study as well as identifying research gaps which needed to be filled and complimented.

3.6 Data analysis and Presentation

Yin (2011) found that data analysis and presentation is systematic application of logical and statistical techniques to describe, group, illustrate, summarise and evaluate obtained data from the field work. Descriptive statistical approach was employed to analyse quantitative response data. This was done by converting quantitative data to percentage and frequencies through the coding system that is imbedded in the Statistical Package for Social Sciences (SPSS). Variables such as household head, size, age, gender and marital status of the respondents were coded for analysis and thus make room for the researcher to do comparisons. The data was then presented through the use of tables and graphs.

Qualitative data was converted through content analysis systems whereby the researcher categorizes the response by their meaning such that similarities and differences can be recognised. Coding system was then used through the use of SPSSand Microsoft excel to analyse the findings of the research. These were presented through the use of bar graphs and tables.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Response rate

The researcher targeted 90 households from Ward 22 of Buhera district for questionnaire administration and 4 key stakeholders for interviews. However, 83 questionnaires were successfully administered and accounted for 92% response rate. All of the 4 key stakeholders from World Vision, GMB, AGRITEX and Ward 22 Councillor responded which gave the researcher 100% response rate. Mungenda (2003) posits that response rate of 75% and above is sufficient for data analysis and reporting. Hence, 92% response rate was satisfactory to make conclusions for this study. The Table 4.1 shows questionnaire response rate.

Table 4.1: Questionnaire response rate

Household head	*Number of targeted households*	*Number of questionnaires administered*	*Response rate %*
Child	30	27	90
Female	30	30	100
Male	30	26	87
Total	**90**	**83**	**92**

4.2 Demographic characteristics of respondents

The study considered the different demographic and socio-economic characteristics of Ward 22's households. This was done with the realisation that these differences in characteristics have different impact towards PHM since post-harvest practices vary depending on different characteristics of different households. This was also supported by the view of Taylor (2003) that PHLs do not homogenously occur but vary due to crystallized circumstances in which the crops are grown, harvested and stored. Thus this research considered all these differences as shown on Table 4.2.

Table 4.2: Demographic characteristics of respondents

	Household head							
	Child		Female		Male		Total	
Variable	FQ	%	FQ	%	FQ	%	FQ	%
Gender								
Male	11	41	0	0	26	100	37	45
Female	16	59	30	100	0	0	46	55
Total	*27*	*100*	*30*	*100*	*26*	*100*	*83*	*100*
Education level								
None	4	15	6	20	2	8	12	14
Primary	10	37	17	57	16	61	43	52
Secondary	13	48	7	23	8	31	28	34
Total	*27*	*100*	*30*	*100*	*26*	*100*	*83*	*100*
Marital status								
Single	27	100	0	0	0	0	27	33
Married	0	0	0	0	20	77	20	24
SPM	0	0	30	100	6	23	36	43
Total	*27*	*100*	*30*	*100*	*26*	*100*	*83*	*100*
Age								
>20	22	81	0	0	0	0	22	27
21-30	5	19	3	10	6	23	14	17
31-40	0	0	4	13	8	31	12	14
41-50	0	0	4	14	5	19	9	11
51-60	0	0	8	27	3	12	11	13
61-70	0	0	9	30	3	12	12	14
70+	0	0	2	6	1	3	3	4
Total	*27*	*100*	*30*	*100*	*26*	*100*	*83*	*100*
Household size								
>4	27	100	4	13	4	15	35	42
4-6	0	0	10	33	9	35	19	23
7-10	0	0	14	47	13	50	27	33
10+	0	0	2	7	0	0	2	2
Total	*27*	*100*	*30*	*100*	*26*	*100*	*83*	*100*
Scorch-cart ownership	2	7	10	33	14	54	26	31
Cattle ownership	3	11	9	30	18	69	30	36

Key: FQ= Frequency

The researcher considered the educational level as it relates to respondents' perception both to indigenous and exotic PHM methods. For all surveyed households, 52% have attained primary level, 34% reached secondary level and only 14% were illiterate. The greatest percentage of respondents who reached secondary level was the male headed households (61%). However, all respondents did not pursue further with education to tertiary level. Thus, this explains why this community adheres greatly to indigenous PHM since the adoption of modern day technologies is vehemently influenced by educational level one has reached.

In terms of age of respondents, the majority were in between 20 years and below and this age group was dominated by child heads (81%). However, for female headed households, 27% of respondents were in the range of 51-60 years as compared to their male headed households' counterpart whom their largest proportion of 31% was in the range of 31-40 years.

About 42% of all surveyed households in Ward 22 indicated that their household sizes are below 4 members followed by 23% who indicated that their household sizes are in the range of 4-6 members. However, all child heads indicated that their household sizes are below 4 members. Female heads (47%) and male heads (50%) indicated that their household sizes constitute members in the range of 7-10. This also concurs with what has been postulated by the Ward Councillor during an interview, he said that,

"Owing to the fact that my Ward is known far and wide for Johanne Marange Apostolic church members, their household sizes are so big to about 8 and above members of which most of these members are still young even to provide labour for the whole family."

Thus, this entails shortage of much needed labour at most small grain post-harvest stages such as assembling and threshing despite the abundance of people.

Asset ownership was high in male headed households followed by female headed and lastly the child headed households. Cattle ownership constituted 30% and 69% for female and male headed household respectively and for scorch-cart ownership it was on 33% and 54% for female and male heads respectively. This best explains why female headed households are more exposed to PHL than their male counterparts. For child headed households only 7% and 11% have scorch-carts and cattle.

4.3. Current small grain post-harvest practices used in Buhera district

4.3.1 Small grain post-harvest practices at assembling stage

Research findings showed that all surveyed households from Ward 22 of Buhera district indicated that they rely on labour to collect and ferry harvested grains from the field to drying platforms. The Ward Councillor also cemented this point during an interview by saying that most households get labour through what known as *masadza* (food for work). This was also supported with the findings of the study by Chingarande and Kandiwa (2015) that in Shamva district, assembling of grains is done by the use of baskets to carry harvested grains to drying platforms.

4.3.2. Small grain post-harvest practices at drying stage

All surveyed households in Ward 22 of Buhera showed that they relied on sun to dry their grains. This also connives with the results of the study by World Bank (2011) where they found that sun dying is the dominant method used to dry grains in SSA. The surveyed households in Ward 22 of Buhera indicated that they used stalks (40%), *ruware* (25%), bare ground (22%), tents (10%) and cribs (3%) as drying platforms (Table. 4.3)

Table 4.3: Practices used at drying stage

		Household Head			Total
		Child	Female	Male	
Drying platforms	Bare ground	**17** (94)	**1** (6)	**0** (0)	**18** (22)
	Stalks	**10** (30)	**21** (64)	**2** (6)	**33** (40)
	Crib	**0** (0)	**0** (0)	**3** (100)	**3** (3)
	Ruware	**0** (0)	**0** (0)	**21** (100)	**21** (25)
	Tent	**0** (0)	**8** (100)	**0** (0)	**8** (10)

Bolded figures show frequency and those in brackets show percentage.

4.3.2.1 Bare ground

Use of bare ground drying platform was high in child headed household (94%) and this practice was very low to other household head types (Table 4.3). Results of this study found out that the practice is done by just sweeping the ground and put grain panicles directly on the soil. One child respondent was quick to say,

"*Toisagohoredupasipanengepasinamabundozvotoomazviripo." (We just put our grains on swept ground for drying).*

4.3.2.2 Cribs

Use of cribs (*ndyanga*) was another drying platform pointed out by the households in Ward 22 of Buhera district. The practice was insignificant in child and female headed households. It was only indicated in male headed households.

4.3.2.3 *Ruware*

Use of *ruware*was only indicated by male heads (Table 4.3). Kiaya (2014) also supported these findings that use of *ruware* is another practice that farmers can employ at drying stage. The researcher observed that grains are put of flat areas of *ruware*for drying. All of the respondents that indicated that they used *ruware* were the male heads.

4.3.2.4 Tent

Research findings of this study indicated that use of tent was only indicated in female headed households. Results showed that the practice is performed by spreading the tent on the ground first and putting the grains on top. The practice was very insignificant to other household head types.

4.3.2.5 Stalks

Results of this study indicated that use of stalks was high in female headed households (64%) followed by child headed households (30%) and was very low in male headed households (6%). Findings showed that the practice is performed by using plant stovers whereby farmers take the stalks from the field and spread on the ground first and place their grains on top of stovers. This practice is referred to as *mbuwa*in local language and is shown on plate 4.1.

Plate 4.1: Use of stalks as drying platform
Source (Field survey, June 2017)

4.3.3 Small grain post-harvest practices at transportation stage

Results of this study established that the entire surveyed household in Ward 22 transport their grains either from the field to threshing floors or from threshing floors to home store. The researcher found that farmers do transport their grains either by head load or wheel barrows or by using scorch-carts. The Ward Councillor indicated that for most households which transport their grains using scorch-carts, they normally send their children to perform the task. This was also supported with the results of Chingarande and Kandiwa (2015) that in Shamva district grains are normally transported by children especially when the households have to transport their grains by scorch-carts.

Table 4.4: Transport means at transportation stage

		Household head			Total
		Child	Female	Male	
Means of transport	Head load	**15** (63)	**7** (29)	**2** (8)	**24** (29)
	Wheel barrow	**8** (57)	**2** (14)	**4** (29)	**14** (17)
	Scorch-cart	**3** (7)	**22** (49)	**20** (44)	**45** (54)

Bolded figures show frequency and those in brackets show percentage

4.3.3.1 Scorch-carts

Research findings indicated that use of scorch-carts was at 54% for all surveyed households. However, it was high in female headed (49%) and male headed (44%) households respectively (Table 4.4). Findings of this study established that cattle drawn carts were used to move grains from one place to another. Unfortunately, only 7% of those who indicated that they used scorch-carts were the child headed households.

4.3.3.2 Head load

Transportation of grains was also done by head load. For this practice, 63% were the child headed households and 29% were the female headed households (Table 4.4). These results also go hand in hand with findings of Rugumamu (2011) in Tanzania where transportation of grains from one point to another is by head load particularly by the females and the children.

4.3.3.3 Wheel barrow

Results of this study also revealed that grains are also transported from one stage to other using wheel barrows. Use of wheel barrows was high in child headed households at 57%. The researcher observed that when farmers transporting their grains for example from threshing point to home storage, they first put the grains in sacks. However, others put the grains directly on the wheel barrows and then put some loaded sacks with grains on top.

4.3.4 Small grain post-harvest practices at threshing stage

The surveyed household in Ward 22 of Buhera district indicated that they used beating (58%) and cattle trampling (42%) to thresh their grains. These results also connive with the findings of World Bank (2014) that in most developing countries the farmers mainly depend on practices such as beating using sticks and trampling using animal power. Threshing can be done twice or thrice for the same yield that is re-threshing of grains to recover grains left on panicles.

Table 4.5: Threshing practices

		Household Head			Total
		Child	Female	Male	
Threshing strategies	Beating	**24** (50)	**19**(40)	**5**(10)	**48** (58)
	Cattle trampling	**3** (9)	**11** (31)	**21** (60)	**35**(42)

Bolded figures show frequency and those in brackets show percentage

4.3.4.1 Beating

Beating of grains using sticks was found to be the dominant practice in child headed (50%) followed by female headed (40%) households. The practice is performed by beating the grains until almost all grains are assumed to be out of the panicle ears. Thus, Chingarande and Kandiwa (2015) pointed out that this practice requires man availability considering their physique.

4.3.4.2 Cattle trampling

Results of this study established that trampling of grains using draught power was employed by the surveyed households in Buhera of which the greatest proportion was the male headed households (60%). However, this practice was low in child headed households (9%). Through the use of this practice grains removed from the panicle ears by the hoofing effect of the cattle.

4.3.5 Small grain post-harvest practices at storage stage

4.3.5.1 Storage structures

The research findings indicated that the use of ordinary rooms was as high as 69% followed traditional granaries at 24% and improved brick granaries was at 7% for all surveyed households in Ward 22 of Buhera district. These results go hand in hand with those found by ZimVac (2014) that in Manicaland, ordinary room is much preferred storage facility. The researcher found that since large proportion (63%) of female heads were in the aged group of 51yearsand above (Table 4.2)this influences their adherence to the use of traditional granaries. At district level, the GMB uses stacks as indicated by GMB Buhera Depot Manager.

Table 4.6: Storage structures

		Household Head			Total
		Child	Female	Male	
Storage structures	Traditional granaries	**2** (10)	**13** (65)	**5** (25)	**20** (24)
	Ordinary rooms	**25** (44)	**15** (26)	**17** (30)	**57** (69)
	Improved granaries	**0** (0)	**2**(33)	**4** (67)	**6** (7)

Bolded figures show frequency and those in brackets show percentage

4.3.5.1.1 Ordinary rooms

Research findings established that use of ordinary rooms at storage was relatively at same level in female headed and male headed households at 26% and 30% respectively and it was prominent in child headed households (44%). The results from the field indicated that these rooms were either on separate structure or were on the same structure which the family members use to sleep. These results were also supported with the findings of the study by Mvumi*et al* (2017) in Makoni, Hurungwe and Gokwe that ordinary rooms are usually on the separate structure.

4.3.5.1.2 Traditional granaries

Use of traditional granaries isnot yet been completely ignored particularly in Ward 22 with 65% of female headed households indicating that they use traditional granaries. This contradicts the findings of Marambanyika*et al* (2014) that the use of traditional practices such as *tsapi* are now eroded and ignored, However, this proved to be true to the results of this study in child and male headed households since the use of traditional granaries was at 10% and 25% respectively.

4.3.5.1.3 Improved brick granaries

Results of this study established that use of improved brick granaries was better adopted by male headed households (67%) while it was very insignificant in child headed households and in female headed households(33%).

4.3.5.2 Grain protection practices

The surveyed households in Ward 22 of Buhera district indicated that they used chaff (19%), sunning (13%), ashes (8%), *Mutikiti* leaves and crushed barks (6%), dung (4%), Actelic*Chirindamatura*dust (5%) and the greatest percentage (45%) used none of these grain protection practices (Table 4.7)

Table 4.7: Grain protection practices

		Household Head			Total
		Child	Female	Male	
Grain protection practices	Actelic*Chirindamatura* dust	**0**(0)	**3**(75)	**1**(25)	**4**(5)
	Dung	**0** (0)	**2**(67)	**1**(33)	**3**(4)
	Ashes	**0**(0)	**6**(86)	**1**(14)	**7**(8)
	Mutikiti leaves and crushed barks	**0**(0)	**3**(60)	**2**(40)	**5**(6)
	Chaff	**0**(0)	**10**(62)	**6**(38)	**16**(19)
	Sunning	**0**(0)	**4** (36)	**7**(64)	**11**(13)
	None	**27**(73)	**2**(5)	**8**(22)	**37**(45)

Bolded figures show frequency and those in brackets show percentage

4.3.5.2.1 Chaff

Research findings indicated that use of chaff was prominent in female headed households (62%). The practice is performed by spreading the chaff at the bottom and top of the storage facility. This has the capability of hindering the pests to access the grains. One female respondent was quick to say,

"Tinoshandisa hundi nekutihunovavasakahakunazvipfukutozvinozodyambeudzedu." (We use chaff so pests may not infest our grains because chaff is sour).

4.3.5.2.2 Sunning

Results of this study also indicated that, farmers do mid-retrieval of their grains and sunning them again so as to prevent remoistening of grains and by the way other pests die or disperse. This practice was only high in male headed households (64%) as compared to other household head types.

4.3.5.2.3 *Mutikiti* leaves and crushed barks

Use of *Mutikiti* leaves and crushed barks was another grain protection practice indicated by the households. About 60% of the respondents that indicated the use of *Mutikiti*leaves and crushed barks were the female heads while 40% constituted the male head respondents.

4.3.5.2.4 Ashes

Findings of this study also established that ashes from sorghum, maize and pearl millet stalks are used to thwart pest infestation on grains. The ashes are spread both at the bottom and top of storage facility or mixed with the grains. Use of ashes was prominent in female headed households at 86% and the remaining percent of 14% was the male headed households.

4.3.5.2.5 Dung

Use of dung was high in female headed households (67%) chiefly because they have accumulated wisdom in indigenous PHM. The researcher found that farmers mix cow dung with water and then plastering the floors and inside walls of the traditional granaries, hence this closes some spaces which that can be used by some of small pests to scamper through to the grains or hide.

4.3.5.2.6 Actelic*Chirindamatura* dust

Use of chemical such as Actelic*Chirindamatura*dust was prevalent in female headed households (75%). The Extension officer indicated that those who bought chemicals from a company called Supermax were mainly the heads from female headed households in the range of 31 to 60 years. Mvumi*et al* (2017) was also of the same view with the above findings that women are more preservative at storage than their male counterparts.

4.3.6 Small grain post-harvest practices at winnowing stage

Results from the field established that all households clean their grains from chaff and stones. More so, results of this study indicated that use of winnowing trays and dishes are the dominant tools used to clean the grains. The grains can be cleaned just after threshing or when they are preparing for milling. The cleaning process is performed through what they call *kuurutsa* or *kurudza* in local language as shown on Plate 4.2

Plate 4.2: Women doing grain winnowing
Source (Field survey, June 2017)

4.4 Small grain post-harvest management challenges

4.4.1 Challenges faced at assembling stage

Carelessness of hired labour, shortage of labour and equipment perceived to be the major constraints at assembling stage in Ward 22 of Buhera district

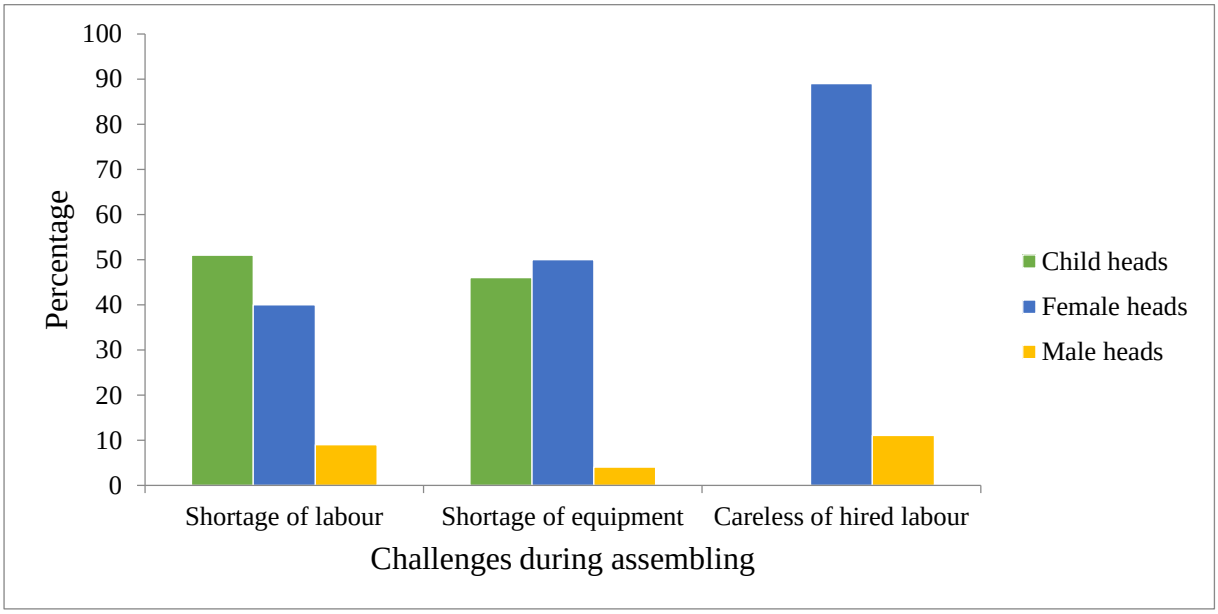


Figure 4.1: Challenges faced at assembling stage

4.4.1.1 Shortage of labour

Fifty-one percent of respondents that indicated challenges of shortage of labour were the child heads, followed by the female heads (40%). However, only 9% were the male heads. Results of this study found out that labour inadequacy resulted in the delays to complete moving harvested grains from the field to the drying platforms. Hence, by delaying to complete assembling grains on time, this elevates losses at assembling stage.

4.4.1.2 Shortage of equipment

Shortage of equipment was relatively at the same level both in female and child headed households at 50% and 46% respectively. This was also supported with the findings of the study in Shamva by Chingarande and Kandiwa (2015) that female heads lack adequate equipment and tools to use at assembling stage, so they have to wait for those who have to finish theirs first and borrow.

4.4.1.3 Careless of hired labour

Eighty-one percent of respondents that indicated challenges of carelessness of hired labour were the female heads. Labourers have one thing on their minds which is to finish the given task and be given their money or anything corresponding to the work done than anything else. Hence, in case of grains fall to the soil along the way to drying platforms, they do not pick thus accelerating the magnitudes of loss.

4.4.2 Challenges faced at drying stage

Results from all surveyed households in Ward 22 of Buhera district showed that drying of small grain is affected by rains during the drying period, termites, birds, domestic animals, and poor drying platforms hence the food is rendered unfit for consumption because of moulds, decay and grain germination. World Bank (2011) pointed out that unseasonal rains resulted in grain decay and germination. Thus, in addition to challenges of rains during drying stage, poor drying platforms therefore exacerbates the situation of decay and germination since the grains can be put directly on the soil and hence increase the level of loss.

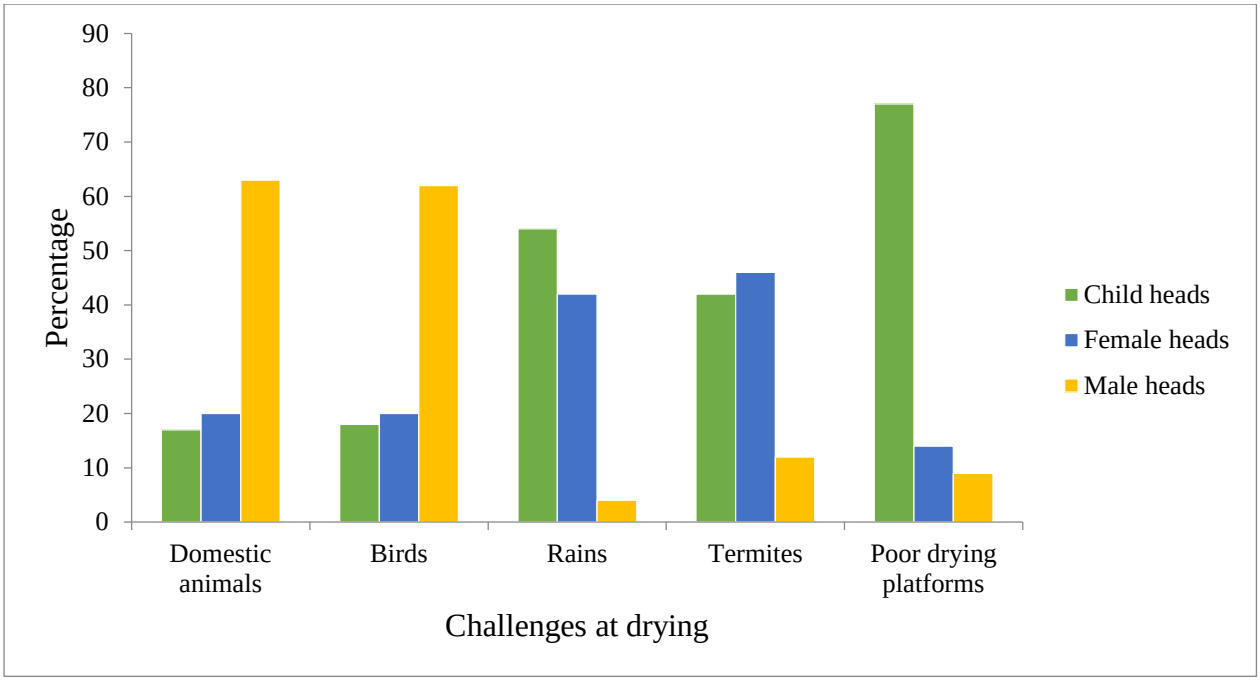


Figure 4.2: Challenges faced at drying stage

4.4.2.1 Domestic animals

Results of this study found out that 63% of the respondents that indicated challenges of domestic animals were the male heads while it was perceived to be low at 17% and 20% for child and female heads respectively. The researcher discovered that most households in Ward 22 of Buhera are far from the *ruware* points where they place their grains for drying before threshing and hence there is free access by domestic animals such as cattle, goats and sheep to the grains on the *ruware* platforms.

4.4.2.2 Birds

Birds such as qualia have been also indicated by the farmers as another challenge at drying stage. These birds were given different local names such as *ngozha* and *shiri dzedutu*. For this challenge, male headed households constituted 62% of all the respondents that indicated this challenge.

4.4.2.3 Rains

Findings of this study also established that 54%, 42% and 4 % of child, female and male headed household respondents respectively indicated challenge of unseasonal rains at drying stage. The Extension officer indicated that if the weather is wet and cloudy this means that

the grains may dampen and then geminate or decay. More so, The Project Evaluation and Monitoring (PEM) manager of World Vision indicated that as much as they are trying to capacitate the farmers with knowledge about PHM but unseasoned rains are an inevitable phenomenon which is difficult to get rid of. He further pointed out that since the grain seeds of small grain like pearl millet are exposed on panicles, they quickly dampen even in case of light rains and later favours the growth of moulds and decay and hence contributing to elimination of food from food supply chain through the food which rendered unfit for consumption.

4.4.2.4 Termites

Findings of this study found that infestation of grains by termites tend to cause food loss. Termites can eat the grains, take the grains to the termite molds or leave a heap of soil on grains which render the food unfit for consumption. This challenge was perceived relatively the same in child headed and female headed households at 42% and 46% respectively and was only 12% in male headed households.

4.4.2.5 Poor drying platforms

Poor drying platforms work hand in hand with rainfalls at drying stage. Practices such as drying grains on bare grounds, in case of rains, causes the grain to germinate and contribute to food loss. The researcher also found that the heavily used bare ground drying platform is associated with elevated loss because the grain can be directly put on the soil and hence, they can germinate or decay even in case of no rains. This is because, if there are continuous days of nocturnal rains (dews), these dews can moisten the grains and since the grains may be heaped, those that are underneath the others may fail to get adequate sunlight and subsequently rot.

4.4.3 Challenges faced at transportation stage

Transportation of grains from field to threshing floors and from threshing flows are constrained by shortage of effective means of transport such as cattle drawn carts, cars and Lorries. Poor roads are another topical issue in Buhera district which disconnects households from major service points such as market points, threshing points and even some farms are far from the homesteads. Hence, farmers end up forcing themselves to perform some of the practices at inappropriate time and places because of the roads that are impassable.

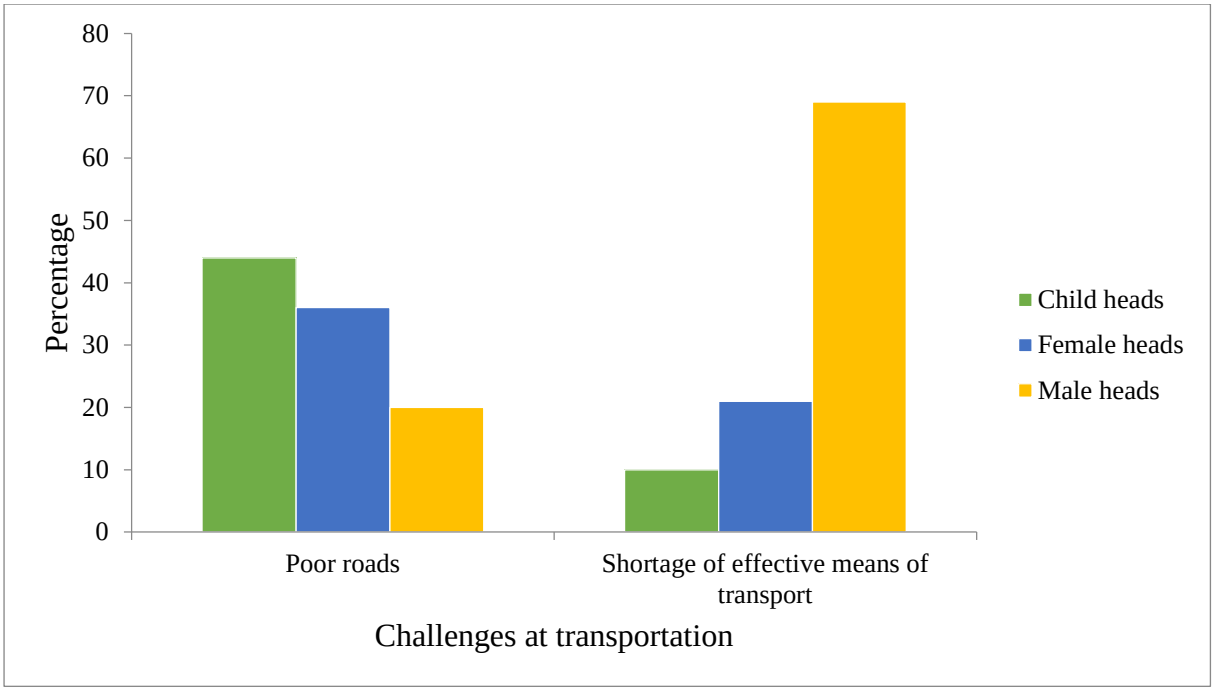


Figure 4.3: Challenges faced at transportation stage

4.4.3.1 Shortage of effective means of transport

As shown of Figure 4.3, female heads and child heads accounted for 36% and 44% respectively for all the household heads that indicated challenges of shortage of effective means of transport as compared to only 20% of male headed households. The Ward 22 Councillor pointed out that small grain shows certain uniqueness from other grains because they cannot be threshed in our houses and hence there is a need to transport them to threshing floors. Chingarande and Kandiwa (2015) pointed out that in most instances, women and child headed households bear much loss at transport stage because they do not own transport means such as scorch-carts so when they borrow, the owners may not want them to do many trips and they tend to overload and incur losses along the way.

More so, the Extension officer indicated that small grains are difficult to transport even by scorch-carts especially if the status of the scorch-cart is old and have some holes or gaps at its base, finger millet and pearl millet can quickly spill since their grain seed sizes are very small. He further indicated that on the transportation stage, child headed households are prone to high losses considering that even if there are some grains fall to soil they do not pick as compared to old females and males who pick due to behaviour change.

4.4.3.2 Poor roads.

The challenge of poor roads was highly indicated in male headed households (69%) as compared to other household head types. The GMB Buhera Depot Manager pointed out that other areas are inaccessible since most of the roads are in sorry state especially the main road from Murambinda that detours Ward 22 to Birchnough Bridge. He also pointed out that considering the sorry state of the roads farmers are incurring elevated losses at transportation due to bumpy roads and potholes that have the great influence to grain spills.

4.4.4 Challenges faced at threshing stage

Findings from Ward 22 of Buhera district indicated that threshing is constrained by labour shortages, incomplete threshing and excessive threshing. Hence food is eliminated from food supply chain through grain damage and grain left on panicles.

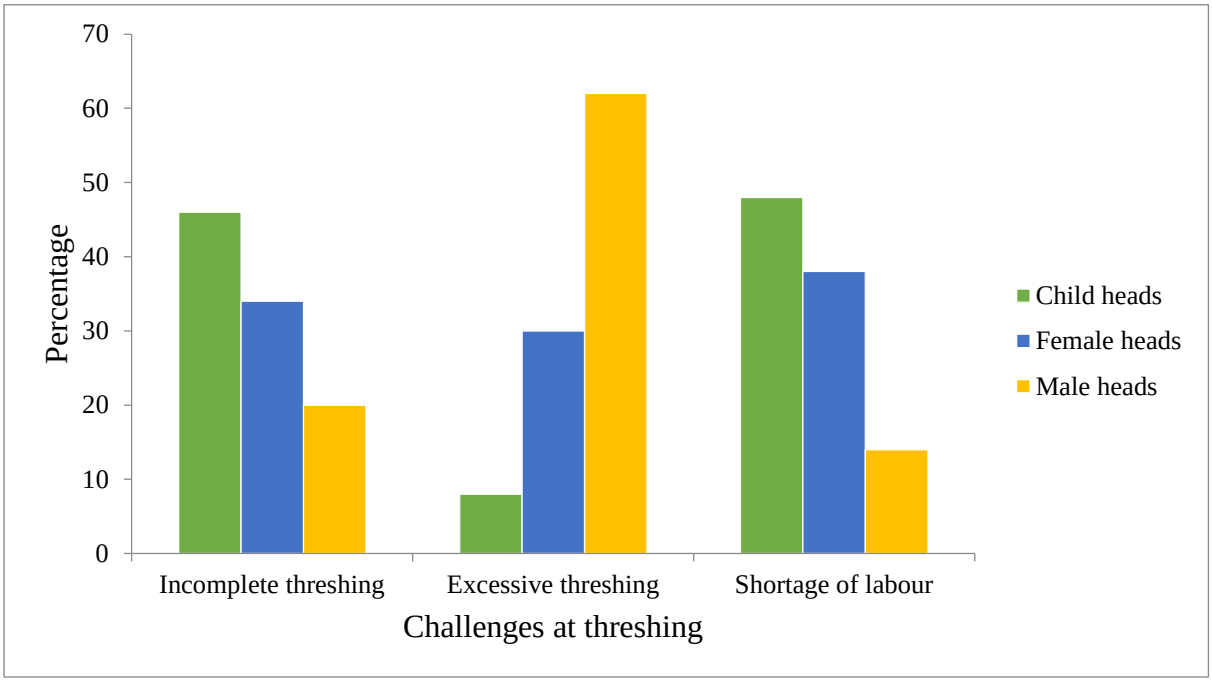


Figure 4.4: Challenges faced at threshing stage

4.4.4.1 Incomplete threshing

The challenge of incomplete threshing was principally felt by the child headed households since they constituted almost half (47%) followed by the female headed respondents (34%). Chingarande and Kandiwa (2015) was also of the same view with the above findings that much of the grains are lost at threshing stage in female and child headed households than in

male headed households. Thus, the research findings established that much of grains are lost at threshing stage through grains left on panicles. This is resultant of incomplete threshing mainly if the threshing exercise has been done by beating method. The Extension officer also indicated that threshing of small grains such as millet and sorghum required to be done by men considering their physique especially when the threshing exercise is to be done by beating method using sticks because these grains cannot quickly pluck out from the seed ears. Another factor contributing to reliance on beating which is highly susceptible to incomplete threshing is unwillingness of farmers to share resources such as cattle. The Ward Councillor indicated that,

"*Vane mombedzavokubatsiravamwevasinavanoonasevatovapfumisa."(Those with cattle think that to assist those without is like giving them wealth).*

He further stressed that, those without cattle are left with no option other than beating with sticks hence much of their grains is left on panicles.

4.4.4.2 Excessive threshing

Results of this study also show that excessive threshing is a topical challenge to those households relies on draught power to thresh their grains. Grains are highly prone to damages due to the hoofing effect of the cattle. This challenge was prominent in male headed households (62%) as compared to other households 30% and 8% for female heads and child heads respectively. This was so because the male heads of 69% have cattle ownership (Table 4.2).

4.4.4.3 Shortage of labour

The challenge of shortage of labour was at 48% and 38% in child and female headed household respectively. Labour unavailability hampers the farmers to thresh their produces effectively. This challenge work in hand in hand with the challenge of incomplete threshing. The researcher observed that whenever labour is in short for, challenges of incomplete threshing is also high. Hence, this greatly facilitates the elimination of the food from food supply chain.

4.4.5 Challenges faced at storage stage

Results of this study established that storage of small grain is constrained by pests, unavailability of exotic storage facilities, poor practices and high costs of chemicals.

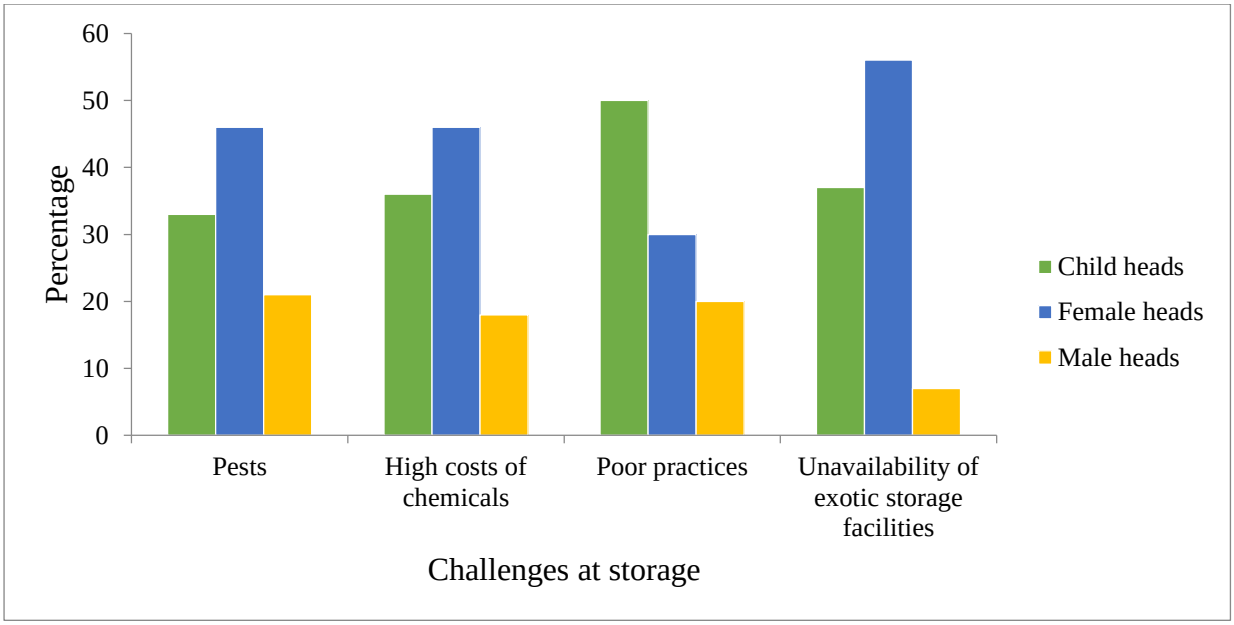


Figure 4.5: Challenges faced at storage stage

4.4.5.1 Pests

Results from the field indicated that challenges of pests were high in female headed households at 46% followed by child headed households (33%) and in male headed households it was perceived to be at 21%. The Extension officer indicated that for the post-harvest season of 2017, fears are high to incur huge loss at storage owing to the eruption and mushrooming of rats in Ward 22. He further noticed that pest such as LGB was a challenge in 2016. These results are in line with the ones of ZimVac (2014) that pests challenge in Manicaland was at 42%.

4.4.5.2 High costs of chemicals

Findings of this study established that challenge of high costs of chemicals was high in female headed households (46%) followed by child headed households (36%). However, the challenge was low in male headed household (18%). During an interview with the Extension officer, he pointed out that in 2016 after the eruption of LGB; farmers did nothing to control it since they did not have money to purchase the chemicals. He went on to say that male headed households incur greater losses at storage because if the women do not have the decision, it means grain protection practices will be low owing to the fact that males pay little attention to PHM.

4.4.5.3 Unavailability of exotic storage facilities

Research findings established that challenge of unavailability of modern day storage facilities was as high as 56% in female headed households while it was at 37% in child headed households and only 7% in male headed respondents. The PEM manager of World Vision indicated that financial constraints hamper the farmers to buy modern day storage facilities such as metal silos and hermetic bags which do not allow growth of moulds and pest infestation. He further indicated that although they are trying their best to equip the farmers with knowledge about better practices that can minimise PHL at storage but continuous loss still occurs because these modern day technologies are not available on the markets in Buhera district and are also unaffordable to them.

4.4.5.4 Unable to construct traditional granaries

The Ward Councillor indicated that the young generation particularly the child heads face challenges of constructing traditional granaries and in turn they tend to use ordinary rooms as storage facilities. This concurs with the results of study by Mvumi*et al* (2017) where they found that the young generation face challenges on constructing traditional granaries. Remoistening of grains due to frequent use of water in the resorted ordinary room storage facilities has greatest impact towards elevating loss at storage. The Extension officer indicated that the main reason why losses are high in child headed and female headed households as compared to male headed households is that women and children are not able to construct traditional granaries.

4.4.5.5 Poor practices

The Extension officer indicated that even those that are using traditional granaries, they also incur high losses if these structures are not properly managed for example 50% of child headed faced further challenges of decay and moulds development due to their reliance on poor storage practices. The researcher observed that most of traditional granaries of the aged were found having cracks and some sides of the structures, the dagga has fallen down hence moisture can quickly enter through and deteriorate the grains. Most of the storage structures were also found to be grass thatched and hence high likelihood of leaking water to the grains causing grain decay. Also, the grass thatched structures offers habitation for rodents such as

rats and these rats can chew or take the food or facilitates in the decay and reduced quality which lead to food loss and food labelled unfit for consumption

At district level, the dominant storage facility of stacking is associated with the challenges of decay since the base of stacking system used was designed by laid poles which are not well elevated from the ground. The stacking system is also associated with over-sunning which results in tearing of sacks during off-loading era and the grains are lost through scattering.

4.4.6 Challenges faced at winnowing stage

Findings of this study show that challenges on winnowing mainly affect male headed households and child headed households. The entire male headed household who were single but previously married indicated that they do not have knowledge and skills on winnowing. One male head respondent said that,

"*Winnowing goes hand in hand with the wind direction and it requires someone who may know tilting angle of winnowing tray so that the grains are not lost to chaff*."

4.5. Determination of level of Post-Harvest Loss

Two methods have been used to determine level of loss incurred from pearl millet in Ward 22 of Buhera. The field measurements were done to justify level of loss obtained from analysis of self-reported loss from the farmers. This was done in response to the view of Hodges *et al* (2014) that self-reported loss to yield reliable data must be justified with researcher's measurements because self-reported loss is associated with under and over estimation.

4.5.1 Self-reported loss from surveyed households

$$TPHL = \frac{La + Ld + Ltt + Lth + Lts + Ls + Lw}{AY + \text{Ɛ} (La - Lw)} \times 100$$

Where TPHL= Total Post-Harvest Loss

Ɛ = summation

La = estimated loss at assembling stage (just after separation of grain from the plant)

Ld = estimated loss at drying stage

Ltt = estimated loss at transportation stage (from drying floor to threshing floor)

Lts = estimated loss at transportation stage (from threshing floor to home store)

Lth = estimated loss at threshing stage

Ls = estimated loss at storage stage

Lw = estimated loss at winnowing stage

AY = Actual yield

4.5.2 Field measurements for non-storage loss

The following formula was used to analyse obtained data from the field measurements

$$\text{PHL for ADTtT} = \frac{EY - AY}{EY} \times 100$$

EY is given by (i) $\frac{APM}{QS} = TQ$

(ii) $TQ \times SY = EY$

SY is amount of yield obtained from a selected quadrant

Where PHL= Post-Harvest Loss

ADTtT= Assembling, Drying, Transportation to threshing floors and Threshing stages.

EY= Expected yield in Kilograms.

AY= Actual yield in Kilograms.

APM= Area under pearl millet cultivation in square metres.

QS= Quadrant size in square metres.

TQ= Total number of quadrants from area under pearl millet cultivation.

SY= Sample yield in Kilograms that is yield obtained from a selected quadrant.

QL= Quantity loss

After obtaining loss from each household, then the researcher totalised these losses according to strata (in this case the strata were made based on household head type). The researcher then finds the averages of the losses per strata as shown on Tables 4.8, Table 4.9 and Table 4.10.

Table 4.8: Level of PHL for 2017 for female headed households

Self-Reported loss estimates (%)										Field Measurements							
Hno	La	Ld	Lth	Ltt	**SB**	Lts	Ls	Lw	**TPHL**	APM	TQ	QS	SY	EY	AY	QL	**%**
1	2	1	0.8	1	4.8	0.8	1.3		6.9	13600	136	100	14	1904	1800	104	5.5
2	1.5	2.6	1.1	1.9	7.1	1.5	1.1		9.7	10950	110	100	12	1314	1200	114	8.7
3	3.4	1.3	4.6	2	11.3	1.3	1.2		13.8	11250	113	100	12	1350	1220	130	9.6
4	2.7	1.8	0.9	0.5	5.9	0.4	0.5		6.8	12110	121	100	9	1090	1030	60	5.5
5	1.7	0.6	0.9	0.8	4	0.4	0.4		4.8	12170	122	100	9	1095	1010	85	7.8
6	2.6	1	4.5	2	10.1	1.3	1.2		12.6	14000	140	100	14	1960	1660	300	15.3
7	2	2.3	4	2.6	10.9	2.4	0.7	0.3	14.3	9300	93	100	8	744	645	99	13.3
8	1.7	1.9	3.6	1.9	9.1	2.1	1	0.2	12.4	10940	109	100	10	1094	980	114	10.4
9	1.7	1.9	3.4	2.1	9.1	2.3	0.9	0.1	12.4	10640	106	100	11	1170	1020	150	12.8
10	1.6	2	2.7	2	8.3	2.8	1.3	0.1	12.5	10230	102	100	11	1125	990	135	12
11	2	2.4	4.8	3.6	12.8	3.6	1.2	0.4	18	8400	84	100	9	756	680	76	10.1
12	2.1	0.6	1.1	1.3	5.1	1.1	0.9		7.1	13430	134	100	14	1880	1760	120	6.4
13	1.9	0.9	0.5	0.8	4.1	0.7	0.5		5.3	12170	122	100	9	1095	1000	95	8.7
14	2.1	1.1	0.9	1.1	5.2	1.3	0.9		7.4	13600	136	100	14	1904	1760	144	7.6
15	3.6	1	4.5	2	11.1	1.3	1.3		13.7	14430	144	100	14	2020	1660	360	17.8
16	1.4	1.8	2.7	1.8	7.7	2.2	0.7	0.1	10.7	10510	105	100	11	1156	1000	156	13.5
17	2.2	2.7	4.7	2.5	12.1	2.5	1.3	0.4	16.3	8600	86	100	9	774	660	114	18.6
18	1.9	0.7	0.9	0.9	4.4	0.6	0.5		5.5	12400	124	100	9	1116	1020	96	8.6
19	2.8	0.5	1	2.3	6.6	1	0.7		8.3	14200	142	100	14	1988	1770	218	11
20	3	1.4	5.4	2.5	12.3	1.6	1.7		15.6	14300	143	100	14	2002	1720	282	14.1
21	3	1.4	5.4	2.5	12.3	1.6	1.7		15.6	13430	134	100	14	1880	1720	160	8.8
22	2.1	2.4	4.5	2.1	11.1	2.5	1.4		15	8000	80	100	9	720	640	80	11.1
23	2.8	0.5	1	2.3	6.6	1	0.7		8.3	14900	149	100	14	2086	1770	316	15.1
24	1.8	2	3.6	2	9.4	2	1	0.2	12.6	10900	109	100	11	1199	1025	174	14.5
25	2.6	1	4.1	1.6	9.3	1.3	1.3		11.9	14200	142	100	14	1988	1700	288	14.5
26	1.7	2	2.9	2.1	8.7	3	1	0.1	12.8	11130	111	100	11	1224	1030	194	15.8
27	2.3	1.5	5	1.7	10.5	1.2	0.9		12.6	13200	132	100	14	1848	1500	348	18.8
28	3.4	2	5.8	2.7	13.9	1.4	1.4		16.7	11850	119	100	12	1422	1220	202	14.2
29	1	2.1	1	1.7	5.8	1.4	1.7		8.9	12150	122	100	12	1458	1300	158	10.8
30	2.9	1.3	4.6	2	10.8	1.3	1.2		13.3	12750	128	100	12	1530	1310	220	14.4
Totals	68	46	91	56	260	48	32	1.9	342								355
Averages	2.3	1.5	3	1.9	**8.7**	1.6	1.1	0.1	**11.4**								**12**

Key: **SB** = Subtotal

Hno = Household number

Table 4.9: Level of loss for 2017 for male headed households

Self-Reported loss estimates (%)										Field Measurements							
Hno	La	Ld	Lth	Ltt	SB	Lts	Ls	Lw	TPHL	APM	TQ	QS	SY	EY	AY	QL	%
1	1.4	0.8	0.6	1.4	4.2	2	1.1		7.3	12430	124.3	100	14	1740	1640	100	5.7
2	0.3	1.5	2.5	2	6.3	2	1.1		9.1	13750	137.5	100	14	1925	1620	305	15.8
3	0.9	0.7	1.8	1.3	4.7	2	1.3	0.7	8.5	11200	112	100	10	1120	1000	120	10.7
4	0.8	0.5	2.1	0.7	4.1	1	1.6	1.4	8.2	8000	80	100	9	720	670	50	6.9
5	1.3	0.6	1.9	3.8	7.6	3	1.3	2.5	13.9	9630	96.3	100	8	770	690	80	10.4
6	0.9	0.5	0.3	1.6	3.3	2	0.8	0.8	6.4	15300	153	100	12	1836	1725	111	6
7	0.3	1.1	0.5	1.6	3.5	1	0.8	0.5	5.9	20500	205	100	9	1845	1730	115	6.2
8	0.8	1.1	0.5	1.9	4.3	1	0.8		6.5	14180	141.8	100	13	1843	1730	113	6.1
9	0.4	0.4	0.4	1.4	2.6	1	1.1		5	12000	120	100	12	1440	1350	90	6.3
10	0.9	0.4	0.3	1.1	2.7	1	1.1	0.8	5.8	15750	157.5	100	12	1890	1780	110	5.8
11	0.5	0.8	1	2	4.3	2	1	0.2	7	10080	100.8	100	10	1008	920	88	8.7
12	1.3	0.8	2.5	2	6.6	3	2.5	2.5	14.7	6200	62	100	10	620	520	100	16.1
13	0.5	0.8	0.9	1.4	3.6	1	1.1	0.5	6	20330	203.3	100	9	1830	1715	115	6.3
14	1.1	0.7	1	2.3	5.1	2	1.4	0.5	8.8	14000	140	100	8	1120	1010	110	9.8
15	1.1	0.8	0.6	1.4	3.9	2	0.8	0.6	7	17140	171.4	100	10	1714	1640	74	4.4
16	0.8	0.6	1.6	1	4	1	0.6	1	6.4	11040	110.4	100	10	1104	1000	104	9.4
17	0.7	0.6	0.3	1.5	3.1	1	0.6		5.1	14840	148.4	100	11	1632	1530	102	6.3
18	0.8	0.6	0.3	1.6	3.3	2	0.6		5.4	11290	112.9	100	14	1581	1490	91	5.6
19	0.5	0.5	0.3	1.1	2.4	1	1.3	0.8	5.6	19040	190.4	100	10	1904	1780	124	6.5
20	0.4	0.4	0.3	1.8	2.9	1	1.1		5.4	13000	130	100	11	1430	1340	90	6.3
21	0.7	0.4	0.3	1.4	2.8	1	1.1		5.3	12830	128.3	100	11	1411	1340	71	5
22	0.3	1.7	2.5	2	6.5	2	1.1		9.3	12590	125.9	100	14	1763	1630	133	7.5
23	0.4	0.5	0.3	1.6	2.8	2	1.1		5.4	13350	133.5	100	12	1602	1490	112	7
24	0.7	0.8	1	2	4.5	2	1		7	7750	77.5	100	14	1085	920	165	15.2
25	0.2	1.3	2.1	1.6	5.2	2	1		7.8	17150	171.5	100	11	1887	1760	127	6.7
26	0.9	0.7	1.8	1.3	4.7	2	1.3	0.7	8.5	12500	125	100	9	1125	1020	105	9.3
Totals	19	20	28	43	109	40	28.6	14	191								210
Averages	0.7	0.8	1.1	1.7	**4.2**	2	1.1	0.5	**7.3**								**8.1**

Key: **SB** = Subtotal

Hno = Household number

Table 4.10: Level of loss for 2017 for child headed households

Self-Reported loss estimates (%)										Field Measurements							
Hno	La	Ld	Lht	Ltt	SB	Lts	Ls	Lw	TPHL	APM	TQ	QS	SY	EY	AY	QL	%
1	1.7	2.7	6.7	1.7	12.8	1.7	4	1.7	20.2	3100	31	100	9	279	240	39	14
2	2.2	4.1	6.9	1.4	14.6	2.8	5.2	1.7	24.3	2960	29.6	100	8	237	220	17	7.1
3	2.4	1.4	6	1.4	11.2	1.7	3.6	1.4	17.9	5760	57.6	100	7	403	340	63	15.7
4	1.1	6.8	4.5	1.8	14.2	1.4	3.4	1.4	20.4	4120	41.2	100	10	412	350	62	15
5	1.3	5.2	7.7	1.3	15.5	1.3	3.8	1.9	22.5	2400	24	100	6	144	120	24	16.7
6	1.8	2.9	4.7	1.2	10.6	1.8	2.9	2.4	17.7	2330	23.3	100	7	163	140	23	14.2
7	2.4	3.6	1.9	1.2	9.1	1.2	4.8	0.5	15.6	46.7	46.7	100	9	420	350	70	16.7
8	2.6	4.1	6.7	1.5	14.9	1.5	5.6	1	23	2000	20	100	9	180	150	30	16.7
9	2.4	3.9	4.9	1.9	13.1	1	5.8	1.9	21.8	2320	23.2	100	9	209	160	49	23.4
10	3.1	3.1	5	1.8	13	1.2	3.7	2.5	20.4	3060	30.6	100	5	153	130	23	15
11	1.9	2.9	4.8	1	10.6	1.4	4.8	1.4	18.2	3000	30	100	7	210	170	40	19
12	2.3	3.8	5.8	1.2	13.1	1.2	3.8	1.2	19.3	3150	31.5	100	8	252	210	42	16.7
13	1.3	2.6	5.3	1.3	10.5	2.6	3.9	1.3	18.3	4000	40	100	9	360	320	40	11.1
14	2.2	3.3	5.4	1.6	12.5	1.4	3.3	1.4	18.6	3580	35.8	100	10	358	300	58	16.2
15	1.8	4.4	5.3	1.3	12.8	0.9	4.4	1.7	19.8	2400	24	100	9	216	180	36	16.7
16	2.9	2.4	2.4	1.5	9.2	1.5	4.9	1.5	17.1	2610	26.1	100	8	209	170	39	18.6
17	2.1	4.2	5.3	1.1	12.7	1.6	4.2	2.6	21.1	2280	22.8	100	8	182	150	32	17.8
18	2.2	3.3	3.9	1.7	11.1	1.1	2.8	1.7	16.7	3520	35.2	100	5	176	150	26	14.8
19	2.3	2.9	4	2.3	11.5	1.7	4	2.9	20.1	4250	42.5	100	4	170	140	30	17.6
20	2.2	2.7	3.8	1.6	10.3	1.6	3.8	1.6	17.3	2600	26	100	7	182	150	32	17.6
21	2.6	3.1	4.1	1.5	11.3	1.5	3.1	2.1	18	2790	27.9	100	7	195	160	35	18.1
22	2.9	3.4	4	2.9	13.2	1.1	2.9	2.3	19.5	2800	28	100	6	168	140	28	16.7
23	2	4	6.1	1.2	13.3	1.2	3.2	1.2	18.9	2740	27.4	100	9	247	200	47	18.9
24	1.6	2.7	2.2	1.1	7.6	1.2	4.1	1.2	14.1	3090	30.9	100	11	340	320	20	5.9
25	2.4	2.9	4.8	1.4	11.5	1.9	3.8	1.9	19.1	3400	34	100	6	204	170	34	16.7
26	2.5	3.7	4.3	1.9	12.4	1.2	3.7	2.5	19.8	2600	26	100	6	156	130	26	16.7
27	2.3	2.6	4.6	1.1	10.6	1.1	3.4	1.7	16.8	3300	33	100	5	165	140	25	15.2
Totals	59	93	131	41	323	40	107	47	516.5								429
Averages	2.2	3.4	4.9	1.5	**12**	1.5	4	1.7	**19.1**								15.9

Key: **SB** = Subtotal

Hno = Household number

4.5.3 Testing for hypotheses

Table 4.11: ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	75.392	2	37.696	18.173	.021[b]
	Residual	6.223	3	2.074		
	Total	81.615	5			

Table 4.11 shows that p<0.021. Hence, the researcher accepted the H_0 that there is no significant differences in the level of loss from self-reported loss estimations and field measurements between child, female and male headed households (p<0.05).

Table 4.12: Paired Samples Statistics

	Mean	N	Std. Deviation	Std. Error Mean
Field measurement	12.00	3	3.900	2.252
Self-reported	8.30	3	3.915	2.261

Table 4.13: Paired Samples Correlations

	N	Correlation	Sig.
Field measurement & self-reported	3	.996	.056

Table 4.13 shows that Pearson's correlation is 0.996. Hence, the researcher accepted the H_1 that there is strong correlation between household head type and level of loss both from field measurements and self-reported loss estimations (p value for strong correlation p=0.00).

4.5.3.1 PHL for female headed households

Self-reported loss estimates indicate that for surveyed female headed households total PHL was at 11.4%. PHL at assembling, drying, transportation to threshing floors and threshing stages was at 8.7% from self-reported loss estimates as compared to field measurements (12%) as indicated on Table 4.8. Huge loss was incurred at threshing stage (3%) owing to challenges of incomplete threshing (Figure 4.4) followed by assembling stage (2.3%) due to challenges of carelessness of hired labour (Figure 4.1). However, loss at winnowing stage was insignificant.

4.5.3.2 PHL for male headed households

Table 4.9 indicates that for surveyed male headed households total PHL was at 7.3%. PHL at assembling, drying, transportation to threshing floors and threshing was at 4.2% from self-reported loss estimates as compared to 8.1% from field measurements. PHL level was generally low in male headed households because this stratum had the highest proportion of asset ownership (Table 4.2). However, winnowing stage perceived to be a difficult stage in male headed households especially those male heads without their spouses due to lack of knowledge and skills on cleaning grains.

4.5.3.3 PHL for child headed households

Table 4.10 shows that, PHL was greatest in child headed households at 19.1%. Field measurements indicated that PHL at assembling, drying, transportation to threshing floors and threshing stages was as high as 15.9% as compared to self-reported loss estimates of 12%. Drying stage (3.4%) and threshing stage (4.9%) perceived to be the major stages in which huge volume of food was eliminated from food supply chain. These elevated losses at drying and threshing was attributed to the adhered to practices used per these stages such as bare ground which are susceptible to grain decay and germination (Figure 4.2) and challenges of incomplete threshing at threshing stage (Figure 4.4). Thus, it is undoubtedly that this high rate of food loss at drying is contributed by poor drying methods which pave the way for grain germination and decay. This best explains that despite poor practices, financial constraints and environmental challenges, these child heads have a wasteful behaviour as articulated by the Ward Councillor.

4.5.4 Cumulative PHL from 2015 to 2017

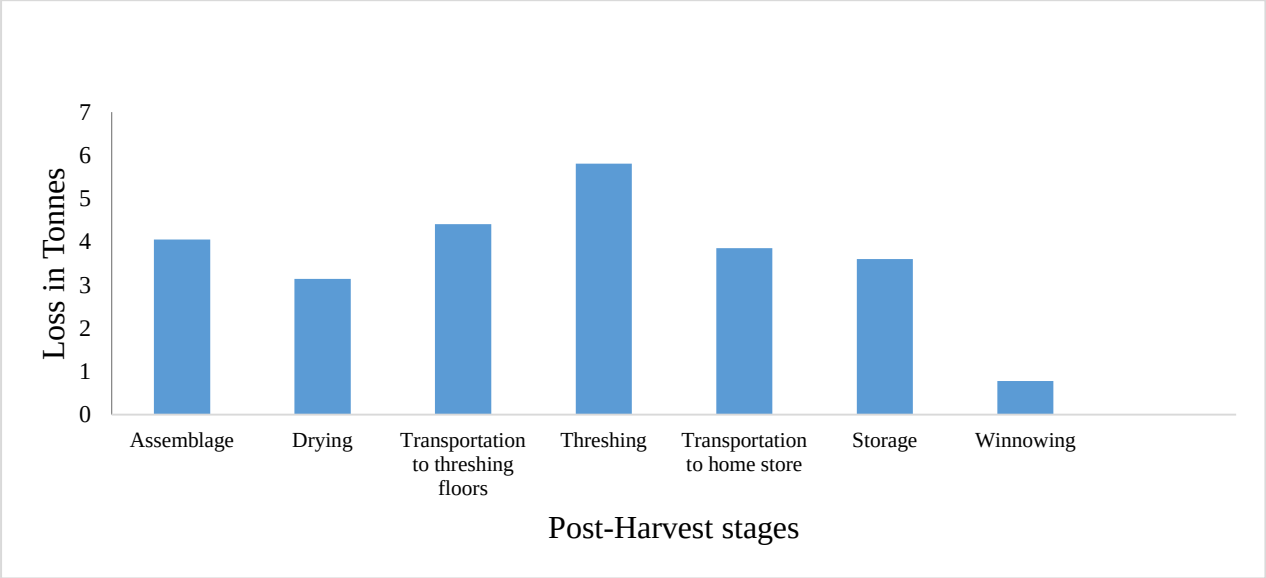


Figure 4.6: Level of loss per stage from 2015 to 2017

Cumulative PHL from self-reported loss estimates from 2015 to 2017 from all surveyed households established that PHL was prominent at threshing stage (5.804 tonnes). The researcher found that the reason behind high loss magnitudes at threshing was contributed by grain damage during threshing and grain left on panicles. Transportation to threshing floor was the second, mainly because the transportation of grains in Ward 22 was done by children and hence grains that fall left on the soil due to negligence by children to pick the grains. Other stages bear loss of 4.051 tonnes (assemblage), 3.139 tonnes (drying), 3.852 tonnes (transport to home store), 3.598 tonnes (storage) and lastly 0.779 tonnes (winnowing).

4.5.5 Level of loss per post-harvest stage per year from 2015 to 2017

Table 4.14 summarizes losses incurred by all surveyed household from ward 22 of Buhera district from 2015 to 2017 per post-harvest stage per each year.

Table 4.14: level of loss per post-harvest stage per year from 2015 to 2017

Stage	Farmers' perception (level of loss (%))		
	2015	**2016**	**2017**
Assembling	5.3	5.3	5.2
Drying	3.9	4.0	4.3
Transportation to Threshing floors	5.7	5.7	5.7
Threshing	7.2	7.9	7.5
Transportation to home store	5.2	4.9	4.9
Storage	3.5	6.4	4.2
Winnowing	1	1	1

Loss at assembling stage was high in 2015 and 2016 at 5.3% and in 2017, it was at 5.2%. Loss at drying stage was highest in 2017 owing to unseasonal rains which perceived to be the major challenge by the majority of surveyed households, however, in 2015 and 2016 it was at 3.9% and 4.0% respectively. Loss at transportation to threshing floors maintained the same level (5.7%) and the researcher concluded that this is a clear indication that no any changes in terms of practices employed at this particular stage. Loss at threshing stage was indicated prominent in 2016 at 7.9% and also storage loss was high in 2016 at 6.4%. This was stressed by the Extension officer that loss at storage was high in 2016 owing to the emergence of LGB and farmers did nothing to protect their grains. He also further alluded that, even for the 2017 post-harvest season loss at storage is expected to be high because of the eruption of rats.

4.5.6 Impact of PHL on food security

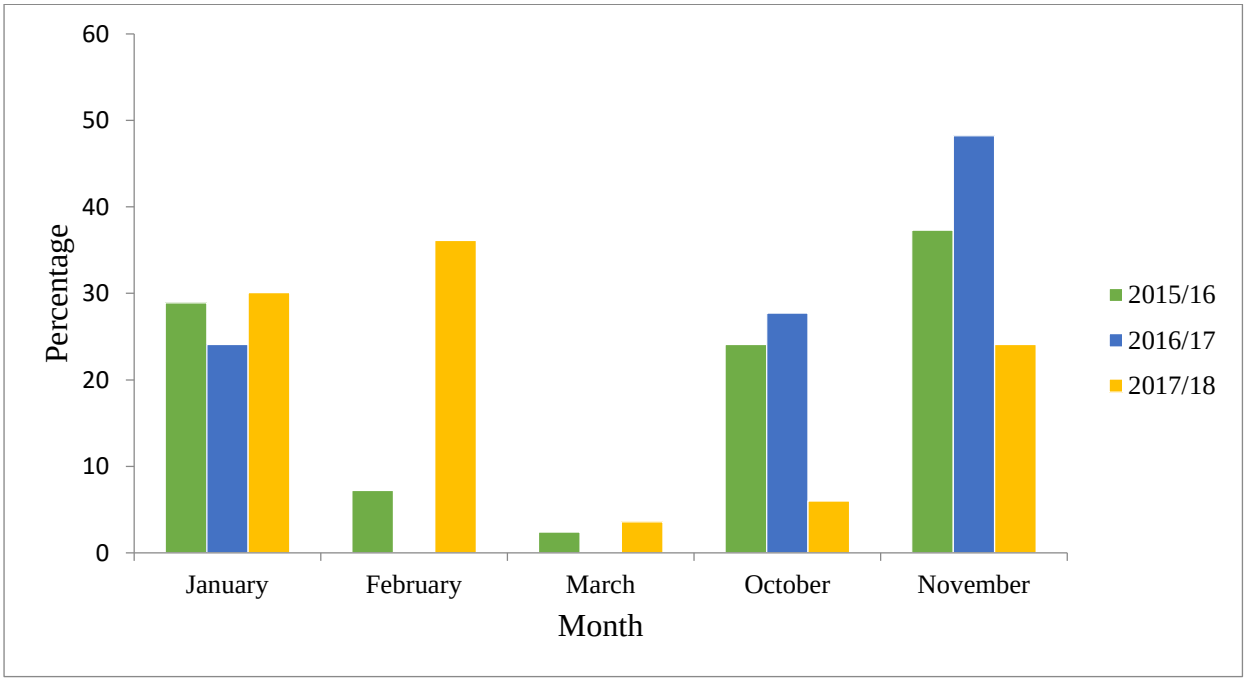


Figure 4.7: Level of food insecurity

Figure 4.7 shows that food insecurity was prominent for 2016/2017 season as 48.2% of all surveyed households depleted their food stuffs by November 2016. For 2015/ 2016 season food depletion was high by the month of November 2015 again at 37.3% and for the 2017/ 2018 season it is projected that food stockpiles will be depleted by the month of February as 36% of all surveyed households indicated that they are expecting to reach February 2018 with their food stockpiles. However, considering that the harvesting season for small grain in Buhera district starts from April (early harvesting) and May (normal harvesting time), therefore the above results shows that for all the three years, no any household reached or expecting to reach next season with its food stuffs and hence incurring food insecurity. The Ward Councillor also colourfully pointed out that,

> *Even if the farmers are heartily willing to manage their grains after harvest, most households are harvesting earlier than preferred (kukamba) due to depleted food stuff in their homes. This act reduces grain quality since the grains are harvested before reaching their maturity stage and hence consumption of food without adequate nutritional value.*

These results connive with the ones found by ZimVac (2016) that in Buhera district, 61% of the total population was food insecure in 2016 for the period January to March and projections show that an estimated 71% would be food insecure for the same period in 2017.

Then, pertaining to results of the study by Mvumi *et al* (2017) where they found out that food amount of 1 tonne per household is sufficient to take through most households to next season in Zimbabwe. Therefore, it is undoubtedly that food loss of 25. 633 tonnes (Figure 4.6) is enough to halve the challenges of food insecurity which the people in Buhera are facing. Thus, it is explicit that any actions towards reducing food insecurity challenges in Ward 22 of Buhera district will face a major threat if PHM is continuously given little attention.

CHAPTER FIVE: CONCLUSSION AND RECOMMENTATIONS

5.1 Conclusion

The research was set to assess the current small grain PHM practices used per stage, challenges faced and level of loss per post-harvest stage and how these are linked to food shortages in Ward 22 of Buhera district. Despite a myriad of remarkably low cost traditional post-harvest-practices such as drying on stalks, *ruware* and bare grounds, use of chaff and ashes, the practices proved to be ineffective towards curtailing post-harvest losses as huge volume of edible food was eliminated from food supply chain through grain germination, decay and grain left on panicles.

More so, there is evidence that the socio-economic factors such as head of the household, size of the household, age and asset ownership are strongly linked to the post-harvest management system. It was learnt that the size of household determines labour availability for most post-harvest stages. Results established that female and child headed households lack adequate labour particularly on threshing using the beating method and hence the researcher concluded that households face elevated loss at threshing due to lack of man power. Age determines farmers' perception towards acceptance of effective post-harvest methods, both indigenous and exotic methods. For example, the Extension officer indicated that aged women and men are better in the management of grains after harvest because of behaviour change influenced by the accumulation of wisdom and experience in the management of grains after harvesting.

Asset ownership proved to be a standard-bearer in PHM. This is so because those with assets such as cattle and scorch-carts have indicated relatively few challenges on stages such transport and threshing. Therefore, the researcher concluded that asset ownership is indispensable in the minimisation of loss at transportation stage.

Results also established that the adherence to low cost indigenous post-harvest practices is attributed by financial constraints which hamper the farmers to acquire better and sophisticated PHM methods such as chemicals, metal silos and acquire the use of driers which shorten the drying period. It was discovered that, the farmers may be willing to adopt improved and better post-harvest management methods, but there is inadequate support either from the government and NGOs who possess necessary modern day knowledge, tools and equipment needed for PHM.

Results shows that on level of loss, there was an underestimation of loss from all the household heads from self-reported loss estimates compared to magnitudes from field measurements. The researcher concluded that, the villagers in Ward 22 do not consider food loss after harvesting as an ulcer to their food security status. Thus, they are suffering from an image problem than a real problem since Rugumamu (2011) pointed out that it is pointless to invest resources on increasing production when the yield gained will eventually be lost to PHL. Thus, this is a clear indication that households in Ward 22 of Buheraspare little efforts towards PHM.

5.2 Recommendations

Considering the research findings and the conclusions made, the researcher therefore came up with the following recommendations;

- The farmers must be aware that good post-harvest handling practices have the ability to minimize post-harvest loss through moulds, decay and germination.
- There is a need for the NGOs and the government to initiate exotic post-harvest technologies aimed at equipping the farmers both with sophisticated tools and equipment and modern day knowledge through awareness creation and training.
- Owing to the fact that modern day storage facilities provides solution to losses at storage, it is vitalthat the government pay same attention to both pre- and post-harvest so that farmers can be supplied with these facilities at an affordable price if possible. One good example can be drawn from Kenya where the farmers benefited from small scale metal silos and hermetic bags project.
- There is a need for continuous quantification of on-farm food loss which can therefore compared with costs of introducing modern day post-harvest practices and costs of recovering food loss.
- There is a need to first solve the problem of food insecurity that has already hit Ward 22 so as to cut the food insecurity cycle that recurs in Ward 22. Considering the remarks given by the Ward Councilor that all households survived through early harvesting, it is a clear indication that there is a need to curb the food insecurity situation to reduce early harvesting which may result in structural food insecurity.

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Appendix 1: Questionnaire Survey for households in Ward 22 of Buhera District.

My name is JohanneNdaboka, a student at Midlands State University. I am doing a dissertation with the topic: **An assessment of small grain post-harvest management practices in ward 22 of Buhera District.** I guarantee that the results are strictly for academic purposes and the recipient's confidentiality will be greatly respected. I kindly request your participation in this exercise.

Field Worker: J. Ndaboka**Village Name**.....**Questionnaire No**.....
Date.....

Tick and narrate where applicable.

SECTION A: GENERAL INFORMATION

1. Gender of respondent Male Female

2. Age of respondent

Age	>18	18-20	21-30	31-40	41-50	51-60	61-70	70+

3. Marital status Single Married Single previously married
4. Highest attained educational level

Illiterate	Primary	Secondary	Tertiary

5. Who is the head ofhousehold? Father Child Mother
6. What is the size of the household? (3 months at home) ……
7. Do you have your own scotch-cart? Yes No
8. Do you have cattle? Yes No

SECTION B: CROPS GROWN

9a. Which crops do you grow? Finger millet Pearl millet Sorghum Cow peas others

b. If others, specify……

10. How much do you produce per year for the following cereal crops?

CROP	**YEILDS IN TONNES**		
	2015	**2016**	**2017**
Sorghum			
Pearl Millet			
Finger Millet			
Cow peas			
Others(*Specify*)			

11. When do you finish your food stuffs?

Year	**2015**	**2016**	**2017/2018(***projection***)**
Month when the food stuff finished			

SECTION C: SMALL GRAIN POST-HARVEST MANAGEMENT PRACTICES

12a. Which tools and equipment do you at assembling stage?.....

.....

b. (i) What system do you use at assembling stage? Machinery Labor

(ii) If labor, where do you get if from? Family members Hired

13a (i) What platform do you use to dry your grains? *Ruware* Cribs Plastered ground Others

(ii)If others, specify ……

b. (i) Which method do you use to dry your grains? …….

(ii)How long does it take for the grains to dry? .....

14a. Which strategydo you use to thresh your grains? Beating Draught power

b.Who is responsible for the threshing exercise? …….

c. Do you re-thresh your panicles? Yes No

15. Which strategies do you use at winnowing stage? ……

……

16a. What storage facility(s) do you use to store your grains? …….

……

b. Which pest control measures do you use at storage stage? ……

……

17a. (i) How do you transport your grains? Man-power Bicycle Scorch-cart Others

(ii)If others, specify…….

b. Where do you get the means of transport?Own/Personal Hiring

SECTION D: CHALLENGES FACED BY FARMERS IN POST-HAVEST MANAGEMENT

18. Which stage(s) do you face challenges of high post-harvest losses? Assembling Drying Transportation Threshing Storage Winnowing

19. What are the challenges that you face on the following stages?

Assemblage…….

Drying ……..

Transportation …….

Storage……
……

Threshing…….

Winnowing ……...

20. What are the magnitudes of losses per each stage do you think you have encountered for the last three seasons or years?

Pearl millet

STAGES	**LOSSES (in Kgs)**		
	2015	**2016**	**2017**
Assembling			
Drying			
Threshing			
Transport to threshing floors			
Storage			
Transport to home store			
Winnowing			

21.Please list any other challenges that you face in the Post-Harvest Management of small grains…..
.....

THANK YOU FOR YOUR PARTICIPATION

Appendix 2: Semi-structured interview guide for Project Evaluation and Monitoring Manager, World Vision.

1. How do you perceive food security in Buhera District?
2. Is there any support that is underway to minimize post-harvest loss?

Objective 2: Practices used at post-harvest stages

3. Which crops are targeted and their respective post-harvest stages?

Objective 3: Management challenges associated with post-harvest stages

4. What are the challenges associated with Post-Harvest Management practices?
5. What are the farmers' responses and their perceptions towards modern day post-harvest reduction methods?

Objective 4: level of loss per post-harvest stages

6. What is the percentage of loss estimates per each stage for pearl millet from 2015 to date?

THANK YOU FOR YOUR PARTICIPATION

Appendix 3: Semi-structured interview guide for Ward Councillor

1. What is Ward 22's population composition?
2. How do you perceive food security in your ward?

Objective 2: Practices used at post-harvest stages

3. What are the traditional or exotic methods that the villagers are using on Post-Harvest Management?
4. Are there any co-operatives in your ward that allow sharing of assets or resources required for Post-Harvest Management?

Objective 3: Management challenges associated with post-harvest stages

5. What are the challenges faced by the villagers in Post-Harvest Management?
6. What are the measures that can be put in place to reduce Post-Harvest Loss?

THANK YOU FOR YOUR PARTICIPATION

Appendix 4: Semi-structured interview guide for Extension officer.

1. How do you perceive food security in Ward 22?
2. Which crops are dominantly grown by the farmers?
3. What do you understand by the term Post-Harvest Management?

Objective 2: Practices used at post-harvest stages

4. Which post-harvest stages do you think are vulnerable to high food loss?
5. What are the traditional or exotic methods that the villagers are using to retard Post-Harvest Loss?

Objective 3: Management challenges associated with post-harvest stages

6. What are the challenges faced by the farmers in Post-Harvest Management?
7. Are there any modern post-harvest reduction methods introduced to farmers?
8. How do you perceive traditional and exotic post- harvest reduction methods?
9. How frequently do you conduct workshops with the farmers for information dissemination relating to Post-Harvest Management?

Objective 4: level of loss per post-harvest stages

10. What is the percentage of loss estimates per each stage for pearl millet from 2015 to date?

THANK YOU FOR YOUR PARTICIPATION

Appendix 5: Semi-structured interview guide for GMB Buhera Depot Manager.

1. How do you perceive food security in Buhera District?
2. What do you understand by the term Post-Harvest Management?

Objective 2: Practices used at post-harvest stages

3. Which specific stages do you think are vulnerable to high Post-Harvest Loss?
4. Do you offer market and national storage for small grains?
5. Do you provide transport for smallholder farmers to ferry their grains to GMB?

Objective 3: Management challenges associated with post-harvest stages

6. What are the challenges faced at storage of small grain?
7. Is there any support you give to small grain farmers?

Objective 4: level of loss per post-harvest stages

8. What is percentage of loss estimates at storage level on small grain?

THANK YOU FOR YOUR PARTICIPATION

Appendix 6: Observation checklist

Photographs were taken

What the researcher planned to observe	**What was actually observed**
To check for the status of the roads	
To check for drying platforms used	
To check for threshing method	
To check for winnowing strategies	
To check for storage facilities used	