EXTENDING THE THEORY OF STORAGE TO A PERISHABLE COMMODITY IN AN UNDERDEVELOPED MARKET: A CASE OF UGANDA

Thesis

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Declaration

I, Tibaingana Anthony, declare that the thesis/dissertation, which I hereby submit for the degree Doctor of Philosophy at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.

Signature: ……..

Date:…….

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Table of Contents

List of Tables

List of Figures

List of Abbreviations

FAO	-	Food and Agricultural Organization
FGDs	-	Focus Group Discussions
GDP	-	Gross Domestic Product
IFPRI	-	International Food Policy Research Institute
SSA	-	Sub-Saharan Africa
SPSS	-	Statistical Package for Social Sciences
USAID	-	United States Agency for International Development

Abstract

The challenges limiting agricultural development in underdeveloped markets relate directly to inappropriate storage facilities. These challenges are not unique to Uganda where majority smallholder maize farmers use traditional storage. Inappropriate storage leads to losses in quantity and quality, which negatively affect food and income security. The study is premised on the theory of storage advanced by Kaldor in 1939. Its aims were: to examine the role of household characteristics on choice of storage type used; to assess whether the cost of storage can be used to identify the optimal storage type; to evaluate the theory of storage extension to underdeveloped market; and to explore smallholder maize farmers' perception of using storage types as a strategy for building a business framework. The study was conducted in the eastern region of Uganda using concurrent mixed method research. The study was conducted in the eastern region of Uganda using concurrent mixed method research and a multistage cluster sampling method. Districts and sub-counties were selected based on highest, medium and low maize production. Simple random sampling was used to select a sample of 270 smallholder maize farmers, maintaining equal distribution across districts. Respondents for the focus group discussion and key informant interviews were purposively selected. A questionnaire was used to collect quantitative data. Focus group discussion and interview guides were used to collect qualitative data at community level.

The findings show a significant relationship between choice of storage types used and the household characteristics; district (location) *p-value* = 0.000, gender *p-value*= 0.009, acquisition of the storage type *p-value*= 0.000, and seasonal use of storage type *p-value*= 0.032 at a confidence level of $p<0.05$. The cost of storage cannot be used to identify the optimal storage method. Household characteristics and cost of storage affected smallholder maize farmers' share of the maize marketing margin. Most participants supported using storage as a strategy to increase their share of the maize marketing margin.

The study shows how storage can be used as a strategy to increase the share of the maize marketing margin for smallholders and that with adjustments for context the theory of storage can be extended to underdeveloped markets. Findings close the knowledge gap concerning the theory of storage and its extension to underdeveloped markets, and underlines that storage strategies need to be improved to ensure improved grain quality and quantity to support the business framework. The findings provide information about storage challenges useful to smallholder maize farmers, researchers and policy-makers.

CHAPTER ONE

1. Introduction

This thesis explores extending the theory of storage to an underdeveloped market. The work concentrates on household maize storage, because this aspect is most pertinent for food and income security. In this chapter, the key constructs of the study are delineated and linked to the problem studied. These constructs include storage types; marketing margins; the context of the study; the statement of the problem; the purpose of the research; the research questions and objectives; and the scope and importance of the study as presented in the preceding subtopics. In conclusion, this chapter provides a foundation for studying the extension of the theory of storage to an underdeveloped market.

1.2 Background to the research problem

One of the key business activities performed globally is agriculture (Shanbhogue & Nayak, 2014). The agricultural sector employs a significant percentage of national populations, and sustains all the countries of the world (Pretty, Toulmin & Williams, 2011). This necessitates serious measures to ensure the sector fulfils its full developmental potential. At some stage, the products of the agricultural sector need to be stored for future use (Odegard & van der Voet, 2014). Storage is thus a key aspect of agricultural production because it impacts on food availability and marketing margin through markets (Kummu *et al*., 2012; Joseph, Irwin & Garcia, 2015).

Without good storage facilities, smallholder maize farmers experience huge grain losses that deny them food and income security. Equally, the resources consumed by the production process are lost (Sekumade & Akinleye, 2009). Although smallholder maize farmers desire effective storage processes in order to meet future cash and food needs, many nevertheless sell their maize

immediately after harvest, when prices are low. When they attempt to store their maize, it is affected by pests, rodents or rot, or may even be stolen – as a result of the inefficient traditional storage types used. Smallholder farmers thus need safe storage for both food and income security (Gitonga, De Groote & Tefera, 2015; Midega, Murage, Pittchar & Khan, 2016).

Maize is chosen for this study because of its dual function as both income and food, and because it is the most cultivated crop in Uganda [Uganda Census of Agriculture (UCA), 2008-09] as well as globally (Di Domenico, Christ, Hashimoto, Busso & Coelho, 2015). Although maize is perishable, it makes a significant contribution to the diets of both rural and urban populations (Baoua *et al*., 2014). Given this importance, effective storage for maize after harvest is often a key need (Jenkins & Leung, 2013).

Smallholder farmers in Uganda produce maize for both home consumption and sale (Atukwase, Kaaya & Muyanja, 2012). On average, they produce about two tonnes annually (*ibid*). Over eighty percent of Uganda's maize is produced by smallholders (Sserumaga *et al*., 2015). Despite storage playing a crucial role in production and sale, the majority of smallholder maize farmers still use traditional storage types (Thamaga-Chitja, Hendriks, Ortmann & Green, 2004), with limited efficiency (Adigal & Singh, 2015). Maize storage is a challenge to smallholder farmers (Shepherd, 2012; Sun *et al*., 2013; De Groote *et al*., 2013). This challenge negatively impacts on the proportion of the marketing margin realized by smallholder maize farmers and consequently impacts their food and income security. Storage challenges are further exacerbated by the fact that the traditional storage types used by the majority of smallholder maize farmers entail high storage costs (Mohammadi, Najafi & Mosavi, 2015). Consequently, the costs of storage (both losses during storage and direct financial costs) have a direct impact on the marketing margin because they can reduce farmers' bargaining power, selling price, and income. This underlines the importance of

studying the practices and perceptions of smallholder farmers, particularly in a context where current understanding of rural maize grain storage and its implications remains inadequate (Shepherd, 2012).

The study evaluates the theory of storage in the context of underdeveloped markets, and the theory of storage is pivotal within it, based on an observation made in Holbrook, Bourke & Fairbairn (2015) who argued that a theory is important in providing foundational underpinning for the study concepts. In Uganda (a developing country), over 80 percent of the rural poor depend on agriculture as a source of income. They need to store their produce in the transaction referred to as transitory storage (Xhoxhi, Pedersen, Lind & Yazar, 2014) for either sale or household use.

Storage is defined in this dissertation as the process by which products are kept for future use (Suleiman, Rosentrater & Bern, 2013). It is an interim and repeated phase as products transit from producers to consumers (Adetunji, 2007; Thamaga-Chitja *et al*., 2004). Thus it is a mechanism that can be used to manage periods of over-supply and to buffer against periods of under-supply. This offers the opportunity to develop a business framework around the concept (Smith, 2013). Smyth (1989) established three systems of storage: central, community and domestic. Central storage occurs at district or town headquarters, community storage occurs at village level, and domestic storage takes place at the individual private/household level. This study focused on domestic storage because this is the storage type most commonly used by smallholder farmers (Jenkins & Leung, 2013). It is their predominant buffer against either over- or under-production, and determines the marketing margin they can realize. Further, domestic storage is less studied, especially in the case of smallholder maize farmers (Park, 2006). Sun *et al*. (2013) argue that private storage is critical for smallholder farmers because it can ease consumption problems as well as price variations.

Although venerable, the theory of storage is still in use today (Kaldor 1939; Working 1948; Brennan 1958). Many scholars made significant contributions to the theory (and these will later be considered in detail), but did not assess it in the context of underdeveloped markets. In contrast to much of this previous work, the aim of this study is to extend the theory of storage to underdeveloped markets as a business application. Creswell (2009) emphasizes that a theory used in a study should be described and thus a description of the theory of storage, as applied in developed markets, follows.

Gorton, Hayashi, and Rouwenhorst (2012,p.2) advance two major assumptions of the theory of storage, namely: "Holders of inventories receive implicit benefits called convenience yield, and commodity producers and inventory holders hedge futures and spot price risk by taking short positions in futures market". According to Kaleta and Górnicki (2013), the theory of storage states that commodity price increases in times of low inventory and decreases when inventory is abundant. The theory further indicates that storage eases production deficiencies but is affected by the cost of storage which, in turn, affects its hedging function, consequently impacting on the marketing margin. Storage additionally assists in keeping inventories safe and maintaining continuous flow (Chalotra, 2013). The theory is premised on three aspects: the storage cost; the motive for stock holding on physical market; and the price discovery function of the futures market depending on the storage type(s) used.

Storage types have an effect on the speculative behavior of smallholder farmers (Fantacci, Marcuzzo, Rosselli & Sanfilippo, 2012). Smallholder maize farmers act in the belief that they are likely to benefit in future if they store their products; this is referred to as convenience yield (Gorton *et al*., 2012). Pfuderer (2014) argues that the theory predicts the likelihood of low prices

during harvest that will rise gradually until the next harvest season. Authors such as Jones, Alexander and Lowenberg-DeBoer (2011), Van Tonder and Van Rooyen (2012) and Sørensen (2002) argue that price seasonality is driven by commodity patterns, with the highest price being realised on the last month before harvesting.

Similarly, Botterud, Kristiansen and Ilic (2010) note that storage plays a crucial role in price formation which, in turn, bears on the share of the marketing margin realised by the maize holder. The aim of this study was to explore whether the theory of storage briefly sketched above can be extended to an underdeveloped market to uncover the storage behaviour of smallholder farmers in such a context. Maize farmers in Uganda were selected as the study population; they face severe storage challenges akin to those facing their peers in other developing countries. The individual smallholder maize farmer constituted the unit of analysis.

Onubuogu, Esiobu, Nwosu, and Okereke (2014) define smallholder farmers as "those farmers who produce on a small-scale, are not involved in commercial agriculture but produce for subsistence level, and cultivate less than five ha of land annually on average". In this study, farmers are defined as smallholders on the basis of the amount of maize produced: smallholders are those who cultivate less than two hectare and thus produce two tonnes or less annually. Andersson (2015) notes that the majority of smallholder maize farmers in Uganda (and particularly in the eastern region) cultivate on average one acre. Indeed, in sub-Saharan Africa (SSA) overall, 80 percent of smallholder farmers cultivate less than two ha (Harris & Orr, 2014).

1.2.1 Marketing margin

In business, a margin is the difference between two values or sums of money. Carambas (2005) views marketing margin as an equilibrium entity that is a function of the difference between equilibrium retail and farm prices. To Poudel (2013), the marketing margin is simply the difference between the farm gate price and retail price (P2 – P1), and for Wohlgenant (2001) it is a function of the difference between the farm gate price and the retail price of a given product.

More broadly, Smith (1992) defines marketing margin as the difference between the value of a product at one stage in the marketing process and its value at another stage. The concept of marketing margin may also be applied to an individual or company buying a product with the intention of reselling it. When companies buy a product in order to act as its distributor or retailer, they must attempt to sell it at a higher than initial purchase price. In this context, the marketing margin is the difference between what the company pays for the product and what it charges for it. Taking into account these nuances, for the purposes of this study the maize marketing margin is defined as the difference between the farm gate price (P1) and the final market price (P2) of the smallholder's maize grain before the grain is transformed into another product such as meal. Various actors along the maize marketing chain, including maize traders, attempt to increase their share of the marketing margin through value-adding or through activities such as extended storage, transportation and packaging. By contrast, smallholder maize farmers utilising poor and inefficient types of storage cannot wait for higher prices by storing their produce to sell later when prices increase. Thus smallholder farmers tend to sell their maize at low prices, and sometimes have to buy from the market at higher prices if the need arises.

This “sell low, buy high” practice, as described by Stephens and Barrett (2011), which exists among many smallholder maize farmers, carries embedded constraints. It not only reduces their income through selling low, but also denies them the opportunity to access enough food for their households. Park (2006) argues that improved private smallholder storage significantly helps smallholder maize farmers to keep their maize and wait to benefit from higher prices during the post-harvest period, and could thus help to address the challenges of “sell low, buy high”.

However, there are many different storage types. Thus identifying optimal storage practices for underdeveloped markets is a key need (Udoh, Cardwell & Ikotun, 2000). Because maize starts to deteriorate as soon as it is stored (Adetunji, 2007), it is difficult for smallholders to realize an increased share of the marketing margin with traditional storage types. Storage types and their impacts have not been studied in the context of underdeveloped markets. In the light of this problem, establishing the costs of different types of storage, and investigating the possibility of using storage strategies within a business framework to increase smallholder farmers’ share of the maize marketing margin merits investigation.

1.2.2 The context of the underdeveloped market

The context of the underdeveloped market can best be explained by describing the situation of market participants. Such markets are characterized by inadequate market information and poorly developed infrastructure, including stores, roads and markets. Because smallholder maize farmers lack market information and employ less effective traditional storage types, they are vulnerable to accepting poor marketing terms from traders. This reduces their ability to earn a higher share of

the marking margin (Xhoxhi *et al*., 2014). Thus storage may be considered as a strategy that can improve the terms of trade for smallholder maize farmers.

In developed markets where storage is efficient and scientifically regulated, perishable products may be stored for a longer time without deterioration, allowing an extended period for negotiating marketing terms. This is not the case in Africa, where maize is a major food for many people (Omotilewa Ricker-Gilbert, Shively & Ainembabazi, 2016; Jones *et al*. 2011; Mdangi *et al*. 2013; Hell, Cardwell, Setamou & Poehling, 2000) and for Ugandans in particular (Ranum, Peña-Rosas & Garcia-Casal, 2014). In Uganda, the contribution of maize to the economic wellbeing of the country's smallholder farmers needs to be understood from many perspectives; one is the storage options that Ugandan farmers can access.

Most smallholder farmers earn their income from selling their agricultural produce (Fafchamps & Hill, 2005). In this business context, smallholder farmers are faced with three options. Firstly, they may sell at farm gate price; secondly, they may transport their produce to a larger market where they can realize a higher margin; or thirdly they may invest in storage and wait for higher prices. The decision between these options is influenced by the cost of, and existence or absence of, storage, as well as by the cost and availability of transport (*ibid*).

Maize, as the most planted crop globally (Erenstein, Samaddar, Teufel & Bluemmel, 2011), demonstrably has the capacity to be stored for long periods of time (Smyth, 1989). Why this does not happen effectively in Uganda, and what storage options exist for smallholder farmers, is the subject of this study.

Everyone needs food to survive. This need motivates smallholder farmers to grow maize and other crops in the twin hopes of generating income and having enough food for their households. They also store and purchase maize for either consumption or trading. However, the storage challenges facing smallholder farmers in Uganda result in their enduring unfavourable consumption and maize price patterns throughout the year. Traders, by contrast, see maize demand surging during times of scarcity, presenting them with a business opportunity in the form of increased prices (Park, 2006).

The choice of storage types made by smallholder maize farmer depends on, among other factors, what is available, and what is affordable. Grains such as maize go through a number of processes before they are consumed or traded, of which storage is the first, starting at household/local or village level. If this initial grain storage is not properly managed, it can cause loss of stocks (Kaleta & Górnicki, 2013). However, storage itself can entail considerable capital costs, which can have significant negative effects on the farmers' share of the maize marketing margin – and hence on their income (Delgado, 1999).

Waithaka, Thornton, Herrero, and Shepherd (2006) have described how smallholding in SSA remains problematic, and maize storage is one component of the problem (Kadjo, Ricker-Gilbert, Alexander & Tahirou, 2013). Poor storage negatively affects the quality as well as the quantity of stored maize available for sale and, *ipso facto*, contributes to low prices. This in turn impacts negatively on smallholder maize farmers' ability to earn a higher share of the maize marketing margin and on their incomes, food security, livelihood and productive capacity. Uganda shares in all these SSA challenges.

Thamaga-Chitja *et al*. (2004) contend that effective storage is crucial for the continued supply of maize. Smallholders attempt to protect their maize from damage through their choice of storage types, but remain challenged by inadequate traditional storage types (Hell *et al.*, 2000).

Traditional storage is the predominant type used by smallholder maize farmers (Jenkins & Leung 2013; Thamaga-Chitja *et al*. 2004; Proctor, 1994). These traditional methods include granary, basket, crib, house roof, house corner, above-the-fire, clay pots, old jerry-can, tins and sacks. However, some smallholder maize farmers with more robust finances have adopted modern storage types such as metal silos, triple bags, modern cribs and warehouses. Shepherd (2012) demonstrated a clear correlation between a smallholder farmer's wealth and the use of improved storage.

In Uganda, maize is grown in four main regions: North, West, East and Central. The 2008/2009 Uganda National Agriculture Census (UNAC) provides information in relation to total regional production and the total area under maize production. It also shows differences in production by region. The eastern region is the highest producer and the North the lowest (Table 1). However, despite differing levels of maize production, the concept of maize storage is relevant for all the regions.

Table 1: Total area (Ha), total production (t) and production of maize per region

Region	**Area (Ha) (%)**	**Production (t) (%)**
Central	189,135 (18%)	449,859 (19%)
Eastern	388,762(38.3%)	1,108,554 (46.9%)
Northern	247,780 (24.4%)	305,798 (12.9%)
Western	188,583 (18.6%)	497,745 (21.1%)
Total	1,014,260(100%)	2,361,956(100%)

Source: Uganda Census of Agriculture 2008/2009

Storing for a longer time may benefit smallholder farmers, but that storage must be effective. For Ugandan smallholders, effective storage facilities are either unavailable, inadequate, or poorly developed (Abass *et al*. 2014). Potentially, smallholder maize farmers who adopt improved storage facilities would be able to take advantage of the better marketing margin that could be earned after longer storage

The inefficiency of smallholder maize farmers' storage facilities forces them to do two things. First, they sell their produce immediately after harvest, and usually at farm gate prices. Second, if they run out of maize before the next harvest (which is normally the case) they have to purchase maize from village traders or market to feed their families – by which time maize prices have risen (Stephens & Barrett, 2011). Botterud *et al*. (2010) argue that storage plays a crucial role in price determination, which, in turn, has a bearing on marketing margin share. However, the poor storage types reported in the tropics have continued to lower marketing margins, especially among smallholder maize farmers (Wambugu, Mathenge, Auma & Van Rheenen 2009), and that is the key concern of this study.

Some previous studies have investigated the theory of storage in agricultural products (Fama & French 1987; Brennan1958; Working 1949). However, whether the findings of these studies are applicable to smallholder maize farmers operating without efficient storage, particularly in underdeveloped markets with poorly developed infrastructure, merits further investigation.

1.3 Problem statement

A number of the constraining factors confronting agricultural development at smallholder maize farmers' level in underdeveloped markets relate to their lack of appropriate storage facilities. This has led to high losses in both grain and in the resources invested in producing it, and has denied smallholder maize farmers in underdeveloped markets the opportunity to be food and income secure. Smallholder maize farmers have been identified as crucial partners in contributing significantly to the income of many developing countries (Smale, Byerlee & Jayne, 2011). Yet underdeveloped storage facilities impact negatively on the whole maize business framework within which this population group operates, denying them the ability to demand better prices and leading to their realizing a low share of marketing margins. They are deprived of a potentially higher share of the maize marketing margin because of the costs associated with inadequate storage: both direct financial costs and the costs of grain-stock loss (Kaminski & Christiaensen, 2014). Smallholder maize farmers are in a poor bargaining position (Armah & Asante, 2006) because they cannot store their maize and wait for the higher prices that usually emerge in the period between one month after harvest and the next harvest season (Atukwase *et al*., 2012). One aspect of this is that when there is a glut at harvest, the smallholders' need to sell immediately realizes an extremely low price and a reduced share of the harvest-period marketing margin. Yet as Shepherd (2012) observes, the majority of smallholder maize farmers cannot access safe storage to hold on to the maize for longer. For many decades, smallholder farmers globally have faced storage challenges, which have continued to contribute to a low marketing margin share, and consequent low incomes (Jones *et al*., 2011). Thus the majority (67 percent) of smallholder farmers have remained proportionately poor especially in developing (low and lower-middle income) countries (Shiferaw, Prasanna, Hellin&Bänziger, 2011). This creates a vicious cycle since

effective storage is correlated to smallholder maize farmers' wealth (Shepherd, 2012), the majority of them cannot afford modern (considered to be cost-effective and efficient) storage facilities. The cost of storage is an important determinant of farmers' decisions about which type of storage to use and how long to store their maize (Mdangi *et al*., 2013) and in the absence of financial resources such smallholder farmers are forced to continue using traditional storage types.

Despite the existence of various studies on storage types, there is an extreme paucity of work investigating how storage types influence the share of the maize marketing margin realized by smallholder maize farmers in underdeveloped markets, and nothing on this topic in Uganda.

This explored the extension of the theory of storage to an underdeveloped market and to the possibility of using storage in a business framework to enable smallholder farmers to increase their share of the marketing margin. In addition, the study identifies the different storage types available to and used by smallholder maize farmers and the costs associated with each, to discover the best options that can be recommended to them.

1.4 Purpose statement

The aim of this study was twofold. First, to examine the role of storage options in influencing smallholder maize farmers' marketing margin, and to explore the farmers' own perceptions of storage as a business strategy to increase their share of the maize marketing margin. Secondly, to evaluate extending the theory of storage to underdeveloped markets, using the case of Uganda.

Kirimi *et al*. (2011) argue that, because of limited household storage, smallholder farmers sell off their maize immediately after harvest. However, little is known about how this "sell low, buy high" practice described by Stephens and Barrett (2011), affects smallholder maize farmers' share of the

marketing margin realized. This study was necessary because it is essential to understand how the theory underlying storage – used successfully in efficient markets (Fama & French, 1987) – can be applied in the context of underdeveloped markets characterised by poor market information and poor storage infrastructure. The theory's observable characteristics in the commodity markets of Uganda are described in relation to their context. Applying the theory to an underdeveloped market – a context where it was not developed and has not been applied before – makes a significant contribution to knowledge.

1.5 Research questions

The study was guided by the following research questions (RQ);

RQ1: Can the theory of storage be extended to underdeveloped maize markets of smallholder maize farmers in Uganda?

RQ2: Can the storage types of smallholder maize farmers in Uganda be identified and characterized? If so, do these characteristics affect choice of storage and the maize marketing margin realized by the smallholder farmers?

RQ3: What are the costs (quantity, quality and financial) associated with the identified storage types? Do the associated costs affect the share of the maize marketing margin realized by smallholder farmers in Uganda?

RQ4: What is the effect of household characteristics on the choice of maize storage types and length of storage?

RQ5: What are the experiences and perceptions of smallholder maize farmers in adopting and using a storage business framework to increase their share of maize marketing margin?

1.6 Objectives of the study

The objectives (OB) of the study were to:

OB1: Develop a framework for an extended theory of storage applicable to the underdeveloped markets in which smallholder maize farmers in Uganda participate;

OB2: Identify and characterize the storage types used by smallholder maize farmers in Uganda;

QB3: Assess the costs associated with the identified storage types;

QB4: Assess the effect of farmers' household characteristics on choice of maize storage types and storage length; and

OB5: Explore smallholder farmers' experiences and perceptions on developing maize storage business framework to increase their share of the marketing margin.

1.7 Motivation of the study

This study was motivated by a desire to understand the maize storage types used and how they could be optimized to enable smallholder maize farmers to increase their incomes by focusing on increasing their share of the marketing margin. An additional and extremely important motivation was to analyse what contribution the type of storage employed made to household food and income security; food insecurity is pervasive in sub-Saharan Africa and all dimensions of remediation demand intensive study.

1.8 Scope of the study

The study was conducted in Uganda where over 80% of the population depends on agriculture for a livelihood (Ronner & Giller, 2013). Specifically, it was carried out in the Eastern Region, because out of the four administrative regions producing maize in Uganda, the eastern is the

highest maize producer (Uganda National Agriculture Census, 2008/2009), and also the region most accessible to the researcher. Smallholder maize farmers' household characteristics were studied to understand how they impact on the share of marketing margin through storage types used. Different storage types were examined to discover the costs associated with each type. In addition, smallholder farmers' perceptions of a maize storage business framework were elicited.

The research centred on the theory of storage and how it affects smallholder maize farmers' share of the marketing margin in an underdeveloped market. Although multiple variables fall within the ambit of this theory, this research took as key variables in assessing the relationship between storage types and marketing margin the cost of storage, spot and future prices, and storage types. A mixed method was employed to provide the flexibility required in examining an underdeveloped market. In this study triangulation – mixing approaches to obtain two or more view points on a phenomenon being studied (Olsen, 2004) – was employed. This approach is often used when one method is inadequate for studying a given phenomenon (Fielding, 2012). In this study one method was not appropriate in studying both the costs associated with storage and the perceptions of farmers about the storage as a business strategy.

1.9 Definitions of key concepts

Cost of storage – in the context of this study, this term is used to cover both the cost of putting up a storage facility (physical cost) and the cost arising from any storage-related loss of stored crops (Omobowale, Mijinyawa, Armstrong, Igbeka & Maghirang, 2015).

Framework –a sketch or conceptual structure that serves as guide or support to build something capable of expanding into something with greater utility (Bocken, Short, Rana & Evans, 2014). In

this study, the framework developed will guide future researchers in building a storage business model.

Marketing margin – this study employs the definition suggested by Smith (1992) as the difference between the value of a product at one stage in the marketing process and the value at another stage, detailed by Proudel (2013) to signify the difference between the producer's price and the consumer's price.

Safety – in this study the quality offered by a store capable of keeping the grain without deteriorating in quality and quantity resulting from damage caused by pest (Thamaga-Chitja *et al*., 2004).

Storage types – the different methods, processes and facilities smallholder farmers use to keep their maize grain for future consumption or sale (Di Domenico, Christ, Hashimoto, Busso & Coelho, 2015).

Underdeveloped market – a market characterized by low trading volumes; inadequate market information; few buyers and sellers; lack of adequate demand; poor infrastructure development; absence of standards and grading systems; absence of market power; limited government support; lack of proper relationships or connections between markets; mass poverty and illiteracy; low industrialization; and limited technological skills (Fortenbery, 2004).

1.10 Importance and benefits of the proposed study

This study makes two major contributions. First, the findings augment the existing literature regarding the theory of storage in an underdeveloped market environment such as that of Uganda. By evaluating the theory of storage in an underdeveloped market and also finding out how storage

types influence smallholder farmers' share of the maize marketing margin, the study plugs a gap in existing literature.

The theory of storage has been evaluated by many theorists but primarily in developed markets and mainly relating to the stock exchange and metals (Kaldor 1939; Brennan 1958; Telser 1958; Geman & Smith 2013; Cifarelli & Paesani 2012; Geman & Tunaru 2013; Brooks, Prokopczuk & Wu 2013). Kaldor (1939) introduced convenience yield to the theory of storage, Brennan (1958) used the theory to estimate and draw the supply curve of storage, Cifarelli and Paesani (2012) argue that the theory of storage enables stockholding which provides productive value. Authors such as Telster (1958), Fama and French (1987), Symeonidis, Prokopczuk, Brooks and Lazar (2012) and Geman and Smith (2013) identify other issues related to storage such as price volatility, spread, and supply curve. In this study, the theory of storage was employed as a starting-point because the authors above provide a strong foundation for extending the theory of storage to other areas (because few theorists explicitly focus on their theory boundary limitations (Whetten, 1989)). None of them, however, has assessed the theory in underdeveloped markets or for perishable goods.

Second, the study provides evidence-based findings that can contribute to policy debate and policy formulation regarding storage and the maize marketing margin in Uganda. Adigal and Singh (2015) argue that agriculture is the life-blood of rural development and that storage is a function of economic development. Thus it is essential to understand the role of storage in determining the prices of agricultural products. This study contributes to the debate on how to increase the prices realized by smallholder maize farmers, who have the capacity to be motors of economic transformation in an underdeveloped market (Harris & Orr 2014; Collier & Dercon 2014).

Understanding the effects of storage at the household level can provide information useful in designing strategies to reduce storage challenges and thereby strengthen food and income security for smallholder farmers. If improving storage can, as the study posits, be an effective strategy for enhancing smallholder farmers' income from the maize crop, this reduction in insecurity could stimulate development. Collier and Dercon (2014) have argued that strategies targeting the income of smallholder farmers have a far more significant effect than other strategies in stimulating economic growth.

Storage challenges are ubiquitous among smallholder maize farmers in developing countries. Studying the theory of storage in relation to Ugandan smallholder maize farmers' characteristics and storage types, and its implications for these farmers' marketing margin extends the theory in ways that potentially have relevance for multiple underdeveloped markets.

Furthermore, in the context of underdeveloped markets most smallholder maize farmers use traditional storage types which hardly offer enough protection to the maize stored. More so, the maize crop is perishable thus, implying that if it is to be preserved then safe storage is necessary. However, smallholder maize farmers have experienced storage challenges for long and yet they continue to grow maize and store it in the available traditional storage types.

As has been noted, previous storage studies have focused on developed markets and standardized storage approaches. In addition to extending the theory to an underdeveloped market (specifically, Ugandan smallholder maize farmers), this study also considers a range of traditional, differentiated storage types, laying the foundations for further theoretical development related to storage type. Most smallholder maize farmers have relied on traditional storage types inadequate for a perishable crop for a long time, despite the storage challenges these types pose.

This study will thus aid both policy-makers and practitioners. It provides evidence for food and agriculture policy-makers in decision-making on the storage of agricultural products, with a view to improving low household incomes and possibly alleviating poverty and food insecurity among smallholder maize farmers. The findings have the potential to enrich the Government of Uganda's (GoU) existing policy on agricultural modernization. The findings also contribute to privatization and trade policy discussions, which affect many smallholder maize farmers in Africa as a result of structural adjustment programs (Poole, Chitundu & Msoni, 2013). For these reasons, the findings can serve as an input for evidence-based policy dialogue at regional and country levels.

In addition, for practitioners – who need improved storage approaches to protect themselves against income shocks through hedging price changes in the marketplace – the findings provide knowledge about how the "rush to sell" weakens their bargaining power, makes them vulnerable to low prices and consequently reduced incomes and aggravated household poverty.

Some studies acknowledge that agricultural products are more difficult to store due to their perishable and seasonal nature (Symeonidis *et al*., 2012). This is particularly relevant for developing countries, and warrants a more thorough investigation in situations where markets are underdeveloped and storage types are poor. It clearly helps practitioners to have information about how the nature of their products and the storage types they employ can influence the marketing margin. This is particularly so if the study goes beyond the different storage types used and their impact on smallholder maize farmers' share of the marketing margin to explore the option of using storage as a business strategy to increase their share of the marketing margin, as this study does.

In this study, the theory of storage is used to explain how storage types can be useful in understanding smallholder maize farmers' storage practices and their effect on marketing margin

share (Smith, 2013). The negative relationship between storage types and marketing margin continues to challenge Ugandan agriculture. To assist smallholder maize farmers in benefitting from seasonal price changes, it was necessary to undertake empirical investigation.

To sum up, among all the studies reviewed so far on storage and marketing margin, no single study has explored how the theory of storage relates to smallholder maize farmers' share of the marketing margin in underdeveloped markets, nor whether the theory can be used to develop a business framework for smallholder maize farmers. This study explored all these aspects.

1.11 Organization of the thesis

The thesis is organized into seven chapters. Chapter One above has introduced the study and provided a brief overview of the context of the theory of storage. It also covers the statement of the problem, research questions and objectives, the purpose and motivation of the study, and the research and policy contributions of the study. Chapter Two discusses the relevant literature on storage types and marketing margin in greater detail. The key issues covered include the theory of storage, the meanings of spot and future prices, the cost of storage, and the debates on the theory raised by the work of different scholars. Chapter Three describes the methodology employed in carrying out the study, considering aspects such as research philosophy and research design, the identification of the survey sample and size, details of the sampling procedure, the methods by which the data were collected, and analyzed. Chapter Four provides both a quantitative and a descriptive analysis of the data yielded by the study. Chapter Five sets out the qualitative findings on storage types and costs of storage, storage decisions and marketing margin as well as information about smallholder maize farmers' perceptions of the maize storage business

framework. Guidelines and a framework for the extension of the theory are presented in Chapter Six, while conclusions, recommendations, and areas for future study are set out in Chapter Seven.

CHAPTER TWO: Literature review and conceptual model

2. Introduction to literature review

This chapter presents a concise explanation of the theory of storage and its implications for smallholder maize farmers in developing countries. The argument of this research is that smallholder maize farmers would benefit from storing maize more efficiently because it could then be sold later at a higher price and used as input in reproduction, or for meeting unexpected future demand (Stronzik, Rammerstorfer & Neumann, 2009). This chapter traces the theory of storage from its introduction in business studies in the 1930s through its evolution to its current usage. The chapter also discusses justifications for the theory, and elaborates on its role and rationale. Thereafter, the chapter provides a brief narrative on scholarship concerning storage practices in Africa in order to provide a comparative view of what happens elsewhere on the African continent and in Uganda. It also discusses the characteristics of the maize market and the implications of the flow of the commodity from production to market. The chapter concludes by discussing the interrelationships between storage types, costs and marketing margin, and how previous scholarship has assisted in aligning the underlying conceptual model with the research questions and objectives of study.

2.1 The theory of storage

To have a clear understanding of the theory of storage, it is prudent to trace its earlier applications, with a view to seeing how it can be applied to underdeveloped markets. Kaldor (1939) was the first to use the theory of storage in the business perspective by applying it to explain the speculative behavour of merchants. Kaldor (1939) contends that the theory explains how storage moderates

the spread between spot and futures prices as determined by fundamental supply and demand conditions. In this perspective, the theory is related to storage cost, inventory levels and convenience yield, which all depend on the nature of storage. Kaldor (1939) argues that speculators purchase and store products to benefit from changes in price that affect the marketing margins. They buy whenever there is a temporary excess of supply over demand, thereby influencing the price and fall in marketing margin. The same speculators step in as sellers whenever there is a temporary shortage of supply, thereby both moderating price surges and also getting better marketing margins than if they had sold at the time of storage (*ibid*).

Working (1948a, 1949b) introduced the concept of price relation to the theory of storage to explain the prices applicable to different time periods. The fact that prices differ when conditions of plenty or scarcity prevail encourages those who hold stocks to store them and wait for the better price associated with high marketing margins; spot and futures prices are the prices of the same commodity at different time periods. However, the smallholder farmer must be able to store maize effectively to benefit from these price variations. Working made the important prediction that in times of scarcity spot price will exceed futures price; only those capable of effective storage can benefit from the price relations prevailing at different times.

Geman and Smith (2013) suggest that the relationship existing between marketing margin and storage for storable commodities can best be explained by the theory of storage. Nielsen and Schwartz (2004) additionally note that one important benefit of holding stock/inventory is the ability to respond quickly and profitably to demand and supply shocks, but that the decision to hold stock also depends on the current level of maize held and safety of the store. Geman and

Tunaru (2013) contend that it is profitable to hold stock because any shock in supply will mean a shortage of the commodity in the market. This shortage can benefit any smallholder maize farmers who hold stock, offering the opportunity to sell their grain at a higher price in future, thereby obtaining a higher marketing margin. All these discussions nuance the key relationship between storage options, storage decisions and marketing margin that this current study investigates.

Telser (1958) applied the theory of storage to seasonal commodities produced by farmers and concluded that stockholding can be used to predict smallholder farmers' behaviour in relation to future marketing margins. Hence, the stock held at a particular time period was determined by desired margin and price changes from that period to the next time period. Telser (1958), writing about cotton and wheat, used the theory earlier postulated by Keynes and Hicks (1930) to conclude that future price and expected spot price regarded hedgers as buyers of insurance (since they would expect gains in future) and speculators as risk-takers on price changes; Keynes regarded future price as a function of the cost of storage.

Thus Telser (1958) argues that future price equals the expected spot price and its impact on expected margins. He contends that farms hold stock for two pertinent reasons; future price and expected price change. These are both dependent on storage, among other factors. Telser (1958) was tackling questions important for his era: how the risk of holding stock could be matched with the amount of stock held, and how this could influence the marketing margin. From this perspective, stock is held with the intention of future use and those who may want to consume it in the current period must pay a high spot price. However, this happens only if the supply is scarce. Telser (1958) work thus also underlined the importance of storage.

Brennan (1958) postulates that because consumption and supply vary – and frequently are not equal or even similar in any given period – every commodity requires storage. However, the need for storage is intensified when commodities are seasonal, as is the case with agricultural commodities such as the maize, which is the subject of this research. The amount held in store depends on the cost of the commodity stored and the expected marketing margin, while compensation for the stock held is calculated and deducted from the cost of holding an inventory (*ibid*). Gorton *et al* (2012) make the additional observation that offsetting the gain expected in holding stock, a premium risk (referred to as unexpected loss on inventory) is always attached. This pushes smallholder maize farmers who have storage facilities to bear the risk in anticipation of higher marketing margins (Symeonidis *et al.,* 2012). However, because the traditional storage types such farmers predominantly use do not guarantee safety, this acts as a disincentive against waiting for the price changes that will potentially bring a higher share of future marketing margins. Thus Onubuogu *et al*. (2014) contend that their inefficient and inadequate storage resources increase the vulnerability of smallholder maize farmers to multiple risks, including unethical trading practices as well as price and income risk.

The traditional theory of storage as presented by Kaldor (1939), Working (1948), and Brennan (1958) entails the assumption that a holder of stock (such as maize) receives a benefit called the "convenience yield", which declines as stock increases (Cifarelli & Paesani, 2012). When there is a glut of maize, convenience yield is small, thus futures price tends to exceed spot price, which encourages storage (*ibid*).

This assumption is in line with the "Samuelson effect" (1965): that the volatility of the spot price is higher than the volatility of the futures prices (Samuelson, 1965; Perales, 2010). However, such an assumption holds only if the storage method can effectively safeguard the maize crop against damage (against, for example, insects, rats, mould or rot).

The concept of the convenience yield – the productive value that makes it possible to meet unexpected demand – illuminates the benefits of holding physical stocks of maize. However, the convenience yield is affected by the cost of storage. It additionally depends on the level of stock held, and spot and future prices (Kimenju & De Groote, 2010) as well as on the cost of holding stock – which has to be low. The theory also assumes that the difference between futures and spot prices mirrors the carrying cost net of convenience cost.

These conditions are far less likely to hold for smallholder maize farmers in developing markets employing traditional storage types. Most smallholder maize farmers employ storage types incapable of guaranteeing the integrity and security of large stocks. For them, the conventional argument that holding large stocks lowers the costs of storage and increases storage returns (Working, 1949) is highly moot, emphasising the need for the type of research this study undertakes, which interrogates the role played by storage in such farmers' stock-holding practices.

The theory of storage further describes the characteristics observed in commodity markets where soft products are sold (Brooks *et al*., 2013). Soft products need to be stored effectively for future use because of their perishable nature, and the ways their prices can change in different economic circumstances. Such price changes impact on smallholders' share of the marketing margin. The

storage type used determines the safety and quality of the maize (Kaleta & Górnicki, 2013). When maize quality is compromised, this is expressed as a cost of storage and it impacts on smallholders' share of the marketing margin through price (Geman & Smith, 2013).

Thus while much of the earlier development of the theory of storage took place in relation to developed markets, stock exchanges and hard commodities (Kaldor 1939; Brennan 1958; Telser 1958; Geman & Smith 2013; Cifarelli & Paesani 2012; Geman & Tunaru 2013; Brooks, Prokopczuk & Wu 2013), new issues meriting scholarly investigation are emerging in relation to different contexts. What may be valid for efficient markets with proper storage capable of protecting maize from damage by pests and other environmental causes of loss to ensure domestic maize supply (Govender, Aveling & Kritzinger, 2008), may not hold for underdeveloped markets where storage types are predominantly traditional.

Additionally, in such markets, market information is difficult to access. Svensson and Yanagizawa (2009) note that although market information is relevant in bargaining for higher prices at the farm gate, it remains inadequate in underdeveloped markets. Magesa, Michael and Ko (2014) posit that poor market information is among the causes of smallholder farmers' exploitation by greedy traders.

Thus for smallholder maize farmers operating in underdeveloped markets to benefit from the contributions of Geman and Tunaru (2013), Geman and Smith (2013), and Nielsen and Schwartz (2004), their storage types need to be able to provide enough safety to reduce the cost of storage and lead to an increased marketing margin. However, De Groote *et al.* (2013) point out that the traditional storage types used by smallholder maize farmers fail to offer safe storage.

These inadequate storage types and absence of storage management technologies and on-farm storage are considered to be among the main causes of grain loss in SSA (Gitonga, De Groote, Kassie & Tefera, 2013). The role of storage is to retain and protect the product until it is required (Smith, 1992). When inadequate storage leads to grain loss, this compromises smallholder farmers' ability to earn better margins in future through price fluctuations. Reducing post-harvest losses through proper grain management practices will enable smallholder farmers to bargain for a better share of the marketing margin, and hence increase their incomes.

In this regard, dealing with the scarcity of safe on-farm maize storage among smallholder farmers in underdeveloped markets is crucial for income and poverty alleviation (George, 2011). Limited to traditional storage types, smallholder farmers tend to sell off their maize immediately after harvest. They aim to avoid storage losses but garner only low prices. However, if they choose to hold on to their maize stocks, insecure storage has an impact on the quality and quantity of maize. Bern, Yakubu, Brumm and Rosentrater (2013) posit that without proper maize grain storage, grain loss among smallholder farmers is likely to be very high. Smallholders' stored maize becomes uncompetitive in the market due to poor storage (Kaleta & Górnicki, 2013).

Further, storage is considered an important element in promoting the maize crop, because it regulates price volatility – a factor directly related to income (Nkonya, 2002). Storage is important in stabilizing prices. When demand is low, the maize can be kept, which reduces the supply in the market. When demand is high, the stored inventory can be released to the market to stabilize any surge in prices. However, using traditional storage types such as granaries, cribs, sacks, and baskets, limits the capacity of smallholder maize farmers to store for long periods, because storage comes with high costs in terms of loss in quality and quantity. Traditional storage types offer

inadequate protection, making the grain susceptible to deterioration **(**Dubale, Solomon, Geremew, Sethumadhava & Waktole, 2014). Thus the costs associated with storage adversely affect smallholder maize farmers' share of the marketing margin.

Sørensen (2002) applied the theory of storage in modelling seasonality in agricultural commodity futures, and building on this work Joseph *et al*. (2015) noted that storage plays a significant role in seasonal products by providing the option to carry excess supply over to future sales periods. This is consonant with Working's (1948) argument that the theory of storage provides a vivid explanation for the differences between spot and futures prices in physical inventories. Such inventories face the challenge of the costs incurred in storage; such costs impact on the income of the holder of the inventory. Inventory is kept to meet rigidities where consumption and supply is in an inelastic function of price (Bown, Ortmann & Darroch, 1999). The advantage of an inventory is that it creates convenience yield, important in creating temporary profitability. In times of scarcity prices surge but storage can be instrumental in maintaining supply and assuaging high demand by using the maize grain stored at a time of glut. However in the context of smallholder maize farmers employing inefficient traditional storage types, convenience yield may be impossible to realize as the cost of storage may out-weigh the benefit derived from storing such a perishable commodity. This is evidenced in the "sell low buy high" example articulated by Stephens & Barrett (2011).

The seasonality of maize helps to explain smallholder farmers' behaviour in relation to their storage types and prices. The seasonal maize harvest pattern gives them two peak periods of decision-making between harvesting and planting. Production in some countries occurs only twice a year, whereas consumption continues throughout the year. Gitonga *et al*. (2013) note that the

seasonality of maize requires storage to bridge the gap between seasons and circumvent price fluctuations, which are evened-out by stored inventory (Kimenju & De Groote, 2010). The potential to draw supply from storage in times of no harvest thus influences maize sales and storage decisions (Innes, 1993). In this context, however, it is again important to note that the types of traditional storage widely used by African smallholder farmers offer inadequate protection against grain losses and consequent increased storage costs (George, 2011; Smith, 1992).

Yet smallholder farmers in many SSA countries continue to use these storage types. Previous research (Omobowale *et al*., 2015) suggests that one reason for this is limited resources (fixed cost of storage), which can deter the construction of good storage facilities. The fixed costs of storage are normally incurred regardless of whether the store is being used or not, and hence it contributes to a large proportion of total costs in commercial grain operations (Suleiman & Rosentrater, 2014). Fama and French (1987) argue that the cost of storage is crucial in determining the magnitude of seasonal variation in spot and futures prices. They note that perishable products attract high storage costs and that these high costs means larger expected spot-price changes to motivate storage between harvest seasons. Building on this scholarship, this research explores in more detail Ugandan smallholders' motivations and business model perceptions in retaining traditional storage approaches.

All the constraints identified above have made smallholder maize farmers unable to participate in big markets within the country. Consequently, they sell their maize at the farm gate for a low price, thereby reducing their share of the marketing margin. This scenario has maintained a maize poverty cycle in eastern Africa (FAO, 2014). Kadjo *et al*. (2013) contend that the literature on

grain storage emphasizes inter-temporal price decisions made because of the prevailing situation faced by the farmer.

Commodity markets have their greatest liquidity in the future, which implies commodities need to be stored for future markets (Geman & Smith, 2013). This accords with the concept of convenience yield advanced by Gorton *et al*. (2012), who noted that it depends on the cost of storage predicted at the point when smallholder farmers decide to store. However, as the work of Omobowale *et al.* (2015) above indicates, the costs of different storage types continue to challenge smallholder farmers. Their decision to sell maize grain on-the-spot or in the future is influenced by a number of factors such as prevailing income, cost of storage, and quantity harvested. It is therefore crucial for smallholder maize farmers to know which storage type is likely to support higher returns for their transactions, one element of the practitioner-relevant information this research seeks to develop.

Hernandez and Torero (2010) focus on one of the factors that influence the farmer's decision to sell: price. They identify spot and future prices as the two types of prices critical to smallholder maize farmers' decision to sell: when spot price is low smallholders may wish to store and sell in future. Spot price is the price paid or received when the commodity (maize) is sold immediately after harvest. Futures price is the price whose realization smallholder farmers anticipate when they sell maize in future (IFPRI, 2010). Lee and Zeng (2011) argue that real decision to sell depends on the current state of the market and the advantages the smallholder maize farmer can access, including the ability to store safely in the event that the current price is low.

This consideration of price points towards the business models smallholder maize farmers may hold as their basis for decision-making. Kotler, Burton, Deans, Brown and Armstrong (2012) observe that price is among the constructs smallholder maize farmers use to bargain for an increased share of the marketing margin. This implies that smallholder maize farmers use price to speculate on their income. If they are to bargain for higher prices they have to be able to store the maize they produce. Further, the decision to store attracts its own costs: the risk taken by smallholder famers when they store their maize for consumption or in order to wait for better prices in the future.

Lai, Myers and Hanson (2003) argue that the degree of risk-averseness of farmers is another factor in their sell/store decisions: more risk-averse famers sell more grain at harvest time, even if this reduces potential income. However, this work was conducted in Michigan, where farmers have access to secure storage types. Perceptions of exposure to risk are likely to be very different in the absence of such facilities; hence one focus of this research is on Ugandan smallholder maize farmers' perceptions.

2.2 Grain storage practices in Africa

In all parts of the world, grain storage is critical in ensuring food supply for both domestic use and sale (Tefera *et al*., 2011; Omobowale *et al*., 2015; George, 2011). Yet many countries in Africa still suffer from food insecurity. In South Africa, for example, despite the adequacy of food supply, approximately 3 percent of the population suffers from food insecurity (Thamaga-Chitja *et al*., 2004). One fundamental reason for food insecurity is lack of adequate storage which is not exceptional to Uganda, and a foundation of the study. In fact, Omotilewa *et al. (*2016) argue that

the relationships between post-harvest grain management practices, storability concerns, and adoption of improved seed varieties in SSA remains poorly understood.

Despite the significant progress made in food storage methods internationally, many African countries still rely on traditional storage methods for food, fodder and seed (Shepherd 2012). Many different types of grain storage systems are employed at farm level in Africa (*ibid*). In many countries, storage of shelled maize in jute sacks in farmers' houses is the predominant mode of holding grain for both domestic consumption and for later sale. However, little is known about the impact of such storage on household incomes and food security in Uganda. Such commonly used traditional storage types can result in heavy postharvest losses. This exacerbates the need to "… improve smallholder rain-fed maize production in a sustainable manner is important … as maize is a staple food. Smallholder maize production is often characterized by low yields, which are often significantly lower than the potential of the land" (Walker & Schulze, 2006).

The variables impacting on the storage of crops such as maize include the length of storage, losses during storage – including deterioration in quality – and the volume of storage. None of these have been fully interrogated in the Ugandan context. One detailed study of storage practices in KwaZulu Natal in South Africa, (Thamaga-Chitja *et al.* 2004*);* provides insight into farmers' options and choices there. For example, although some smallholder maize farmers use a combination of storage methods, the traditional granary (known as *inqolobane*) is the predominant storage method it is used by 52 percent of sample households (*ibid*). *Inqolobane* is widely used because it is comparatively cheap to construct and maintain, and easily accessible to the sample respondents. Forty-two sample households (31 percent of the sample) used commercially available corrugated

iron tanks to store maize grain (*ibid*). These researchers demonstrate that maize losses during storage using iron tanks are far lower than those for traditional methods (*ibid*). Across the developing world, about 50 - 60 percent of maize grain is stored in traditional structures (Kumar & Kalita, 2017).

The KwaZulu Natal study (Thamaga-Chitja *et al., op. cit.)* describes how re-used maize meal sacks (polythene, polypropylene and cotton) are also used to store maize on the cob by 31 percent of sample households. These sacks are either stacked on the floor in an upright position or stacked on top of one another in the kitchen area or an empty room. The researchers (*ibid.*) additionally found that 70 percent of sample households stored maize by hanging cobs from the roof over the cooking area or open wood fire. This process enabled fumigation by smoke, thus preventing insect damage. However, roof storage was predominantly used for storing smaller quantities of maize seed. Farmers or households that did not practice this storage method were obliged to purchase seed every year. In Uganda, as in many other African countries, these storage types are used. However their impact on the maize marketing margin of smallholder farmers is not known.

Thamaga-Chitja *et al.* (2004) determined the efficiency of storage systems by employing two factors; storage length and incurred losses. Their finding was that of the maize storage methods used by sample households, all were inefficient except for metal tanks. Yet despite the high incidence of maize losses during storage, the majority of the sample households used the popular *inqolobane.* The researchers note that although storage periods ranged from 3 to 24 months, the average range was between 5.6 to 6.6 months. These findings on efficiency provide one foundation for studying the efficiency of storage types in the Ugandan context.

Despite its inefficiency, *inqolobane* storage was used by both relatively wealthier and poorer households to store maize. This was mainly because it is accessible, flexible in size and affordable. The amount of land used for cultivation, however, was significantly related to the use of metal tanks and *inqolobane*: households with larger harvests diversify their storage practices to avert losses and balance the risks of loss. Although effective storage is crucial for smallholder farmers' income and food security majority still grapple with storage challenges (George, 2011).

Against this kind of background, attempts by government ministries and development partners to introduce innovative approaches to grain storage in Africa have had mixed success. Shepherd (2012:150) observes that "… the promotion of improvements to traditional stores has generally been more successful than the development of new; and more expensive, structures. In some countries, farmers have consistently resisted innovations in storage, usually for sound economic reasons…" His work indicated that smallholder farmers will accept innovation if it originates from their communities, rather than being perceived as both innovative and 'foreign'. For example in Cameroon, Zambia, Burundi and Benin farmers resisted improved storage, such as the unpopular cribs made of wood and chicken-wire mesh introduced by donors to Benin (*ibid*).

Like Thamaga-Chitja *et al. (*2004), Shepherd (*ibid*) further notes that there appears to be a correlation between the wealth of farmers and the use of improved stores. He cites various countries: in Tanzania, metal bins are used more by larger farmers than by smaller farmers, in northern KwaZulu Natal in South Africa, wealthier households are more likely to use metal tanks than poorer ones; in Ghana, wealthy farmers are able to construct improved drying cribs. Farmers seem prepared to tolerate quite high losses before they undertake complex or expensive changes to their storage systems. This is why in Ghana traditional storage has been developed to meet both the climatic and social needs of farmers, mainly because it is relatively inexpensive (*ibid*).

In Malawi, it has been difficult for farmers to accept the idea of metal bins. The main reason is concern about theft, because the padlocks on the silos can easily be broken. Thus they prefer to store their maize inside their homes. Where the bins are used by some farmers, these farmers rely on extension officers to fumigate the stores because they lack extension advice on doing it themselves (Shepherd, 2012; Zuma-Netshiukhwi & Stigter, 2016).

The construction of village stores offers another avenue through which improved grain storage has been adopted in Africa. However, either the village stores are unused or not used for their intended purpose. This implies that the farmers do not understand the value of such stores, either in terms of their functionality or role within the supply chain (Zuma-Netshiukhwi & Stigter, 2016)

Yet in the 1970s and 1980s, international donors active in SSA constructed storage facilities for primary cooperative societies. These could have offered considerable benefit to farmers. In Tanzania, for example, a thousand stores, each with a capacity of 300 tonnes, were constructed in the 1980s for use by societies to hold surplus production prior to marketing. However, because of mistrust of the cooperatives, farmers decided to store their maize at home (Shepherd, 2012). In Sierra Leone, The United Nations Food and Agricultural Organization (FAO) constructed 50 village stores each with a 50 tonne capacity for farmer associations. Instead, the farmers used them for purposes other than grain storage. Shepherd (2012) cites five reasons for this behaviour: worry that others would see how much they produced; a lack of confidence in association record-keeping; shortages of jute bags; in some places, mistrust of village officials and others holding the keys, and fear that items in storage may disappear; and concern over seizure of stocks by the government.

In Benin, maize storage practices vary between agro-ecological regions and ethnic groups. Storage structures in the South of the country (which has a bimodal rainfall pattern) differ from those used

in the North, where rainfall is unimodal. In the South stores are constructed from plant materials; in the North a high percentage of stores are built from clay. These findings provide information about what happens in other African countries; however nothing as focused specifically on the Ugandan context which was the gist of the study.

The work of Shepherd (2012) and others clearly reveals how smallholder maize farmers across SSA use different grain storage systems in different countries, determined by a number of factors. Nevertheless, traditional storage methods dominate, for food, fodder and seeds, mainly because of their affordability and easy maintenance (*ibid*). Throughout, these storage methods result in heavy post-harvest losses leading to food insecurity and low incomes for the smallholder grain farmers. This underlines the need for further exploration of farmers' motivations and business models. This research adds detailed information from a new country context – Uganda – and integrates farmers' perceptions into the storage theory framework.

2.3 Implications of the theory of storage

Using wheat, Working (1949) theorized that inventory levels and in particular the 'year-end carryover' (the inventory still existing at the end of one 'harvest year' prior to the arrival of the new harvest), would be instrumental in understanding the behaviour of grain prices. Working argued that the basic strategy of storing crops would only work in situations where cash-future basis exceeded the cost of storage. There is concord between this and the more recent findings of Kim, Zulauf and Roberts (2015). This is because Working views the return on storage as determined by supply and demand.

Kaldor (1939) argues that a situation may occur when spot price exceeds futures price, which is referred to as "backwardation". This has been disputed by Hernandez and Torero (2010), who contend that holding a physical inventory seems at first glance to be illogical, because from the futures market it is clear that prices are expected to fall. However, for Kaldor (1939) it was right to simply buy the commodity later at a lower price, or to buy a long-dated future, rather than purchase in the spot market. This led to Kaldor's introduction of the term 'convenience yield', defined as the convenience or benefit derived from holding the physical commodity rather than a paper futures contract. Working (1949) built on this concept, proposing that the convenience yield can be measured as a percentage of the yield the holder of the physical grain implicitly receives to offset unexpected change in price. Working posits that the behaviour of commodity futures and spot price is related to storage costs, inventory levels, and convenience yields.

Benavides (2004) describes this as illustrating how strongly fundamental supply and demand conditions underlie Working's (1949) analysis of the spread between spot and futures prices. Symeonidis *et al*. (2012) argued that convenience yield is an optional stream, taken by those smallholder maize farmers who want to sell their maize to the market when prices are high and keep it to take advantage of increased future prices when they are low. However, this option is open only to those smallholder maize farmers whose storage types can guarantee the safety of the stored maize, to prevent escalated storage costs that will negatively influence the marketing margin (Abebe, Bijman & Royer, 2016).

Thus it is possible, following Working (1949), to posit that the return on storage is determined by supply and demand, mitigated or aggravated by storage types (Siaplay, Adam, Brorsen & Anderson, 2012). If storage is to generate economic benefit to smallholder maize farmers through

this moderation function, then the stored maize must be sold at a price that will cover the costs of storage from harvest to the time when it leaves the store (Proctor, 1994). The need for such a price calculation raises a question central to this research: how do smallholder maize famers arrive at their storage decisions?

Siaplay *et al*. (2012) drew on core storage theory to study the basis of storage decisions. They discovered that smallholder farmers' decisions to store or sell are complex comparable to a game of win or lose – which unfortunately has to be played every time they produced grain. In their study, futures price and futures price-spread were used in predicting return on storage similar to Working's (1949) approach.

Brennan (1958) demonstrated that Working's curve was observable in many markets, but especially in developed markets. Brennan examined empirical data for a number of agricultural commodities (eggs, cheese, butter, wheat, and oats) over a period of years. However, Brennan's contribution has a different perspective from Working's. Whereas the latter framed the theory in terms of annual observations, the former saw it as applying at all times, using monthly observations. Specifically, Brennan reworked the theory of storage to include 'convenience yield', given that spot prices can exceed futures prices.

Stronzik, Rammersdorfer and Neumann (2008), argue that the benefits that accruing to smallholder maize farmers from holding inventories arise because the stored maize could be used as input for the production of other commodities. In addition it enables smallholder maize farmers to meet unexpected future demand (Vorotnikova, 2016). The contribution of Stronzik *et al*. (2008) is that the theory of storage shows that commodity futures and spot prices differ by the cost of storage and interest costs of holding minus convenience yield.

According to Geman and Smith (2013), the theory of storage as related to storable commodities makes two predictions involving the quantity of the commodity held in inventory. First, when inventory is low (i.e., under situations of scarcity), spot prices will exceed futures prices, and spot price volatility will exceed futures price volatility. Second, during periods of abundant inventory, both spot prices and spot price volatility will remain relatively subdued. These predictions support an analysis of commodity storage as being undertaken for three main reasons: as a buffer against uneven or seasonal supply; as a buffer against uneven demand; or as a buffer against any other supply or logistical disruption that could otherwise necessitate the expensive pause of an industrial or business process.

As noted, during periods of surplus the spot price will be low (because there is more maize available) and in times of scarcity the spot price may be high (because of limited supply) (Proctor, 1994). A low spot price will encourage those who have facilities to store the commodity, so that they can benefit from futures price. However, smallholder maize farmers without storage facilities will be forced to sell at lower price, which will impact on the income they realize. Yet, those farmers who choose to store will be exposed to issues of pilferage, pests, drying, weight loss, damage and handling (Kadjo *et al*., 2013); Kadjo *et al.* (*ibid*) referred to these issues as costs of storage which may consequently influence their marketing margin. This trap – where either option may damage smallholders' income – illuminates the need for investigation of and support for such farmers' decision-making processes.

Benavides (2004) examined the relationship between inventory and viability, considering storable commodities and using a restricted version of the Baba, Engle, Kraft and Kroner (BEKK) model. Benavides (2004) tested the implications of the theory of storage and concluded that supply and demand fundamentals do affect the price dynamics of agricultural commodities such as maize. Benavides (2004) used an interest storage spread as a proxy for supply and demand fundamentals to test this conclusion for grains, and to test Samuelson's hypothesis that spot prices have greater volatility than future prices. The "Samuelson effect" describes how commodity futures become more volatile as they approach maturity, but in contrast to the theory of storage, it does not mention that such conditions apply most strongly during conditions of scarcity (Geman & Smith, 2013).

A study of storable commodities carried out by Benavides (2004) to examine the relationship between inventory and viability used the restricted version of the Baba, Engle, Kraft and Kroner (BEKK) model. Benavides tested the implications of the theory of storage and concluded that supply and demand fundamentals affect the price dynamics of agricultural commodities such as maize. Benavides used an interest storage spread as a proxy for supply and demand fundamentals to test the aforementioned implication for the grains as well as to test Samuelson's hypothesis that spot prices have higher volatility than future prices. The Samuelson effect states that commodity futures become more volatile as they approach maturity, although unlike the theory of storage, it does not mention that such conditions mainly apply during scarcity (Geman & Smith, 2013).

Geman & Smith (2013) further contend that spot price volatility will always exceed futures price volatility, since long-term prices respond mainly to long-term news (as well as all kinds of "noise" introduced by short-term trading). Benavides (2004) made three core findings: the interest-storage-adjusted-spread has a statistically significant positive influence on the spot and futures returns for

both the commodities he studied; spot price returns have greater volatility compared to futures price returns (which is consistent with Samuelson's hypothesis); and the results of the tests are consistent with both theories and with the existing literature related to commodity features.

2.4 Theoretical justification

Fama and French (1987) postulated that the return from purchasing a commodity and selling it in future equals the interest foregone, plus the storage cost, minus the convenience yield from an additional unit of inventory. They also predicted a positive relationship between convenience yield and inventories.

It is worth noting, however, that their predictions are more relevant to developed markets with efficient storage systems than to the markets of developing countries. Generally, in developing countries, discussion of convenience yield among smallholder maize farmers is almost impossible, because there are no inventories. This is because inventories are a function of good and safe storage (Tefera *et al*., 2011). In addition, the maturity date of holding inventory for future sale is predetermined and known with certainty in developed markets, which is not true for perishable commodities like maize in an underdeveloped market. Pests, rats and bad weather can quickly wipe out the maize stocks of most smallholder farmers relying on insecure traditional storage types.

2.5 The contribution of storage

Cereals such as maize form a major part of crop production in Africa and require safe storage due to the seasonal nature of production (Gitonga *et al*., 2015). Indeed, Gitonga *et al (ibid*) note that

safe storage at household level is vital because it directly impacts on income and food security. Good storage has been identified as one of the many ways through which on-farm maize wastage can be reduced (Ajani & Onwubuya, 2013). Thus, improved storage is a potential vehicle for poverty alleviation.

However, as has previously been noted, most smallholder maize farmers in SSA are limited to using traditional storage types such as baskets, granaries, sacks, tins, house-roof, cribs, above-the-fire and house-corners, which do not guarantee the integrity of the harvest and may lead to substantial losses, despite international advances in storage technology. Good storage empowers smallholder farmers to keep their maize and sell later when demand outstrips supply thereby getting higher price and significantly increased income as well as an adequate marketing margin. In his study of the economics of palm oil storage and marketing, Ezealaji (2011) found a correlation between storage and marketing margin. However, the study did not assess this relationship with respect to smallholder maize farmers.

Storage is also important among smallholder farmers because it assuages the price fluctuations experienced by agricultural products like maize (Proctor, 1994). This is critical, because price surges create many challenges for developing countries. The recent 2011 spike in maize prices is a good example of this. Grain price surges have been responsible for political, economic and social unrest in many developing countries (Sun *et al*., 2013). Much of the maize consumed in these countries comes from smallholder farmers. Thus better household storage, ensuring improved maize availability and significantly reduced price fluctuations, would not only contribute to

smallholders' share of the marketing margin but could also impact positively on these socio-political problems.

Mdangi *et al*. (2013) have accurately described the key role secure maize grain storage plays in the economies of developing countries through its ability to even-out fluctuations in market supply from one season to another, and from year to year. However this is only possible with appropriate storage. In situations where storage practices remain unsafe and inefficient, these benefits may hardly be realized.

2.6 The significance of the theory of storage for this research

Stronzik *et al*. (2008) argue that price signals the influence of the operation of storage facilities and infrastructure investments as long as a competitive market environment exists. Thus the development of storage capacities and efficient adjacent markets can reduce volatile spot prices. This basic premise of the theory of storage is rooted in the type of competitive environment that exists in the developed markets where the theory was first developed and employed. In developed markets, the theory works well and is used in price arbitration through inventory management (Stronzik *et al*., 2008; Fama & French 1987; Geman & Tunaru 2013).

However, the performance of this theory in the underdeveloped markets of many SSA countries requires further empirical investigation. Underdeveloped markets are characterized by few buyers and sellers, poor infrastructure, the use of traditional storage types, and inadequate and inefficient market information (Fortenbery, 2004).

Efficient markets provide accurate information in determining marketing margin (Zulauf & Irwin, 1998). However, the market success of smallholder maize farmers hinges on the decisions they make in the absence of such information. One group of decisions centres on storage, which impacts in many ways on their returns (referred to as margin). Storage decisions comprise how to store, for how long, and the impact of the cost of storage on marketing margin. Market efficiency theory has been used to study the behaviour of the futures market to determine who benefits from a transaction, and Zulauf and Irwin (1998) conclude that field grain producers (smallholder farmers) cannot benefit unless they can reduce the cost of storage.

Agricultural marketing in underdeveloped markets is a critical link between producers and consumers, because it enables resources to percolate to smallholder farmers through price changes (Roy, 2012). The argument is that efficient markets enable producers (in this case, smallholder maize farmers) to get the best revenue by reducing the gap (marketing margin) between producers' price and the price paid by the ultimate consumers (Roy, 2012). However, in the absence of efficient storage facilities, smallholder maize farmers using traditional storage types become distressed (residual) sellers, selling their maize immediately after harvest at low prices to village traders or middlemen to avoid wastage (Tefera *et al*., 2011). This widens the gap between producer and consumer prices and negatively affects the share of the marketing margin realized by smallholder maize farmers. George (2011) notes that the inadequacy of proper storage types has contributed to significant loss of maize grain in Africa, which in turn reduces farmers' incomes.

From the studies reviewed, it is clear that the theory of storage is crucial in describing the relationship between price (and thereby income) and inventory, but that previous scholarship has

focused predominantly on developed-world contexts. This research builds on the theory of storage discussed above, exploring to what extent it can be applied to smallholder maize farmers in Uganda. The research enriches a theory originating from developed markets and dominated by European and American studies with data from a developing-country context (including the observations and practices of smallholder farmers themselves) and with analysis of the business framework such farmers employ in making sell/store decisions.

2.7 Assumptions of the maize business framework

A maize storage business framework can be constructed on the basis of the foundation model developed by Fama and French (1987). These scholars contend that when inventory is stored, it can bring benefits to the inventory holder. What has been called the marginal convenience yield arises because inventory has reproductive value – for example, there may be a convenience yield because the inventories are inputs to the production of other commodities or because inventories held can be used to meet unexpected demand" (*ibid*). Holding inventories implies that the holder is prepared to forego the spot price in anticipation of a higher futures price. This increases his/her potential to get a higher share of the marketing margin but also exposes him/her to the risks of holding the inventory.

In the case of maize, the theory of storage relates spot price to futures price a few months forward (Siaplay *et al.* 2012). The maize futures price will equal local spot price plus local storage cost minus local convenience yield. The cost of storage depends critically on the quality and safety of that storage, as ineffective storage leaves the maize susceptible to degradation. Degraded maize attracts a low price and consequently lowers the marketing margin (Omotilewa *et al*, 2016).

However Jones, Alexander and Lowenberg-DeBoer (2014), contend that for storage to be useful to smallholder farmers it must not only be effective but also within their financial reach. The majority of smallholder maize farmers are poor and cannot afford to buy effective storage types. Effective storage technology is expensive and sometimes hard to access, and this increases the cost of storage to the point where storing for future use becomes unprofitable (Stephens & Barrett, 2011).

Storing maize when there is a glut, to use under conditions of scarcity could offer a solution to the problems caused for smallholders by the crop's characteristic price fluctuations (Stephens & Barrett, 2011). Due to the seasonal nature of the crop, smallholder maize farmers can face conditions of both surplus and scarcity. Surplus is experienced at harvest time and immediately following; scarcity occurs after farmers have planted and must wait for the next harvest. To maintain a continued supply of maize throughout the year against this seasonality, and protect price and marketing margin (Poudel, 2013) it must be stored (Suleiman & Rosentrater, 2014).

At harvest time, smallholder maize farmers typically store a portion of their harvest – if they have storage – and sell the rest of the maize at farm gate *ceteris paribus*. In times of glut, prices are depressed by the excess supply of maize, causing competition among smallholder farmers that forces them to sell by undercutting their competitors' prices. Prices fall further when the buyers know the sellers cannot store and face an amplified risk of loss.

In other words, if smallholder maize farmers have no storage and are unable to sell, their maize will rot in the fields and produce no margin at all. Those who buy will transport the purchases from

the farm gate to the local market, where they can choose between reselling immediately on the town's spot market or store the maize for later sale when prices are higher. The farm-gate spot price will be less than the town market spot price.

As noted by Casassus, Liu and Tang (2013), in times of scarcity, smallholder maize farmers either pay a high spot price or "take delivery" from their own storage (if they have any), at an effective cost of the last harvest's farm-gate spot price plus the storage cost for the interval. In the latter case, a benefit clearly accrues to the farmer with lower-cost (i.e. high-quality) storage. Such a benefit should be observable in terms of the farmer's discretionary income and/or spending (*ibid*).

2.8 Characteristics of maize markets

Maize in many developing countries is grown for both income and consumption (Johnson, 2014), and is normally sold to village and town markets (Smale, Moursi & Birol, 2015). However, there is a low level of market participation among smallholder maize farmers because of the high transaction costs they face, including storage and transport costs. Transaction costs are however not uniform among smallholder maize farmers due to asymmetries of market information and unequal access to assets such as storage types (Makhura, Kirsten & Delgado, 2001). High transaction costs are one of the reasons why maize transactions take place in a rural setting in many SSA countries (Kadjo, Ricker-Gilbert & Alexander, 2016).

Storage is a critical factor along the maize value chain (Akowuah, Mensah, Chan & Roskilly, 2015). Since the maize produced may not be consumed immediately, storing it becomes necessary to satisfy demand throughout the year (Di Domenico *et al.*, 2015). Thus smallholder farmers in

both developing and developed countries are concerned with issues relating to storage. However, while in developed countries the majority of farmers can access and use efficient, modern types of storage, in developing countries smallholder maize farmers use predominantly traditional storage types (Proctor, 1994).

Consequently, in developing countries storing maize often leads to a deterioration in quality and causes high post-harvest losses to smallholder farmers which impacts on their share of the marketing margin. In addition, maize marketing entails numerous handling processes that can subsequently impact on quality (Nkonya, 2002; Abass *et al*., 2014). Yet, as noted by Kadjo *et al*. (2016), successful marketing depends on a consistent supply of better quality produce. Storage is a critical factor in ensuring this continued supply of quality maize whenever required by the market (Omobowale *et al*., 2015).

In SSA, markets for agricultural produce are not fully developed, and hence are inefficient. They are characterized by poor infrastructure that limits the flow of, and access to, market information between buyers and sellers (Ssekibuule, Quinn & Leyton-Brown, (2013). Limited access to market information also raises transaction costs and reduces smallholder maize farmers' ability to participate in the big markets. This reduces their share of the marketing margin (Muto & Yamano, 2009).

Because the prices of perishable products depend on quality, and quality is affected by the nature of storage (Muto & Yamano, 2009), storage challenges need to be addressed. Storing at times of glut and low prices to sell in future when inadequate supply draws higher prices is one of the few

ways to ensure a high share of the market margin (Proctor, 1994). However, as already argued in this study, the ability to do this depends entirely on the storage types used.

2.9 Smallholder farmers' maize flow and its implication

For smallholder farmers, maize is produced for both consumption and income (Lama, McEvoy, Parker & Robbins, 2014). Maize is consumed in homes as the first level of consumption; alternatively it may be purchased at the farm gate from the smallholder. Those who buy from smallholders may sell it to traders or nearby town markets. From those nearby markets the maize is sold from district markets to other big buying centres and onwards to the national market. National market buyers sell to the international or export markets. Thus the maize flow may be traced from the farm gate, through a range of agents and traders and from these to various consumers (Gold & Seuring, 2011). (Lama *et al*. (2014) have additionally argued that three-tier maize markets exist, citing examples such as rural business centres, town centres and capital city business centres.) This chain speaks of a need for effective and safe storage at every stage, to maintain quantity and quality. How much of the maize survives these various storages influences the margin realized, since it has a direct impact on the prices paid in different markets.

The assumption made in the flow is that smallholder maize farmers only sell at the farm gate simply because they lack storage and cannot easily transport to big markets, leading to post-harvest loss (Smith, 1992). For any smallholder to even consider selling further along the chain or in future when prices may be higher, they must have access to good safe storage types.

Post-harvest maize loss is regarded as one of the major contributors to losses in marketing margin among smallholder farmers and is a major contributor to high maize prices (Edoh Ognakossan, Tounou, Lamboni & Hell, 2013). Smallholder maize farmers may want to store the grain before marketing because they have produced more than they can consume or to sell immediately; they may wish to consume, or – because of low spot prices – wait for higher future prices. Adetunji (2007) argues that maize is stored for various reasons including food supply when demand outweighs supply; as a form of savings for the producers; to meet the future cash needs of smallholder farmers through sale; for barter exchange or gift-giving; as ingredients for brewing; and as seed for re-planting and poultry feed, among others. However, the final decision to sell or store depends on multiple considerations including household needs, marketing margin needed, prevailing prices (spot) and expected future price – and, inevitably, the availability of secure storage.

The benchmark for any storage type is that the crop stored should retain its high quality during and after storage (Omobowale *et al*., 2015). Therefore the store should protect both the quality and quantity of the maize (Abass *et al*., 2015). Some of the basic rules for storage emphasize that only high quality produce, free of damage and decay, should be placed in storage; that storage rooms should be kept clean; and that the temperature in store rooms should be maintained and monitored (*ibid*). However, smallholder maize farmers, find these essential conditions hard to comply with, especially in underdeveloped markets.

The types and capacities of storage facilities used by smallholder farmers has an impact on their margin, but this impact is difficult to quantify because different storage types are associated with

different storage costs that influence the marketing margin in prevailing market conditions – and over which smallholder maize farmers have no control. When smallholder farmers have good storage, they can store with fewer risks of the losses identified in the literature, including pilferage, weight loss, insect damage, and other deteriorations in quality and quantity. Figure 1 shows the relationship between storage, cost, market characteristics and margin that accrues from the maize flow to smallholder maize farmers.

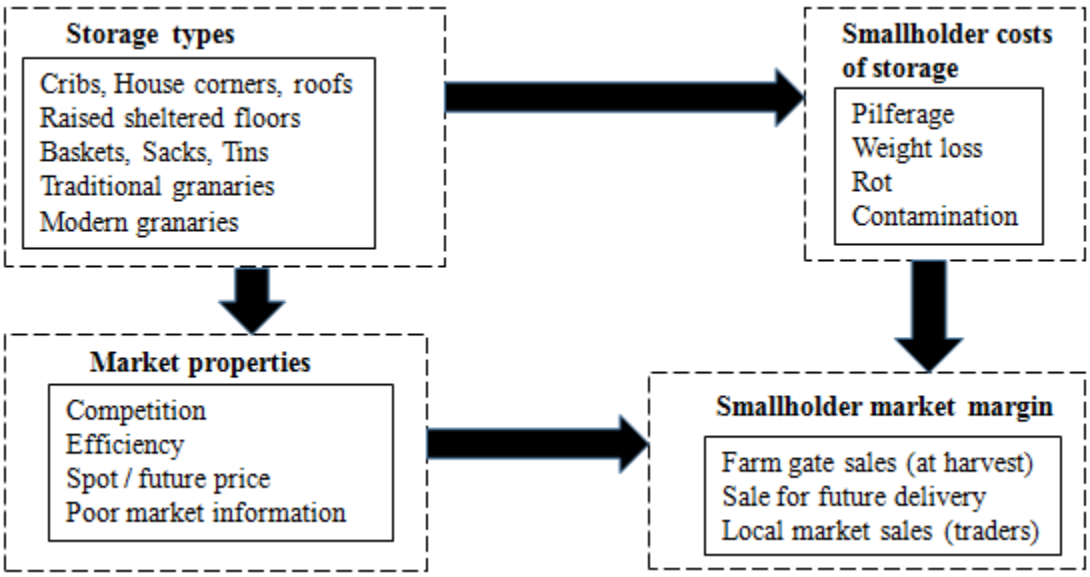


Figure 1: Smallholder maize farmer's storage and income flow

Source: Developed for this study

Figure 1 lays out the various elements critical for the flow of maize from producers to consumers. When maize is produced, it requires either transitional or permanent storage and in the process, storage costs are incurred that influence the marketing margin.

2.10 Theoretical rationale

The theoretical rationale is important in that it explains why and how the variables of the study are interrelated (Creswell, 2009). It also assists the researcher and the reader in focusing on the specific key variables of the study. The theory of storage provides the basis for understanding the importance of storage both in efficient and inefficient markets.

In this study the relevant constructs are storage types, storage costs and marketing margin. Data were gathered to support analysis and interpretation, so as to validate or challenge the theoretical assumption that storage types influence marketing margin. The key independent variables are storage types; they are the phenomenon influencing smallholder maize farmers' share of the marketing margin, compounded by the costs associated with storage.

Kadjo *et al*. (2013) argued that it is storage challenges that make smallholder maize farmers in SSA unable to benefit from price increases during the production cycle. Storage is associated with uncertain margins because of the unpredictability of future prices (Armah & Asante, 2006). Many studies carried out on storage types have examined them in relation to damage by pests and diseases (Eisen *et al*., 2013; Gitonga *et al*., 2013; Jones *et al*., 2011). However, this study sought to discover how the storage used by smallholder maize farmers impacts on the share of the marketing margin accruing to them. Figure 2 shows some of the storage types used by smallholder maize farmers in SSA (Mdangi *et al*., 2013).

Figure 2: Open and closed crib, sacks and maize poured in a corner in smallholder farmer's house.

Source: adopted from Mdangi *et al*. (2013)

Despite the urgent need to find adequate food for the majority of the people in developing countries, many smallholder maize farmers still use these kinds of traditional methods to store their maize grain and as a result risk – and often incur – high storage losses (Alonso-Amelot & Avila-Núñez, 2011). Such storage loss is between 20 – 30% of the harvested maize (Midega *et al*., 2016). In addition, traditional storage types expose smallholder farmers to market abuses by unscrupulous traders who buy their maize at a cheaper price, and this also reduces the smallholders' share of the marketing margin. This is because the storage types available cannot provide adequate protection, forcing on the smallholder the choice between holding their maize and risking losses from insecure storage, or selling quickly at a lower price and gaining only a low share of the marketing margin (*ibid*). Xhoxhi *et al*. (2014) posit that this affects the transfer pricing for smallholder farmers, because traders shift the risk and unexpected cost to farmers.

Maize grains need to be protected throughout their storage period to ensure continued supply (Thamaga-Chitja *et al*., 2004). Tefera *et al*. (2011) posit that traditional storage types are significant in maize grain losses in developing countries, because they cannot guarantee protection against pests. Such losses may be considered an additional cost of storage because they are incurred during storage, and, as pointed out by Fama and French (1987, p.60), "storage costs deter storage", which may have adverse effects on smallholders' share of the maize marketing margin.

For smallholders to gain from the higher prices normally experienced during the lean season they must store their maize when there is a glut (Kadjo *et al*., 2016). This storage benefits them in two ways: firstly, they will have food for their families; and secondly, they can sell at higher prices in the period of scarcity. However, it should be noted that even this potentially beneficial storage attracts some costs.

Moreno *et al*. (2006) present evidence that the types of storage accessible to farmers play a pertinent role in enabling them to store their produce. They studied storage types at the production, harvesting, consumption and sales stages, and concluded that while storage types may impact on the marketing margin, the topic requires a more thorough analysis. This study picks up that thread, seeking to discover how the traditional storage types common among smallholder maize farmers in SSA impact on the marketing margin. For all these reasons, the poor storage types reported in the tropics have continued to lower the marketing margin, particularly among smallholder maize farmers (Wambugu *et al*., 2009).

The economic effect of poor storage also encroaches on the health of smallholder farmers'. Kaaya and Warren (2005) posit that poor storage increases the risk of aflatoxin contamination in maize, which may lead to liver cancer. These health concerns directly impact on the economic role of

smallholder farmers, because maize contaminated with aflatoxin puts consumers at high risk of health hazards too (Mutungi, Imathiu & Affognon, 2016). Indeed, poor household storage among smallholder maize farmers is leading to aflatoxin contamination now being regarded as a world problem, although it mostly affects developing countries (Pokhrel, 2016). This has led to risk-averse farmers apply excessive pesticides – another potential risk to the health of consumers (Pingali (2001).

2.11 Storage types, marketing margin, cost of storage, spot and future price

Using the storage theory as a conceptual foundation, the empirical research was organised and conducted according to the classification of the study constructs. These were divided into four dimensions: storage types and marketing margin; storage types and cost of storage; storage types and spot price; and storage types and futures price. Each of these is discussed in turn.

2.11.1 Storage types and marketing margin

A margin is the difference between two values or sums of money (Traub & Jayne, 2008). Marketing refers broadly to a company's or individual's activities in drawing the attention of potential buyers to its product or service in such a way that they will be interested in purchasing it. The term 'marketing margin' has a specific application to an individual or company purchasing a product with the intent to resell it at a price higher than that paid to acquire it (P2>P1) and is applied in this research to smallholder maize farmers who produce for sale and consumption.

Marsh and Brester (2004) view marketing margin as the outcome of demand and supply forces. It encompasses the processes undertaken by smallholder maize farmers their role as producers selling

to agents. These processes are closely related to storage types because supply comes from grain stored during off-harvest season (Dawe & Maltsoglou, 2014). The smallholder has paid for storing the maize by incurring the costs of storage (Omobowale *et al*., 2015).

Marsh and Brester's (2004) study of marketing margin focused on wholesalers. Poudel (2013), who studied marketing margin in relation to a similarly perishable crop, seasonal vegetables, employed the cost of production and price. This study, by contrast, investigates smallholder maize farmers selling at the farm gate or nearby markets, assessing the share of marketing margin realized at the smallholder/producer level in relation to the variables of storage types and the cost of each storage type.

The marketing margin in the case of agricultural commodities varies because of the seasonality and the perishable nature of the produce (Eze, 2007). Eze argues that when demand and supply are in disequilibrium – as they are with maize – the quantity available for consumption and the price paid will depend on how the market functions in terms of the costs and returns on marketing operations. Because the availability and effectiveness of storage type plays a role in agricultural marketing, it is one of the constructs that need to be considered in marketing agricultural products.

Aidoo, Mensah, Opoku and Abaidoo (2013) argue that those offering a commodity for sale expect to get a high price. However, the price received depends on the quality of the product and this can be affected by storage (Omobowale *et al*., 2015). An important motivation for good storage is that no customer is willing to pay a high price for a poor quality product (Kadjo, Ricker-Gilbert & Alexander, 2015). Yet as has been noted, grain storage generally – and maize storage in particular

– has remained a serious challenge for many smallholder farmers in SSA (Affognon, Mutungi, Sanginga & Borgemeister, 2015) and in developing countries more generally (Hodges, Bennett, Bernard & Rembold, 2013), affecting maize quality. Chunmei, Dan & Gang (2015) have recently underlined how domestic storage efficiency is inadequate among smallholder maize farmers impacting on the quality of maize.

This makes storage a crucial aspect of the agricultural marketing system, because before maize is disposed of through consumption or sale, it has first to undergo storage (Abass *et al*., 2014). Storage thus needs to protect the quality, quantity, and safety of the stored maize (*ibid*.) and the storage stage is a critical one for smallholder maize farmers eager to realize a higher share of the marketing margin.

The relevance of this theoretical discourse to Uganda and other SSA countries is that the effective marketing of maize depends on good storage and that storage should be assessed on the marketing margin realized. If the quality of the maize is good because it has been well stored, then higher margins will be realized. In addition, good storage permits smallholder maize farmers to store surplus grain produced at a time of glut and sell later when demand outweighs supply. This affords smallholder maize farmers some degree of protection from unscrupulous traders seeking to buy at reduced prices. (However, it should be noted that the prices paid for maize depend on farmers' negotiation skills as well as the condition of the maize (Kadjo *et al*., 2015)).

Smallholder maize farmers who lack good storage facilities are left with no option but to take any price offered, which adversely affects their share of the marketing margin and income. Shepherd

(2012) has demonstrated that a correlation exists between storage and the wealth of smallholder maize farmers. It is possible to speculate that the prevalent lack of secure storage among smallholder maize farmers is one explanation for traders' tendency to pay exploitative prices, which in turn exacerbate smallholders' poverty by reducing their share of the marketing margin (Sitko & Jayne, 2014).

Storage is pertinent to the whole food supply chain (Xhoxhi *et al*., 2014). Effective storage can play a crucial role in reducing risks such as unstable marketing margins, and circumventing the unrealistic prices normally experienced during harvest (Coulter & Onumah 2002). And although smallholder maize farmers may receive the lowest margin in the food supply chain due to lack of efficient storage, no previous study has examined the inter-relationship between storage types, storage costs and the share of the marketing margin, the focus of this work. The findings of this study are capable of steering a change in the practices of smallholder agriculture towards a greater degree of commercialization. Pingali (2001) posits that agriculture commercialization requires embedded policies aimed at changing the direction of smallholding towards storage, trade and production, causing a gradual shift from subsistence to commercialization. This is possible because a greater commercial orientation of smallholder agriculture is capable of bringing about a gradual decline in real food prices, *ipso facto* increased competition, lowering the costs of food marketing and processing (Omiti *et al*., 2006). However, this requires a deliberate shift from the production of food towards cash crops, which remains a challenge (*ibid*) in developing countries.

2.11.2 Storage types and cost of storage

Storage types exert an important influence on the cost of storage and the marketing margin realized by smallholder maize farmers (Kadjo *et al*., 2015), because ineffective storage types can reduce the amount, or increase the cost, of goods sold (Delgado, 1999). According to Hell *et al.* (2000), when storage types are poor, they can cause loss due to pest and rodent damage. In this context, the storage costs embedded in the transaction costs exclude smallholders from participating in marketing opportunities (Delgado *op. cit.*).

Cost is one of the key challenges for smallholder storage, and includes any expenses incurred in holding an inventory in store. Jones *et al*. (2014, p. 67) state that "profitable storage depends on the relationship between the stored commodity's value, price seasonality, and the cost of storage". Storage costs, therefore, impact significantly on the smallholder maize farmer's share of the maize marketing margin. When maize becomes damaged before it is consumed or sold this reduces the revenue contribution the crop can make for smallholder farmers (Kadjo *et al*., 2016). Suleiman and Rosentrater (2015) describe maize losses as a "leaky food chain" at every stage from field to market. They argue that much of the loss is incurred during storage along the chain; about 20 percent – 30 percent of the harvested maize is lost before the crop reaches the final consumer (*ibid*).

Although, according to Brennan (1958), there will be farms at any time carrying a commodity from one period to another in anticipation of selling it at higher price, the kinds of losses discussed above exacerbate the storage costs borne by smallholder maize farmers: fixed costs, handling costs, deterioration costs, obsolescence costs, maintenance costs and financial costs. (Sørensen (2002)

additionally argues that holding physical inventory has a cost of carriage beyond the interest forgone.)

In a meta-analysis study of post-harvest loss in SSA, Affognon *et al*. (2015) identified several storage costs and placed them under two main categories; quality loss and quantity loss. They argued that quality loss results from weight loss of the product and quantity discarded. Quantity loss includes price discounting and quantity downgraded. These losses can be expected to impact on the income of the smallholder maize farmer as they increase the cost of storage.

The multiple costs associated with keeping maize in a store include, rent, utilities, damage, pilferage, shrinkage, opportunity cost and insurance (Russell & Taylor, 2006). Brooks *et al*. (2013) demonstrate the place of storage costs in the theory of storage when they note that the theory is built on foundations of time, value and the net returns from physically holding a commodity. Thus an understanding of storage costs is central to this study of the extension of the theory of storage to smallholder maize farmers in Uganda.

2.11.3 Storage types and spot price

Storage offers one potential micro-enterprise pathway for smallholder maize farmers seeking increased household income (Abdu-Raheem & Worth, 2011). Owning and managing a storage facility could allow them to benefit from price variations during different time periods (Dawe & Maltsoglou, 2014). At the macro-level, maize contributes significantly to a population's food basket, and storage constraints have impacted negatively on food security in SSA, with losses averaging between 20 percent – 30 percent (Suleiman and Rosentrater, 2015; Baoua *et al*., 2014).

George (2011) argues specifically that the storage types employed by smallholder farmers in SSA cannot offer the necessary protection to maize against damage by pests. Similarly, Thamaga-Chitja *et al*. (2004) contend that the storage types used by smallholder maize farmers remain inefficient and cause losses whose repercussions include reduced food supply, margin loss, and disruption of food consumption (forcing smallholders to purchase maize at higher prices during lean season, among others). Furthermore, in SSA the loss-related costs of storage are very high; farmers lose one kilogram in every five stored (Kimatu, McConchie, Xie & Nguluu, 2013).

Carter, Rausser, and Smith (2011) note that storage types are critical in controlling the fluctuation between high and low supply of maize, which has an economic impact on the majority of smallholder maize farmers in developing countries. Most smallholders spend a significant proportion of their disposable income on maize purchases (Tadesse, Algieri, Kalkuhl & von Braun, 2014). If storage types were efficient enough to regulate supply and demand, these frequent purchases could be reduced.

Understanding the theory of storage is crucial in regulating price volatility (Fama & French, 1987; Geman & Smith, 2013), since storage (including the types and efficiency of storage) impacts on spot price. Smith and Thompson (2012), who explored the role of market information in spot price, argue that the volume retained for future trading is a function of hedging. However, although these scholars considered spot price as providing direction for the behaviour of farmers, they did not consider any role for storage (and farmers' access to and understanding of it) in influencing that

behaviour. This study examines smallholder maize farmers' understanding and perceptions of storage and its relationship to the business models they employ.

2.11.4 Storage types and futures price

Future price is the price expected to prevail in the exchange of maize in the coming period. Future price is assumed to be determined by spot price and the gains expected by holding inventory. Many speculators use this price as a basis for predictions of their future margin, since they know that future price is almost always higher than spot price.

Future price is related to storage because if a smallholder maize farmer is unable to store then he or she is unlikely to take the future price benefit into account in sell/store decisions. Yet storage influences the future price for smallholder farmers because it is one piece in the puzzle of "sell low, buy high" relevant to commodity prices (Stephens & Barrett, 2011). When maize stocks decline, price becomes highly sensitive and may be moderated by storage (Wright, 2011). Wright *(ibid.*) further argues that storage is important in balancing consumption, available supply, and stock. It is therefore important in understanding the markets for agricultural crops such as maize.

Since the futures price of a maize crop is expected to rise by the sum of the costs of storage, the margin should embed the cost. In fact, Jones *et al*. (2011) argue that smallholder maize farmers who have storage facilities that can keep the maize safe are likely to gain from price seasonality because they are able to store and bargain for a better margin. Many studies on storage reviewed for this research thus emphasize the safety of maize from damage (e.g. Hell *et al.*, 2000; Thamaga-Chitja *et al*., 2004; Dick, 1988). Protecting maize from damage by, for example, insects is similarly important in the context of this study.

However, storage also needs to be assessed in the exchange process because storing without selling does not increase the margin realized. Thus this study explores questions of storage both from the perspective of stock integrity, and as a business strategy that can increase smallholders' share of the marketing margin.

2.12 Smallholder farmers perception of maize storage

Developed markets have efficient systems that provide good market information, and have many buyers and sellers utilising good storage systems that guarantee the safety of their stocks. The market information enables sellers to know where to sell and buyers know where to buy (Svensson & Yanagizawa, 2009), while effective storage protects the inventory from damage by pests (Kadjo *et al*., 2016) and other losses. These resources are important: producers will be able to store, and know when to sell.

Such characteristics are rare – and sometimes completely absent – in underdeveloped markets. This is one aspect of a more general absence of good infrastructure to support storage in underdeveloped markets, and suggests one reason why the theory of storage has not so far been extended to the study of smallholder maize farmers in developing economies. High storage and transport costs are among the leading causes of inefficient agricultural markets in SSA, they lead to smallholder maize farmers realizing only a poor share of marketing margin. This is further aggravated by imperfect information; smallholder maize farmers find it hard to access market information about local and regional markets (Coulter & Onumah, 2002).

Such characteristics are rare and sometimes completely absent in most underdeveloped markets. More so, there is absence of good infrastructure to support storage in underdeveloped markets which could be among the reasons why the theory of storage has not been extended to study smallholder maize farmers in developing economies. High storage and transport costs are among the leading causes of inefficient agricultural markets in SSA leading to poor share of marketing margin realized by smallholder maize farmers. This is further aggravated by imperfect information; the inability of smallholder maize farmers to access market information of local and regional markets (Coulter & Onumah, 2002).

2.13 Conceptual model

This section provides a schematic explanation of the theory of storage and its relationship to the study variables and is an expansion of the elements depicted in Figure 1. From the literature reviewed, it is possible to posit that the theory of storage has been employed effectively in developed market contexts (Fama & French, 1987; Geman & Smith, 2013) but has had hardly any application to smallholder maize farmers in underdeveloped markets with idiosyncratic market characteristics.

This study sought out farmers' perceptions of a business framework. Although storage has been studied in relation to post-harvest loss, and as an intervention targeting smallholder farmers (Kaminski & Christiaensen, 2014), this intervention – the USAID-funded project of a community warehouse – did not play a role in farmers' perceptions. In this context, Kirimi *et al*. (2011) have argued that the village bank and warehouse receipt system failed as a way of increasing household grain storage because it did not identify the fundamental causes of limited grain storage among smallholder farmers.

In addition, Udoh *et al*. (2000) argue that despite the importance of maize, little is known about the various storage types used by smallholder farmers in SSA. Thus there is inadequate information about the optimal alternative storage types available to smallholder maize farmers (Di Domenico *et al*., 2015). In studying marketing margin, Mohammadi *et al*. (2015) found a significant relationship between marketing margin and retail price. So to provide a clear understanding of the theory's extension to an underdeveloped market, an illustration of the key constructs is provided in Figure 3.

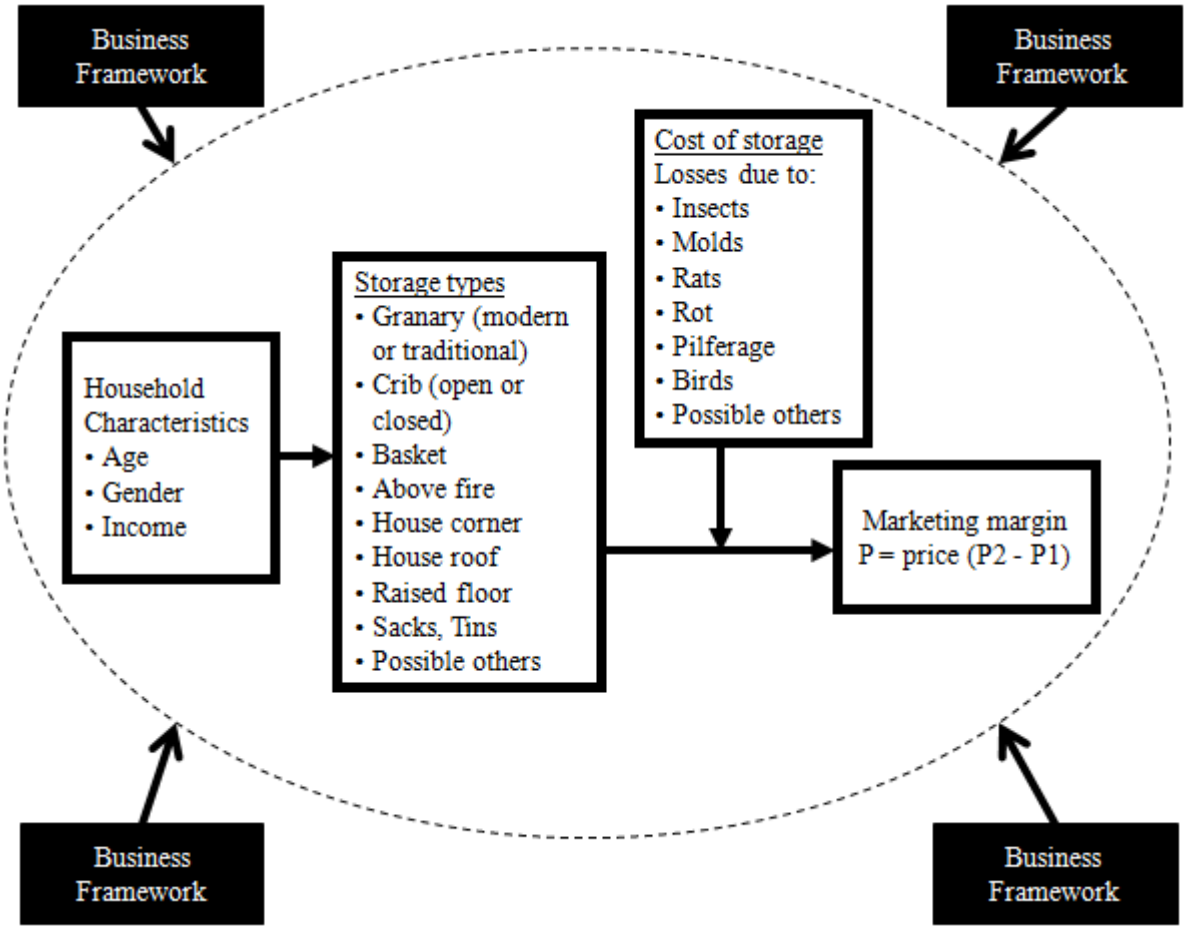


Figure 3: Conceptual model of underdeveloped market storage perspective

Source: Developed for this study

a bid to extend the theory of storage to an underdeveloped market, the assumptions of the theory were reviewed and compared to establish the interrelationship between their effects on independent and dependent variables (Figure 3). The key themes emerging from the literature are the storage types used, the challenges and benefits of these, and the smallholders' storage decisions that are presented and explained in Chapter 5.

In this study a recognised method for collecting information utilising various sources – triangulation (Creswell, 2009; Saunders, Lewis & Thornhill, 2009; Bauer, 2017) – has been employed. Combines quantitative and qualitative approaches is particularly relevant in social research (Olsen, 2004), where triangulation is considered better able to define and analyse challenges in a social context. Triangulation was preferred for this study because studies involving interacting with human beings require one to use different ways of getting information, as some may not be given but can be observed (Bauer, 2017). In addition, many human decisions are made in the course of the research process (Johnson & Onwuegbuzie, 2004). Field engagement offered an opportunity to the researcher to get close to respondents and to compare data from different sources (Fielding, 2012). It is argued that when two approaches are combined (quantitative and qualitative), the inherent weaknesses, deficiencies and or bias intrinsic in each are counterbalanced (Yeasmin & Rahman, 2012). Social realities are complex and difficult to capture using a single method approach (*ibid*). By employing triangulation, this research interrogates the separation of quantitative and qualitative data. One risk, however, of utising triangulation is taking on too many unfocused question which must be guarded by sequencing (*ibid*). A detailed account of data collection using mixed methods, including the ways this risk was mitigated, is contained in Chapter Three.

2.14 Conclusion

Storage has long been used in markets as a supply chain element to buffer against supply and demand shocks. When there is a glut in supply, the commodity is stored; when demand surges, supply is drawn from storage to address consumption needs. Thus storage has been demonstrated to influence the working of the market by regulating supply and demand. As a consequence, storage influences the behaviour of market players who may speculate to benefit from increased prices. The use of storage to regulate supply and demand is more pronounced for seasonal agricultural products, because consumption occurs throughout the year, yet production occurs only in certain seasons.

The literature clearly demonstrates that the theory of storage is used in assessing the behaviour of market players in developed markets. However, very few studies have examined the application of the theory of storage to underdeveloped markets. Even where attempts have been made (Shepherd, 2012), they have most frequently been aimed at recommending the use of modern storage such as warehouses – which, in underdeveloped contexts, are often faced with operational challenges. This vacuum in the reviewed literature motivated this study to focus on the application of the theory of storage to an underdeveloped context, to generate new knowledge.

The earlier authors reviewed, such as Kaldor, Working, Cifarelli and Paesani, used existing or secondary data sets to develop their theoretical contributions. However, in this study primary data was collected and analysed, with secondary data employed only as a supplement. All the authors reviewed here studied applications of aspects of the theory of storage, but focused on multiple and diverse products. For example, Geman and Tunaru (2013) studied real estate and Geman and Smith

(2013) studied metals. The present study by contrast employs the theory of storage to study one agricultural product (maize).

In this study, the assumption is that the study variables (such as storage types) are mediated by the cost of storage, which influences the share of the marketing margin. This share could, in turn, influence smallholder farmers' perception of the business framework related to storage. The central thrust of this thesis is that storage costs are moderated by the storage types used. When there is a glut of maize, the demand for storage surges and consequently increases the cost of storage while simultaneously lowering the price of maize. In developing countries, traditional storage types are the dominant form of storage used by smallholder maize farmers (Jenkins & Leung, 2013) and are associated with low storage capacity and high costs which deny smallholder maize farmers better marketing margins. To extend the theory of storage to underdeveloped market conditions in developing economies, it was important to understand the idiosyncratic nature of underdeveloped markets compared to the efficient markets of the developed world where the theory was first developed and used effectively.

CHAPTER THREE: Research methodology

3. Introduction

This chapter presents a detailed discussion of the research methods used to conduct the study. It covers the following elements: research philosophy, paradigm and research design; site selection; sample size and sampling procedure; data collection and justification, data analysis, validation and reliability. These elements are discussed in order below.

3.1 Research philosophy, paradigm and design

In this study the philosophy, paradigm and design were chosen based on other studies (Creswell, 2009; Saunders, Lewis & Thornhill, 2009; Midega et al., 2016) as well as the researcher's own experience. It is acknowledged that the theoretical position of the researcher influences his or her practice (Bauer, 2017). To understand the storage challenges that obtain at smallholder maize farmer level and to examine the theory of storage extension to underdeveloped markets, a combination of cross sectional smallholder maize farmer level data was collected through surveys, focus group discussions and key informant interviews. These are elaborated in turn in subsequent sections.

3.1.1 Research philosophy

The research philosophy was critical to the study, allowing for precise methodological specification. This was accomplished by evaluating the limitations of other perspectives and methods to identify those appropriate for this study. Every study deploys an implicit philosophy because the research process essentially provides a demonstration of the way in which a chosen philosophy, based on a particular world-view, is deployed (Creswell, 2009), but for rigour it is

necessary to make this implicit. A realist approach ('the what') was required to understand causes and effects in a positivist manner, but this had to be tempered by the pragmatism ('the why') required to understand the social as well as the economic situations of smallholder maize farmers. Smallholder maize farmers were studied within their natural setting with all its constraints, demanding flexibility. Additionally, because the researcher was dealing with human beings, there was careful adherence to ethical practices, as described in section 3.11.

"Research philosophy" describes the beliefs underlying how information should be gathered, analysed, and reported during research (Saunders *et al*., 2009). The philosophies chosen for this study relating to three key aspects: ontology, epistemology and methodology. Symon and Cassell (2012) define epistemology as knowledge about knowledge, and ontology as knowledge about phenomena and the nature of their existence. Whenever a researcher undertakes research, he or she should begin based on explicit assumptions about what there is to learn (Ontology); the relationship of the researcher to what there is to be learnt (Epistemology); and how he or she will learn (Methodology) (Sparkes, 2015). The ontological approach selected – that a 'real' objective world does exist to be discovered – was helpful in shaping investigation to elicit regularities and causal relationships between variables, through applying a methodology – mixed method – chosen to suit the research aims and context. These provided a concrete foundation upon which paradigms could be identified, as discussed in the subsequent section.

3.1.2 Research paradigm

'Paradigm' describes the patterns that help shape the study (Creswell, 2009, p.6). This study was guided by two paradigms: positivist and social constructivist. The positivist view maintains that reality is fixed but objective knowledge is produced using rigorous methods. Positivism was chosen as a paradigm for this study because the interest was in collecting general information and data from a large sample, with a quantitative approach amassing data from which findings could be generalized. Because causes determine outcomes it was necessary to explore rigorously the causes of smallholder farmers' low marketing margin share. The positivist approach underpinned meticulous observation and measurement of the objective reality of the study variables and allowed for quantification as well as rigorous objective investigation through surveys.

However because exploring farmers' behaviour and perceptions – such as their feelings about the storage types they used – was beyond what the positivist paradigm deals with, elements of a social constructivist approach were also adopted. Unlike positivism – where reality is assumed to be waiting to be uncovered – social constructivism posits that reality is constructed through human experiences (Creswell, 2009, p.8). Social constructivism – sometimes called the social construction of reality – is a paradigm that examines the development of jointly constructed understanding of the world (Creswell, 2009, p.8). Its philosophical premise is that understanding, significance and meaning are developed not separately within the individual, but in coordination with other human beings. It has two fundamental elements: first, that human beings rationalize their experience by creating a model of the social world and how it functions, because reality is created experientially (Denicolo, Long & Bradley-Cole, 2016, p. 28); and second, that language is the most important element through which humans create knowledge and construct reality

(Boroditsky, 2011). Social constructivism seeks to uncover the ways in which individuals and groups participate in the construction of their perceived social reality. The social constructivist paradigm enabled exploration of the phenomena from the perspective of the farmers themselves and the communities where they live and work (See Chapter Five).

First, through the literature, different research methods were identified and weighed, and a questionnaire was developed that was used to collect data for the first phase. Second, a more detailed in-depth study was designed to better understand the relationship between the study variables. The use of both paradigms reflects a belief that no one approach is sufficient to developing valid understanding of a phenomenon (Kaboub, 2008). In terms of the specific foci of this research, this means that storage characteristics and the costs associated with storage were intensively studied by the collection of quantitative information, while the relationship between storage types and household characteristics, and the perceptions of smallholder maize farmers were extensively studied through critical interactions to elicit their social reality (See Chapter Five).

The nature of knowledge differs in rationalistic (positivist, quantitative) and naturalistic (social constructivist, qualitative) paradigms (Bauer, 2017.p. 84). Potentially, a tension exists between these two (Saunders *et al*., 2009), which this research design accommodates by employing a mixed method, as discussed in section 3.2. The quantitative and descriptive parts of the study (related to existing maize storage types and estimation of the associated costs) were guided by a positivist paradigm: the assumption that a concrete reality exists apart from the researcher. The qualitative parts (related to the perceptions of smallholders about the possibility of developing a business framework to increase their share of the maize marketing margin) were guided by a social

constructivist paradigm. Employing two such contrasting approaches allowed the researcher to examine the relationship between the farmers' concrete context and activities and their beliefs about these. In addition, real events (about storage types and practices) that could be observed empirically were explained via logical analysis (Kaboub, 2008). Neither positivist nor social constructivist paradigm was superior to the other in fitness-for-purpose in this study; rather each served a particular and complementary purpose.

3.1.3 Research design

Research design' describes the detailed blueprint that guides a study to answer the research questions and achieve the research objectives. The design specifies the procedure that was followed while conducting the research in order to collect the data required to address the research problem. Thus every researcher needs a design before they begin collecting data (De Vaus & de Vaus, 2001, p. 9).

The study employed a cross-sectional design because the aim was to collect data on the prevailing situation relating to smallholder maize storage and conduct an economic analysis of causal effect between cost of storage and marketing margin at a given time. This design was ideal for the study because it permitted farmers' behaviour to be observed. The exploration was conducted by interacting with farmers through focus group discussions, to understand the relationship between storage types and farmers' characteristics described in section 3.4.1. This was best explored in the context in which it occurred. Description and observation were tenable approaches in the design because the phenomena studied could be described. Description was drawn from material provided by surveys, semi-structure questionnaire interviews and focus group discussion using the

procedures described in section 3.2. The interview guide questions were open, to avoid limiting farmers' responses.

Consistent with the research questions and objectives, the study applied cross-sectional, exploratory and descriptive research designs. To reach out to the target sample for focus group discussions – which took place in the second research phase – the researcher contacted agricultural extension workers in the sample sub-counties. Extension workers are well-placed to identify farmers who are able to share their experiences, particularly after receiving a systematic briefing and specifications from the researcher. The extension workers were given sheets containing the names of respondents who had participated in the first research phase. This was important in controlling systematic bias (Powell & Single, 1996). Information about the first phase and extension workers' on-the-ground knowledge both played a role in identifying farmers for the focus groups, thus counterbalancing any risk of subjectivity (the extension workers did not personally weigh the grain each farmer produced to ascertain production levels). The extension workers then gave their suggested farmers' contacts to the researcher and, jointly, times, dates and venues for the small focus group meetings were agreed. The value of focus groups is that they counterbalance inconsistencies between individuals (Goss & Leinbach, 1996). To provide privacy, preclude interruptions, and assuage any fears of making full disclosure before onlookers, the target respondents were interviewed separately from other smallholder farmers in the community. The focus group discussions were conducted in English and where it seemed complicated respondents talked in the local language: either the researcher or a research assistant was able to translate and record responses in English. This was crucial because farmers would adequately express their views. All translations were cross-checked with a language expert to ensure accuracy; however,

sometimes researchers' translations accurately captured the meaning, but not the colloquial flavour, of respondents' speech. A detailed discussion of this process is provided below, in section 3.5.

The quantitative findings are presented in Chapter Four, and the qualitative findings in Chapter Five, but cross-referencing between these chapters is done to strengthen the argument. In Chapter Six, an integration of the findings in the two preceding chapters relating to the extension of the theory is undertaken. Hypotheses for further study are developed in section 7.4.

3.2 Research methods

Although this research had the option of utilising a quantitative or qualitative research method alone, a mixed method was the most suitable for satisfactorily answering the research questions set in section 1.6. That is, certain research questions requiring generalizability, an account of effects, and causality were best answered using a quantitative approach, while others that required exploring why and how the phenomena occurred and describing farmers' experience were better interrogated using a qualitative approach. This is because combination can counterbalance the weaknesses inherent in each approach used singly (Yeasmin & Rahman, 2012). For this specific study, neither quantitative nor qualitative methods alone suffice to address the questions (Palinkas *et al*., 2015; Symon & Cassell, 2012), because costs of storage could only be measured and estimated quantitatively, while farmers' perceptions were best elicited qualitatively. Earlier studies of smallholder storage practices have also employed a mixed method (Midega *et al*., 2016). Therefore, both quantitative and qualitative methods were utilized in this study, in a concurrent mixed method approach (Johnson & Onwuegbuzie, 2004; Feilzer, 2010). A concurrent mixed

method approach is pertinent for this study because it builds on the strengths and minimizes the weaknesses of each approach.

The mixed method was also chosen to permit triangulation. First, a questionnaire was used to collect data via a survey: this allowed responses from a larger population. Second, an in-depth qualitative study with a smaller number of respondents in focus group discussions and key informant interviews were conducted. Coupled with this, the researcher also observed and verified certain phenomenon. These resonate well with the research ontology and epistemology selected, and discussed in section 3.1.1. Analyses from each part of the research process were conducted independently (Section 3.7), but were considered in combination for the presentation of Chapters Four, Five and Six. The aim was to draw information from multiple sources in a convergent manner for confirmation and completeness that allowed for cross-verification from multiple data sources by matching: for example, the poor storage types mentioned in the focus group discussions were also observed by the researcher. Also, the survey made it possible to understand the context and demographic characteristics of the smallholder maize farmers before engaging them in details. This study adopted triangulation because it deals with human behaviour, which is better studied through different methods (Yeasmin & Rahman, 2012). Such methodological pluralism made it possible to access information on different facets of the study phenomena from different viewpoints, thus enhancing the precision of the findings. For example, the quantitative survey allowed collection of data about storage types, costs and household characteristics, providing the basis for valid generalization. The qualitative approach unlocked the in-depth feelings of farmers about using storage as a business strategy, as the vivid verbatim quotes presented in Chapter Five illustrate.

As noted by Greene, Caracelli, and Graham (1989) and Crowe *et al*. (2017), when two or more methods are used to assess a phenomenon, this enhances the validity of the findings. Sparkes (2015) additionally posits that mixed methods allow for more complete and comprehensive understanding of the phenomena being investigated.

The quantitative approach was essential in describing, estimating and optimizing the costs of storage (Coyle *et al*., 2016), but the lived experiences and perceptions of smallholder maize farmers relating to storage cannot be adequately investigated and conveyed using figures alone. Important unknowns from quantitative research were how smallholder maize farmers see the impact of the different storage types and their cost to the marketing margin share. Smallholder maize farmers' understanding of the cost (in terms of quantity, quality and financial implications) of storage to their share of the marketing margin, and their perception of using storage as a business framework to increase their share of the marketing margin were therefore addressed qualitatively. This pragmatic perspective was needed to fully address the research questions and objectives targeting stallholder maize farmers at household level (Zimmerer, 2004). Figure 4 shows a schematic representation of the research process.

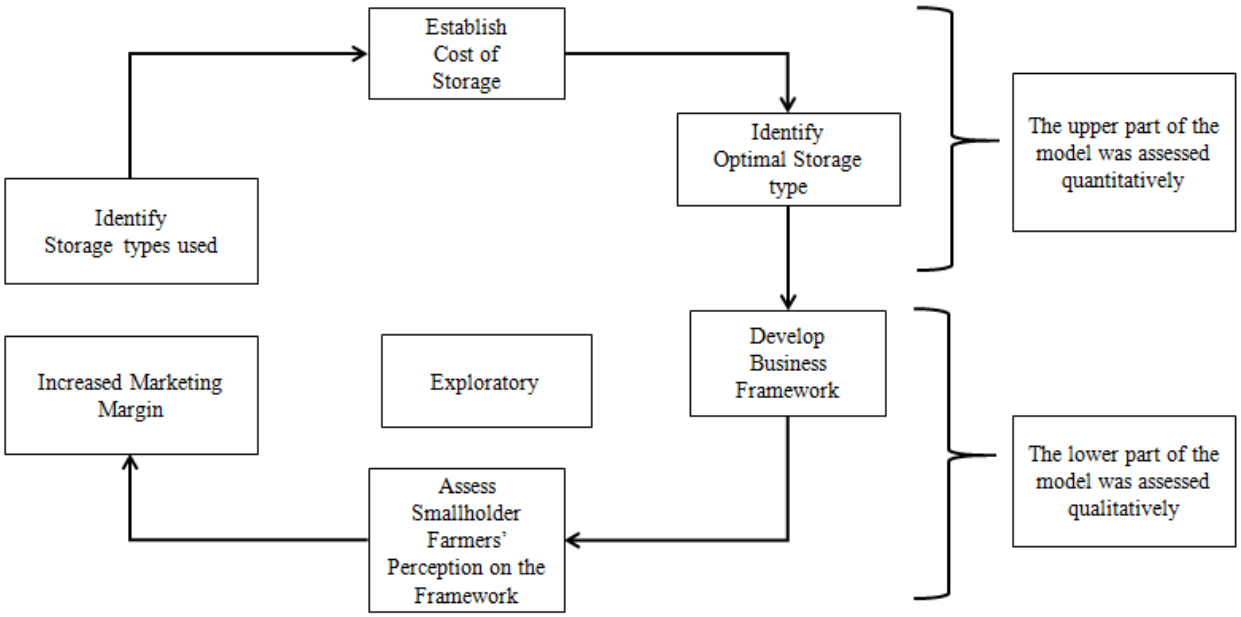


Figure 4: Merging quantitative and qualitative approaches to form mixed method

Source: Developed for this study

Employing concurrent mixed methods in this study to investigate the same phenomena provided complementarity (Johnson & Onwuegbuzie, 2004; Onwuegbuzie & Collins, 2007; Greene *et al*., 1989; Cameron, 2009). Mixed methods also permitted effective triangulation broadened profundity, by incorporating findings from both qualitative and quantitative inquiry and testing the one against the other. Triangulation enabled the convergence and corroboration of results from the different sources. The different viewpoints supported greater precision; the convergences and agreements between the two sets of information enhanced the validity of the results. Results from one method could be used to clarify and enhance those from another: the results from the first phase were used to inform, refine and recast questions for the second phase.

The quantitative component provided data about which factors were more prevalent, and thus could be incorporated into the extended model. The additional insights provided by the qualitative data could be triangulated with the quantitative findings, to establish robustness and enable better

understanding. The researcher was, through this approach, able to incorporate multiple and varied types of research questions, including questions that provided deeper understanding but did not result in testable hypotheses. This is particularly valuable because of the partly exploratory nature of this study, which explores the potential extension of a model.

For sampling purposes, those who participated in the quantitative investigation did not participate in the qualitative data collection. This approach supported completeness: the quantitative data gave a generalizable understanding of the problem and the qualitative data provided detail – key qualities of the mixed methods approach (Ngulube & Ngulube, 2015; Cameron, 2009). Cases were used because they provided detailed descriptions not only of the storage types used but also of the strategic direction of the problems.

3.3 Site selection, description and justification

Uganda is divided into four administrative regions: northern, eastern, western and central. Based on the assumption that demand for storage is a function of levels of production, the Eastern Region was selected because it is the highest maize producing region (as indicated in Table 1). The region is referred to as Uganda's "food basket" because it is the highest maize-producing region in the country. In 2010, the eastern region accounted for over 50 percent of annual national production (Kagoda, Gidoi & Isabirye, 2016). It may therefore be posited that most storage types are likely to be represented in this region.

3.4 Geographical area, sample size and sampling procedure

As a first step, the three Eastern Region districts of Iganga, Manafwa and Katakwi were selected on the basis of the maize produced, for high, medium, and low production respectively. The Ugandan National Agriculture Census of 2008/2009 (Uganda Bureau of Statistics, 2010) clearly elucidates the distinction in maize production per district and sub-county in Uganda. The categorization of high, medium and low is contained in the census report, based on district production levels, and for this reason selection was based on this document.

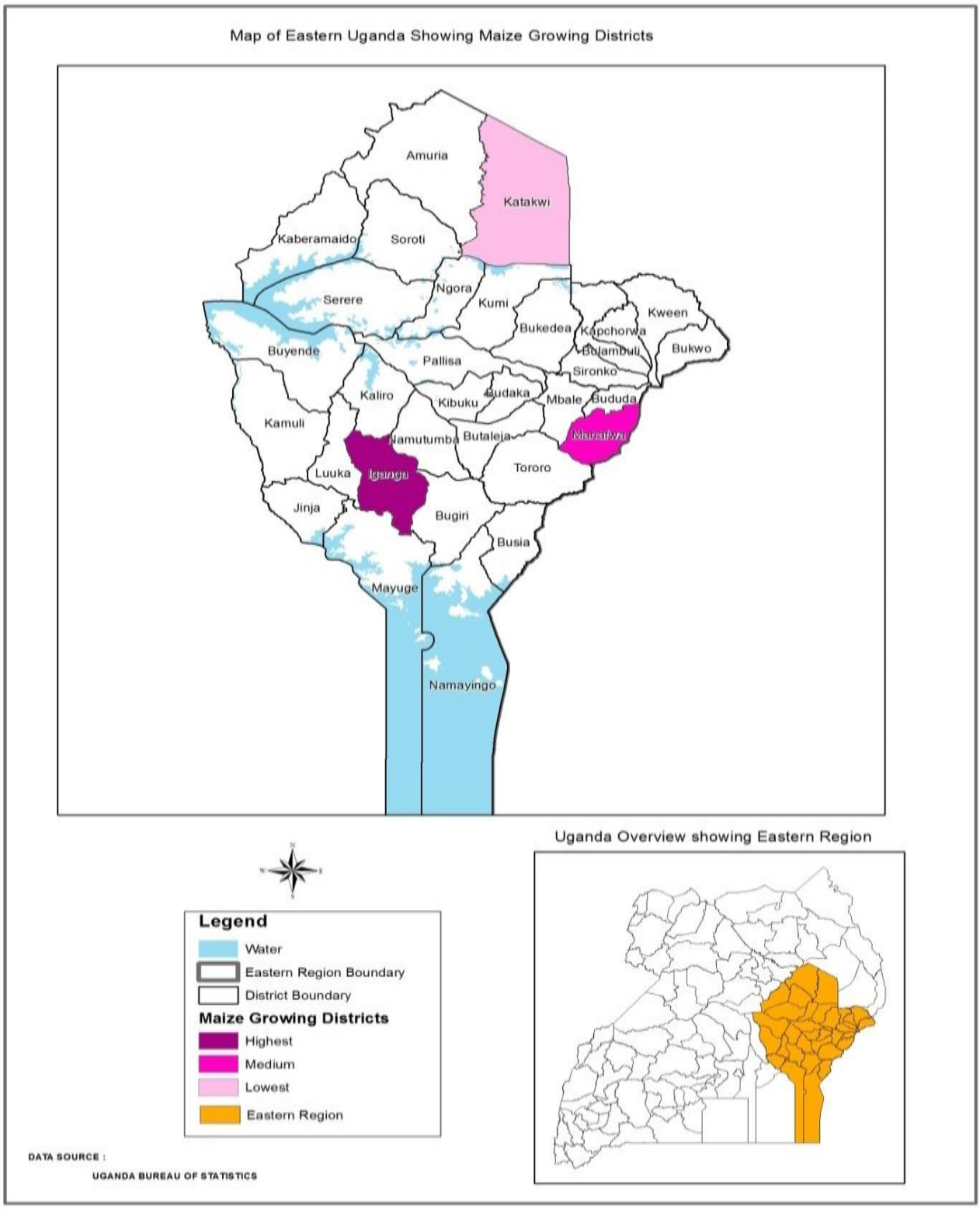


Figure 5: Map of eastern region showing sampled districts

Source: Author's own construction

These districts were selected deliberately on the basis of their maize production levels, resting on the assumption that demand for storage is also a function of levels of production within the selected Eastern Region. The highest and lowest maize-producing districts were selected easily, while the medium-producing district was selected by choosing the district whose production was closest to the average production of all the districts in the region.

The second stage of site selection was to select three sub-counties from each district, also based on the high, medium and low production selection procedure described above for districts. At the third stage, a simple random sample of three villages was selected from each sub-county making a total of 27 villages. From each of the 27 villages, a simple random sample of 10 respondents was selected from a list of farmers obtained from the local leadership or farmers' groups in the village to make a total sample of 270: 90 per district. The characteristics of these farmers were similar, but they operated at different levels of maize production. For all these simple random selection processes, the SPSS random number generator was used. Although the size of the sample was budget constrained, this number was deemed to be large enough to allow statistical inferences to be drawn. Household heads, as defined in Ugandan National Agriculture Census of 2008/2009, were the target respondents. However in their absence, any adult in the household with knowledge of maize storage was interviewed.

For the Focus Group Discussion (FGDs), the extension worker from each sub-county was asked to assist in identifying maize farmers who could constitute the FGD as described earlier. Focus groups were limited to 12 participants for ease of management (Goss & Leinbach, 1996) and to

eliminate concerns about the data saturation that can arise from large numbers (Mason, 2010). Half of each dozen were male, and half female heads of households, which helped to moderate any hidden gender biases in questions or process. Within each group, the extension worker identified four good farmers, four average farmers and four poor farmers based on the amount of maize the farmers produced.

In addition, age was important, because the majority of the population in Uganda is youthful and this needs to be reflected in the research population. For this reason, youth (16-29), adult (30 - 49), and elderly (50 years and above) farmers who had not participated in the survey were targeted. A total of 108 respondents were identified for the FGDs in the selected areas of Iganga, Manafwa and Katakwi. Farmers participating in the quantitative sample survey were eliminated from participation in the FGDs.

3.4.1 Conducting and organizing focus group discussion

Powell and Single (1996) have defined a focus group as a collection of individuals assembled to discuss and comment on personal experiences. It allowed the researcher to ask a group of people about their experiences in maize storage (Reisner *et al.*, 2017). The process is based on interviews that generate verbal data through interaction (Millward, 1995, p.413). Wettergren, Eriksson, Nilsson, Jervaeus and Lampic (2016) further state that this type of data collection, when participants interact in a moderated discussion, offers the possibility of transcending individual interviews. The respondents for these focus groups were smallholder maize farmers who had not participated in the quantitative survey but who shared key characteristics pertinent to the study. Farmers' contact details were obtained and used to call them for appointment in advance (Powell & Single, 1996). Upon accepting the appointment, they were requested to come to the sub-county

where they were briefed as a group about the study and its purpose before the formal discussion began. Consent forms were given to participants to sign, as proof of their willingness to participate in the discussion (Ali, McLachlan, Kanwar & Randhawa, 2017). The participants were informed that both recording and note-taking would be done. The researcher and the research assistants were introduced, an overview of the topic was given, and ground rules for conversation were established. Participants were encouraged to sit in a semi-circle to maximize face-to-face interactions.

The FGDs were facilitated with the assistance of three trained research assistants requested from the Economic Policy Research Centre (EPRC) of Makerere University. These research assistants were already trained: they were masters of business administration (MBA) students with data collection skills, and those selected also had knowledge of the local language and could be used to interpret questions, if the farmers did not understand them in English. In Katakwi, they also translated farmers' vernacular responses into English for the researcher, who was not familiar with that particular language. The quality of the translation was checked for accuracy using an independent English reader who knew the local language. The researcher led the discussion, using the FGD guide (Appendix E); the research assistants acted as note-taker and additionally recorded group dynamics and other observations that could not be captured by the voice recorder. The discussions were audio-recorded.

Because FGDs can explore a wide range of issues (Colucci, 2007), this process enabled the researcher to gain sufficient information about smallholder maize farmers' experiences and perceptions on storage. The free and open discussion provided a wealth of information and many

diverse experiences and perceptions about household maize storage emerged. The FGDs also offered insights into farmers' understanding of their storage and how it influenced their everyday life. The group interactions encouraged participants to make connections (Goss & Leinbach, 1996) between various concepts related to household maize storage. At the end of the discussion participants were given refreshments as a goodwill gesture for participation (Ali *et al*., 2017). One limitation of this process is that no observer monitored the interviews to check such potentially biasing aspects as an authoritarian questioning style; however, recordings of the process are available.

3.4.2 Reasons for key informant interviews

Key informant interviews (KIs) were also conducted with the agricultural extension workers of the different sub-counties. The main purpose of these was to collect information from professionals knowledgeable about the communities under study. Sub-county agricultural extension workers in the high, medium and low producing sub-counties were interviewed. Although the target for KIs was nine, only six actual interviews were completed because three of the key informants were not available at the agreed times. The nine were initially selected on the agricultural system's established basis of one extension worker per sub-county. Of the six completed interviews, three were in Iganga, two in Katakwi and one in Manafwa district. A semi-structured interview format was selected because it allowed flexible inquiry into the selected topic (de Valenzuela *et al*, 2016). To maximize comfort, we allowed the extension workers to propose the date and time for their interviews. These well-connected and informed community experts provided insights about storage problems, and some recommendations for storage improvement. Candid and in-depth answers about maize storage were gathered directly from knowledgeable people.

3.5 Unit of analysis

The unit of analysis was the individual smallholder maize farmer; studied from the perspectives of the storage types used, the challenges experienced and the perceptions of maize storage as a strategy to increase their share of the maize marketing margin.

3.6 Data collection instruments

A structured questionnaire was used to collect quantitative data. The questionnaire was designed on the basis of measurement scales. Scales are devices used to quantify a subject's response on a particular variable, and may be: nominal to name or label variables; ordinal to order variables; or interval to give the order of value plus the ability to quantify the difference between each one. Appendices F & G show the scales used for the variables. The questionnaire contained items on storage decision-making processes and costs; maize production and proportion stored; current storage type and technology used; cost of storage; drivers of storage decisions; maize sales; maize purchases; maize farm gate prices; and maize prices in local markets.

To augment this, smallholder maize farmers' perceptions of storage types and the potential impacts of storage on the share of the marketing margin, as well as smallholder maize farmers' perception of a storage business framework were captured in the FGDs and KIs. FGD and KI interview guides were developed and these are shown as appendices D & E. The questions in the FGD and KI guides were open-ended to stimulate a discourse and allow follow up on the pertinent issues, and as previously mentioned both note-taking and audio-recording were used to record the interaction.

Some of the interview guide questions were adapted from Hell *et al*. (2000), while others were developed by the researcher based on the findings of the first phase, on the premise that the qualitative study was complementary to the quantitative results. In other words, issues reported in

the first phase, but not extensively covered then, were identified for follow-up. Qualitative lines of enquiry were developed to probe these further, after the issues had been identified as themes and aligned to the study objectives. Details of this process are provided in Section 3.8.2.

A sample survey was used in the quantitative phase. The purpose of a sample survey was to develop data from the sample that was generalizable to the broader population, so that inferences could be made about the characteristics, experiences and perceptions of smallholder maize farmers (Onwuegbuzie & Collins, 2007). The survey was done in two waves. The first wave collected all the descriptive data: demographic characteristics; storage types used by smallholder maize farmers; maize prices; quantity produced and consumed; size of land used to produce maize; forms of land ownership; nearest market from homestead where maize is sold; and maize buyers. The first wave of the survey thus helped to clarify all the contextual issues relating to storage types and provided data about the storage types used by smallholder maize farmers.

A preliminary analysis of the first wave survey informed the design of the second wave structured questionnaire, which was used to estimate the costs of storage associated with the storage types identified in the first wave. In the second wave questionnaire, farmers were asked about only those storage types identified in the first wave as having been used by them. Farmers were not asked about storage types they had not used. The second wave survey focused on estimating the costs associated with identified storage types. Both survey waves were conducted through face-to-face interviews.

Concurrent with the second wave survey, the nine FGDs and six KIs were conducted to understand the experiences and perceptions of smallholder maize farmers and local farming experts. This

provided a means to gain a deeper understanding of storage types and choices. The KIs were used to complement and clarify findings from the two waves of questionnaires and the FGDs as well as information on the kinds of extension services available to smallholder maize farmers. Sub-county agricultural officers were selected because they understand the storage challenges facing the farmers they serve and are responsible for solving these.

In summary, after the first wave survey was conducted, a preliminary analysis was performed. This preliminary analysis was used to inform the design of the second wave, and the interview schedules for the FGDs and the KIs. Following this, the second wave survey and the FGDs and KIs were conducted concurrently. While research assistants were conducting the second wave survey, the researcher conducted the KIs there after research assistant joined the researcher for focus group discussion. Every after an interview or discussion we held a meeting replayed the tapes when still fresh to the data to compare it with the notes and picked key themes for further analysis. Subsequently, analysis of the second survey and the FGDs and KIs was conducted, speeding up the final stage (analysis/interpretation) of a three-stage data collection and analysis process.

3.7 Data analysis, interpretation and presentation

Data collected was used to: describe storage types; estimate the amount of maize stored; identify the drivers of storage decisions; estimate costs; identify optimal storage types based on costs; discuss price charged to estimate the share of the marketing margin which the farmers get; and find out how smallholder maize farmers can increase their share of the marketing margin. Subsequently the researcher presents how analysis was done for the two methods.

3.7.1 Quantitative analysis

Analysis was done at three different levels: univariate to assess one variable descriptively; bivariate to establish significant relationships between two variables, and qualitative to elicit farmers' perceptions.

The Statistical Package for Social Scientists (SPSS), version 23, was used to analyze the quantitative data. This enabled descriptive statistics (frequencies, percentages and means) to be aggregated into summaries and tables at district level. Descriptive statistical analysis was used to determine the most prevalent socio-economic characteristics of the smallholder maize farmers. Chi-square and one-way analysis of variance (ANOVA) were conducted to assess the differences between storage in the districts. The level of significance was set at $P \leq 0.05$. The Chi-square test was used to determine if there was a statistically significant relationship between two nominal variables while ANOVA was used to determine whether there was any statistically significant difference between the means of two or more independent variables. Descriptive statistics enabled farmers' characteristics to be described, while the Chi-square test supported determination of the relationships between variables.

3.7.2 Qualitative analysis

Analysis of the qualitative data aimed at exploring four aspects: contextual (what are the farmers experiences and perceptions of the storage?); diagnostic (why do traditional storage types persist?); evaluative (how can these storage types be improved?); and strategic (who are the smallholder maize farmers?) (Ritchie & Spencer, 2002, p.307). The researcher followed Ritchie and Spencer's (*ibid*.) five steps of framework analysis: familiarise to understand the raw data; identify a thematic framework; index where themes apply to their text; map the data to pull similar characteristics together; and define concepts. This framework analysis method is one of the most widely employed for handling qualitative data because of its systematic approach. It is well suited to research that, as this project does, derives its qualitative data from answers to specific questions administered to a pre-designed sample.

Interviews were conducted because they enable a more detailed exploration with few respondents to collect information not captured in the survey. This provided the opportunity to probe for more information and clarifying of means and to observe to assess the authenticity of the answers given. After each interview, the researcher and the research assistant replayed the recording and compared it with the notes while the information remained fresh in their recollections. The aim was to capture key themes for further analysis.

For each focus group discussion, qualitative analysis began with careful organization of the raw data: reading transcripts and interviews from the field to obtain a general sense of the information collected to identify key issues and concepts. Recorded information was replayed to seek more meaningful insights and any which emerged were added to the write-up. Pictures were assembled

and attached to the matching data. The ideas were segmented, putting together information that talked about the same thing or issue, and labeled for theme creation. The themes thus created reflected the original areas of inquiry, plus new themes that had emerged (Table 25). NVIVO 10 software was then utilized to perform thematic analysis.

Verbatim quotations (words, sentences and phrases used to make claims (Sandelowski, 1994)) about the central issue from participants were used to reinforce the points that emerged as themes from discussion; these deepened understanding while providing evidence in participants' own voices. The quotations are presented in italics in Chapter 5, to create a clear visual distinction between the researcher's narrative and the participants' words.

3.7.3 Data coding process

Coding divides data into manageable segments to allow quick access to relevant information. It is a "way of indexing or categorizing the text in order to establish a structure of thematic ideas in relation to it" (Oliveira, Bitencourt, Teixeira & Santos, 2013). Thus the first step in coding the data was to trawl through the data to identify similarities in what was contained in the data. This helped to organise the data and eliminating irrelevancies. Then, a Microsoft Word Document file of the data thus assembled was imported to NVivo 10 software as a new project.

Codes were generated by reading each excerpt several times to ensure familiarity with the content. In this way, codes for the important themes expressed were identified. In NVivo 10 software, the themes were organized into nodes and sub-nodes (referred to as parent and child nodes respectively). Open coding was done by identifying concepts related to the constructs of the study

(Oliveira *et al*., 2013) in order to express the data in terms of these concepts. Word frequency was used to identify key phrases and how often they recurred in the text, which enabled the association of a given code with specific data. On-screen coding stripes of different colours were used to highlight and differentiate the various code texts. The resulting texts related either to themes developed through the literature review (deductive coding) or to new themes emerging from the transcripts (inductive coding). These were highlighted, copied and dragged to their relevant nodes (themes). This process is known as selective coding (*ibid.*). Codes were developed for all the 'big ideas' of the research – for example, storage types used, benefits and challenges, quality and selling price, storage decisions and associated costs, perception of farmers of maize market, perceived selling costs and influence of marketing margin. Each of these was divided into themes and sub-themes: for example, under storage types the sub-themes are traditional and modern. These themes are employed as the headings for Chapter 5.

Data collection was guided by the research questions and objectives (section 1.5 & 1.6). In the first phase of data collection, the interest was to identify only those storage types used by the smallholder maize farmers. A descriptive analysis was conducted to identify all these storage types and reduce the data to manageable categories, as well as to single out the most-used storage type.

Understanding of how extensively any particular method was used, and by which farmers, was based on the averages (means) derived. All this was important to the goal of identifying optimal storage types through cost estimation. Household characteristics were identified through descriptive analysis and estimation of the cost per storage type by a bivariate. To satisfactorily answer the research questions other inferential statistical operations such as analysis of variance

were performed, and these are detailed in Table 1 below. Subsequent chapters – Four, Five, Six and Seven – are thus based on findings derived from the data generated by the survey, the FGDs and the KI interviews.

3.8 Limitations of the study

Given the fact that storage types and decisions are likely to be influenced by the level of production – which varies both seasonally and annually– a longitudinal study would have been optimal. However, because of time constraints, a cross-sectional design was used for this study. It is therefore recommended in Chapter Seven that future longitudinal studies are needed to understand the impact of storage types on smallholder maize farmers' marketing margin over different periods. Also due to budget constraints, one region only was studied. As a result, if certain storage types are specific only to other regions (for instance, to the medium and low producing regions) these may be missed. In this research, the medium and low producing regions were proxied by the medium and low producing sub-counties of the selected, high-producing Eastern Region, but this may not adequately cover all regional variations.

During data collection some information emerged that raised questions. This was probed in more detail, but, where this did not resolve the doubts, it was approximated using current information. For example, where a respondent gave a price far above the expected price, it would be approximated in relation to the current price or using price information obtained from a different farmer in the same area. An additional limitation was any hidden subjectivity that may have influenced extension workers in suggesting farmers' names for discussion group. This was dealt with by requesting the extension worker to select from different villages within the sub-county. In addition, checks were conducted on the list of farmers obtained from the sub-county, to confirm

the selected respondents. Attrition of respondents in the focus group was an anticipated limitation, but this was mitigated by surveying a large sample. The researcher consistently sought clarification from respondents, and used processional immediacy to check for methodological coherence and attain reliability in qualitative collection.

Although the target respondents were household heads, the researcher was aware that sometimes the data required might not necessarily come from household head: for example, the decision to store may be made by two household members or more. This was mitigated by collecting information from all those who made the decision to store: for example, household head, or both household head and spouse.

In the focus group discussion a number of factors affecting marketing margin were raised (see Section 5.8). However, it was not possible to measure the relative significance of each of these factors on farmers' maize marketing margin share and thus they are recommended for future study.

3.9 Relationship matrix for analysis plan

In this sub-section a matrix detailing the link between the research questions and objectives, related literature reviewed, sample population, relevant data collection tools and data analysis is presented (Table 2).

Table 2: Relational Matrix

Research questions	Research objectives	Related literature reviewed	Sample population	Data collection instruments	Data analysis Methods
RQ1: Can the theory of storage be extended to underdeveloped maize markets of smallholder maize farmers in Uganda?	**OB1:** Develop a framework for an extended theory of storage applicable to the underdeveloped markets in which smallholder maize farmers in Uganda participate.	Delgado (1999); Hell *et al*. (2000); Brennan (1958); Jones *et al*. (2014); Affognon *et al*. (2015); Russell and Taylor (2006); Udoh, Cardwell and Ikotun (2000) and UBOS 2008/2009 agriculture census	Smallholder maize farmers	Structured questionnaire	Univariate to assess descriptive single variables, bivariate used to establish significant relationships between two variables using SPSS Version 23
RQ2: Can the storage types of smallholder maize farmers in Uganda be identified and characterized? And if so, do these characteristics affect choice of storage and the maize marketing margin realized by the smallholder farmers?	**OB2:** Identify and characterize the storage types used by smallholder maize farmers in Uganda.	Delgado (1999); Hell *et al*. (2000); Brennan (1958); Jones *et al*. (2014); Affognon *et al*. (2015); Russell and Taylor (2006); Udoh, Cardwell and Ikotun (2000), UBOS 2008/2009 agriculture census and Shepherd (2012).	Smallholder maize farmers	Structured questionnaire	Univariate to assess descriptive single variables, bivariate used to establish significant relationships between two variables using SPSS Version 23
RQ3: What are the costs (quantity, quality and financial) associated with the identified storage types? Do the associated costs affect the share of the maize marketing margin realized by smallholder farmers in Uganda?	**QB3:** Assess the costs associated with the identified storage types.	Delgado (1999); Hell *et al*. (2000); Brennan (1958); Jones *et al*. (2014); Affognon *et al*. (2015); Russell and Taylor, (2006); Udoh, Cardwell and Ikotun (2000). UBOS 2008/2009 agriculture census and Shepherd (2012).	Smallholder maize farmers	Structured questionnaire	Univariate to assess descriptive single variables, bivariate used to establish significant relationships between two variables using SPSS Version 23
RQ4: What is the effect of household characteristics on the choice of maize storage types and length of storage?	**QB4**: Assess the effect of farmers' household characteristics on choice of maize storage types and storage length.	Dawe and Maltsoglou (2014); Shepherd (2012); Eze(2007); Poudel (2013); Sørensen (2002) and Shepherd(2012).	Smallholder maize farmers	Structured questionnaire	Univariate to assess descriptive single variables, bivariate used to establish significant relationships between two variables using SPSS Version 23
RQ5: What are the experiences and perceptions of smallholder maize farmers in adopting and using a storage business framework to increase their share of maize marketing margin?	**OB5:** Explore smallholder farmers' experiences and perceptions on developing maize storage business framework to increase their share of the marketing margin.	Dawe and Maltsoglou (2014); Shephered (2012); Eze (2007); Poudel (2013); Sørensen (2002).	Smallholder maize farmers	Focus group discussion and interview guides.	Thematic analysis using NVIVO 10

Source: Developed for this study

3.10 Reliability and validity

Survey results needs to be reliable, valid and replicable. In this study, reliability and validity were considered and enhanced in the following ways:

3.10.1 Reliability and validity in the quantitative investigation

Every researcher designing a study should be concerned about reliability and validity. Golafshani (2003) defined reliability as extent to which a measurement instrument is capable of producing the same result over a given period of time. It implies the repeatability of the instrument with similar results. In this study, the reliability of the measurement instrument was tested through piloting of the data collection instruments to test for internal consistency (Tavakol & Dennick, 2011).

For this study, validity and reliability were strengthened following Radhakrishna's (2007) five steps. First: the purpose, research questions and objectives, were properly examined in relation to the respondents' backgrounds (such as education level and accessibility) to select a feasible sample. Secondly, using the literature, content questions were developed aligned to the objectives of the study. In the third step, the questionnaire was organised in terms of format, layout, font size, question ordering and the measurement scales used, to ensure readability and construct validity. When the questionnaire had been finalised, its validity was established by answering the following question; is the questionnaire measuring what it intends to measure? Will it be understood by the sample? Is it comprehensive enough to collect information that addresses the research questions and objectives?

Two types of instrument validity are important. Content validity concerns the ability of the questionnaire to adequately investigate all the variables, while construct validity concerns ensuring

that the instrument measures the intended constructs (Noble, Helen & Joanna, 2015). Pretesting was undertaken to further strengthen both of these.

Pre-testing involved administering the questionnaire to a small number of smallholder maize farmers in a similar environment to that of the study. The questionnaire was pre-tested in Luwero district with smallholder maize farmers of similar characteristics to those of the target population. Ten smallholder farmers were randomly selected from five villages in Kalagala sub-county: the total sample for the pre-test was thus 50 respondents. This helped to check if the instruments would capture the desired data in a form that can be measured, and whether effective administration procedures were being followed. Carcary (2009) called this type of activity a research audit, enabling confirmation of the instrument and its reliability to produce valid information. Since validity in quantitative research rests on the measurement instrument, this pre-testing assisted in enhancing validity. In cases where questions seemed ambiguous they were noted down and later rephrased.

Reliability was established via the pilot test, where data was collected from 50 respondents not included in the sample. Data was analysed using SPSS version 16. A reliability Cronbach's α alpha of .801 was observed which indicates the internal consistency of the instrument (See appendix F&G).

As well as conducting the survey through instruments and methods with recognised utility, replicability was further reinforced by administering the instruments to respondents in different contexts, to ensure they all understood it in the same way. Question wording was adjusted wherever necessary to achieve this.

3.10.2 Reliability and validity in the qualitative investigation

For Elo *et al*. (2014), reliability and validity are expressed in credibility, dependability, conformability, transferability and authenticity. To ensure these qualities were present during the qualitative segment of the research, two strategies identified by Morse, Barrett, Mayan, Olson and Spiers (2008) were used. The first concerns researchers' behaviour and the atmosphere of enquiry. The second is the researcher's ability to self-correct during the conduct of research. The researcher consciously aimed to be responsive and adaptive to changing circumstances, sensitive and holistic. He sought clarification, summarized and applied processional immediacy (nearness), and checked for methodological coherence. Before starting the focus group discussions, the ground rules established the desirability of only one person talking at a time, and cell phones being switched off to avoid interruptions. During the discussions, farmers confirmed each other's statements and sometimes volunteered additional supporting information, which increased the reliability of their contributions.

Other strategies – such as peer debriefing of farmers where an issue raised was contested – were encouraged to generate more information about their experiences and perception. This also helped to confirm whether the information given was accurate in terms of the research questions (Nichols & Hunter Childs, 2009). This was done after all FGDs to assess the level of conceptualization of the questions asked in the focus group guide. In addition, prolonged engagement and observation, and audit trails for confirmatory purposes were undertaken (Cutcliffe & McKenna, 2004). Through prolonged engagement and observation – that is to say, by spending more time with the respondents – in-depth understanding of the phenomena was achieved. In the subsequent audit

trail, we examined the qualitative interview guide questions and the answers given and compared these with the notes taken, to identify any inconsistencies.

Verification was done at every level of the data collection process through the audit trails. This was important in identifying and correcting errors before developing the model and analysis. At the planning stage, the most appropriate data collection methods, sampling strategies and unit of analysis, as explained in sections 3.4, 3.5 and 3.6, were selected. Reliability and validity were further reinforced through organization (carefully ordering the information); verification (checking on categorization, interpretation and representtivity); and reporting (full, open communication about how results were created).

3.11 Ethical considerations

Ethics is a critical aspect of any research project (Saunders *et al*., 2009). In research, ethical considerations aim at protecting the subjects of that research (Fahie, 2014). Miller, Birch, Mauthner and Jessop (2012, p.177) and Artal and Rubenfeld (2017), view ethics as the morality of human conduct and note that in the social sciences, ethics is about moral deliberation, choice and accountability on the part of a researcher throughout the research process, to avoid causing harm and to protect individuals. In practice, protecting those involved in research is also a good demonstration of a professional relationship (Miller *et al*., 2012). Ethical research is normally guided by three key aspects: confidentiality/privacy, informed consent from, and no physical or emotional harm to, the subjects of research.

Leedy & Ormrod (2010, p.62) add a fourth to this list: honesty. All four were applied in the research phases of data collection. To enable participants to participate on the basis of informed

consent, information was provided during a briefing process that preceded the signing of a consent form. The form confirmed their willingness to offer information and their awareness that were free to withdraw at any time if they felt at risk of harm (although withdrawing was not encouraged) (Artal & Rubenfeld, 2017). Protection from harm, however, extended beyond protecting identities in the final analysis and providing the freedom to withdraw.

In addition, smallholders participating in the FDGs had a space relatively private from the broader farming community in which to conduct their discussions, and gender balance among their numbers was intended to mitigate gender domination in the discussion process. To protect participants from any risk of bodily harm arising from conflict during the discussions, the FGDs were held at the sub-county offices where security is provided by the sub-county. To protect them from financial harm, farmers were also given transport to avoid their incurring costs through participating in the study. In relation to honesty, all respondents were briefed fully in advance on the nature and purpose of the study: how it would be conducted and what the findings would be used for.

In addition, sensitivities around local custom and culture were considered. The second phase of data collection was done in the planting and weeding season. For this reason, finding respondents in their homes, especially in the morning, was very difficult. In some communities, following farmers to their gardens was considered impolite. For this reason, data was collected in the afternoons when they had returned home. Such displays of respect on the part of researchers increased rapport with the farmers.

CHAPTER FOUR: Smallholder farmers characteristics, associated costs and choice of storage

4. Introduction

This chapter presents the results and findings of the quantitative study in relation to the research questions and objectives. Figures and tables are used to summarize the results and findings. Based on the results, possible explanations and conjectures concerning the phenomena under study are also provided. Post-hoc analysis using the Tukey test was conducted only where the tested relationships were significant, to establish the exact variable categories that are a source of significant relationships.

4.1 Organization of the chapter

This chapter is organized according to the research questions and objectives of the study. First, the demographic characteristics of, storage types used, and choices made by, smallholder maize farmers are described. This addresses the questions about identifying and characterizing the storage genres used by smallholder maize farmers. In addition, this information contributes to the consideration of further questions: whether the characteristics of smallholder maize farmers affect their storage choices and length of storage (and therefore the maize marketing margin they are able to realize); what the costs of different types of storage are; and whether storage costs could be used to optimise storage choice.

(NOTE ON ROUNDING: In the discussion sections of this chapter, decimal points are rounded up or down to the nearest whole number – for example, any figure with a decimal point of 0.4 percent or below is rounded down;0.5 or above, up.)

4.2 Socio-demographic characteristics of the respondents

This section presents the distribution of respondents with different socio-demographic characteristics across their levels of maize production. Table 3 summarizes the results of questions concerning the socio-demographic characteristics of smallholder maize farmers in the quantitative sample, and the commentary discusses the relationship of these characteristics to other aspects of storage investigated, such as decision-making roles.

Table 3: Distribution of socio-demographic characteristics of respondents (%)

Household characteristics	District and Production Level			
	IGANGA High n=90	MANAFWA Medium n=90	KATAKWI Low n=90	Total N=270
Sex				
Male	36	69	64	56
Female	64	31	36	44
Age				
16-29	46	25	49	40
30-49	44	64	39	49
50 and Above	10	11	12	11
Mean (standard deviation)	40(15)	45(14)	40(16)	41(15)
Highest level of education attained				
None	12	3	12	9
Primary	61	53	43	53
Secondary	26	27	36	29
Tertiary	1	17	9	9
Occupation of the household head				
Farmer	96	78	85	86
Salary earner	0	16	7	7
Trader	2	3	3	3
Student	2	3	4	3
Non-response	0	0	1	0.4
Number of people in the household				
1-5	24	33	36	31
6-10	60	57	48	55
Above 10	16	10	16	14
Mean (standard deviation)	7(3)	6(3)	6(3)	6(3)
Household structure				
Household head	45	76	66	62
Spouse	44	18	18	27
Child	10	6	12	9
Grandchild	1	0	3	1
Brother	0	0	1	1

Source: Primary data

In terms of gender, the sample comprised 44 percent females and 66 percent males. In the high maize-growing district of Iganga, women, at 64 percent, comprised the majority of smallholder maize growers. The proximity of Iganga to big towns such as Jinja and Kampala creates a trading

opportunity, and men are predominantly engaged in this activity. By contrast, in the medium- and low-producing districts of Manafwa and Katakwi, agriculture is a male-dominated activity.

However, gender did not coincide with decision-making power over maize storage types (figures presented at Table 13), although being a household head did. Only 20 percent of female farmers were household heads, and household heads in general made the decision about which storage type to use (50 percent) because the financial importance of maize in households makes it a crop whose disposition males decide. However, there were cases where household head and spouse made decisions jointly by household head and spouse (39 percent). Such cases were characterized by a high degree of working together from planting through to storage, which increased cohesion, and the decision to sell was also agreed upon collectively. There were limited circumstances, where a spouse made the decision alone (12 percent). This was most prevalent where the men were salary earners (rather than exclusively farmers), or elderly, or where everyone in a household was producing maize individually (See Chapter Five).

The average age of smallholder maize farmers was 41 years, spread between a minimum age of 16 years old and a maximum age of 90. The high and low maize-producing districts demonstrated a similar average age of 40 years; the medium maize-producing district had a slightly higher average age of 45 years.

Across all districts, smallholder maize farmers had, at most, a primary level of education with a mean average of seven (standard deviation = 4) years of schooling. The minimum years spent in school was zero; the maximum was 16 years. Likewise within districts, most respondents had attained only a primary level of education: 61 percent in Iganga and 53 percent in Manafwa, though only 43 percent for Katakwi.

The average number of people in a household was six across sample districts, with Iganga having the highest number at seven members per household, while Katakwi and Manafwa both had an average of six. A household size of six to ten predominated, with this being the size of 60 percent of households in Iganga, followed by 57 percent in Manafwa and 48 percent in Katakwi. High- and low-producing districts showed an equal percentage of households (16 percent) in the household size category of ten and above; the medium-producing district had only ten percent in this category.

To understand the economic situation of the smallholder maize farmers, their occupational status was studied. Overall, an average 86 percent of respondents were engaged solely in smallholder maize farming: 96 percent in Iganga, 78 percent in Manafwa and 85 percent in Katakwi. These figures portray smallholders who are highly dependent on the success of their farms and have no other financial resource to draw on in adapting their storage, or improving household food and income security.

However, some few farmers were also engaged in additional concurrent economic activities. For example, seven percent of respondents were both smallholder maize farmers and salary-earners (16 percent in Manafwa; seven percent in Katakwi; and none in Iganga). The slightly higher percentage of smallholder maize farmers also doubling as salary earners in Manafwa is due to the proximity of the border. Because Manafwa is near Kenya, it becomes more attractive for those who are employed to also engage in smallholder maize farming, motivated by the availability of a market in Kenya. The remainder of those with dual occupations were smallholder maize farmers who also engaged in trading (two percent in Iganga; and three percent each in Manafwa and Katakwi), or

smallholder maize farmers who were also studying. This reinforces the picture of high dependence on earnings from maize-growing.

4.3 Maize growing characteristics

Table 4 summarizes the hectarage used to grow maize, the maize yield, and the rates for rented land during the second season of 2014/2015.

Table 4: Maize land use and yield by district

Farming Characteristics	IGANGA (High) n=90	MANAFWA (Medium) n=90	KATAKWI (Low) n=90	Total N=270
Total land used for farming in ha	1.5	1.6	1.9	1.7
Land used for maize growing (in %)	55	53	39	48
Maize yield (kg/ha)	1,752	2,331	807	1,630
Rent amount per ha (UGX)[1]	77,800	163,000	94,400	111,733

Source: Primary data [1]Exchange Rate: 1USD = 3,300 Uganda Shilling (UGX) at the time of data collection

The average area of land used for farming in the sampled districts was 1.7ha. It was highest, at 1.9 ha, in Katakwi, followed by Manafwa at 1.6 ha and Iganga at 1.5 ha. The average proportion of land used for maize growing was highest in Iganga at 55 percent, followed by Manafwa at 53 percent and Katakwi at 39 percent, underlining the importance of maize in the production system. The average maize yield was highest in Manafwa at 2331kg/ha, followed by Iganga at 1752kg/ha and Katakwi at 807kg/ha. This accords with other information about Uganda's average production per hectare, which remains low (Oo, 2016). Comparative figures from the SSA region show production per ha, for example, at 2500 kg/ha in South Africa, 1500 kg/ha in Nigeria, 5800 kg/ha in Mauritius and 7100 kg/ha in Egypt (*ibid*).

The amount of land allocated to maize was highest among the age group of 30–49 years old compared to the elderly who are 50 years old and above. The majority of smallholder maize

farmers, 95 percent, were farming land below 1.6 ha; only five percent used land above 2 ha. The small hectarage allocated to maize places a limit on increased production and keeps the farmers trapped in food and income insecurity.

The study found that smallholder maize farmers acquire land for maize growing through four main methods: purchase, inheritance, gifts and renting. Table 5 summarizes the methods used to acquire land for maize growing in the sample district.

Table 5: Method of land acquisition by district

Acquisition method	Name of the district			Overall %
	Iganga (High) %	Manafwa (Medium) %	Katakwi (Low) %	
Purchased	27	34	57	39
Inherited	43	50	28	40
A gift	24	11	10	15
Rent	6	5	5	6
Total	100	100	100	100

Source: Primary data

Land allocated to maize was acquired through purchase (39 percent), inheritance (40 percent), rental (15 percent) or as a gift (six percent). In Iganga, 27 percent, 43 percent, 24 percent and 6 percent of smallholder maize farmers, respectively, had purchased, inherited, rented or obtained land as a gift. In Manafwa 34 percent, 50 percent, 11 percent and 5 percent, respectively had purchased, inherited, rented or obtained land as a gift. In Katakwi those who purchased were 57%, inherited were 28%, rented were 10% and obtained land as a gift were 5%. Overall, smallholder farmers were found to acquire land through two predominant methods: inheritance and purchase. Notably, however, these two acquisition methods act as a constraint on the majority of poor smallholders, whose families may not have had enough land to inherit, but who also do not have enough money to buy adequate land for maize cultivation.

There is a trend towards renting rather than land ownership, and this is likely to intensify as the population grows, because of the fixed supply of land for agriculture. The findings thus also imply a need for improved access to agricultural land, because the small plots allocated to maize (sometimes as small as 0.4ha) limit the amount that can be produced.

4.4 Storage characteristics

Smallholder maize farmers used different storage types, reporting on the types they had used for the second harvest season of 2014/2015. Most farmers (62 percent) stored for consumption purposes. Some stored for sale (33 percent), and as seeds for re-planting (five percent).

Table 6 summarizes the results of the storage types question by district.

Table 6: Storage type used by district (%)

Storage types	IGANGA (High) n=90	MANAFWA (Medium) n=90	KATAKWI (Low) n=90	Average N=270
Granary	0	9	23	11
Crib open	0	0	7	3
Crib closed	0	3	3	2
Basket	0	0	1	0
Above fire	0	0	1	0
House corner	10	11	6	9
House roof	1	0	1	1
Sacks	89	76	58	74
Total	**100**	**100**	**100**	**100**

Source: Primary data

These results show that across all districts, sacks were the most-used storage type (74 percent); granaries were the second most used storage type at 11 percent, followed by house corners at nine percent. Other storage types such as cribs, baskets, above the fire and house roof were minimally used, with baskets, open crib and house roof storage hardly used at all in the high and medium

maize producing districts. Between districts, sack usage stood at 89 percent in Iganga, 76 percent in Manafwa and 58 percent in Katakwi. This may be because sacks are readily accessible everywhere. However, why sacks are not used as much in Katakwi as in Iganga and Manafwa warrants further investigation, and this is discussed in Section 7.4 below.

However, there were other interesting differences between districts. In Katakwi (the low maize-producing area), all eight storage types investigated by the study were used, while in Manafwa (the medium maize-producing area) only four types - house corner, granary, sacks and open cribs - were used. In Iganga (the high maize-producing area), only three storage types - house corner, house roof and sacks - were used.

Some variations in storage type use are easily contextualised. Granaries were used in Manafwa (nine percent) and Katakwi (23 percent) but not in Iganga. In that district, smallholder maize farmers reported that the raw materials for granaries were scarce and thus costly, and that skills too had to be outsourced as farmers lacked the expertise. Farmers more generally reported that baskets were risky compared to sacks because their open tops made them less effective in protecting the maize from pilferage and pest damage.

Additional links between farmers' situation and storage type choice also emerged. Farmers with no education used only three storage types: sacks, house corner and house roof. Male farmers used granaries more than female farmers, for a number of reasons that are discussed as part of the report on qualitative information in Chapter Five. Female farmers used house corner storage more than men.

No female farmers used closed cribs. It was observed that it could be physically challenging to place and remove maize from a closed crib and this may have deterred female smallholder maize

farmers from using this method. Besides, cribs were expensive to construct or purchase and the majority of the women could not afford them (see Chapter Five).

Various preservation methods were employed to protect maize during storage, including sun-drying, smoking, mixing in red pepper or ash mixed with water, pesticide fumigation, and neem tree leaves (a recent innovation) (see Chapter Five).

The findings overall did not support the assumption employed in designing this question, that the use of a specific individual maize storage type is largely a function of levels of production. A greater diversity of storage types was found in the lowest producing district than in the highest. (In the case of the highest maize-producing district, Iganga, that is also where trading is a major activity among men, as mentioned earlier. This is a possible limiting factor on investment in storage types in Iganga.) During the FGDs, some farmers explained that it was cheaper to sell raw maize than to struggle with the demands that storage could make, particularly in the context of their proximity to main trading towns. In addition, smallholder maize farmers admitted to inadequate skills in granary construction. These kinds of varying circumstances are so common among smallholder farmers that storage types can vary within the same country, even sometimes from region to region, as earlier noted by Shepherd (2012).

Broadly, the findings demonstrate that the choice of specific individual storage types was based on a far more diverse range of factors, including farmers' location, as well as on the level of maize growing. Two broad categories of storage types (in-house and non-house) were employed as the basis for other questions, and the relationships between these broad categories and other factors are discussed in more depth under section Section 4. 6.1 below. Chapter Five contains more

detailed qualitative information about why granaries and other innovative methods of maize storage are not a popular choice among smallholder farmers.

4.5 Stored quantities by smallholder maize farmers

Maize is stored for three main reasons; for consumption (62 percent), to sell later after harvest time at a higher price (33 percent) and for seed (five percent). There was a gender difference here: more male smallholder maize farmers (64 percent) than female (36 percent) stored maize to sell later when prices are high. More male farmers (52 percent) also stored for consumption than female farmers (48 percent). This interesting finding demonstrates the function of maize as a dual-purpose crop (Di Domenico *et al*., 2015). Male farmers preferred to keep it because they could both consume it in the household and sell it when they needed money. Even the maize kept as food could be sold when, in emergency situations, there was a need for money (See Chapter Five).

Using analysis of variance (ANOVA) the means of the quantities of maize stored across districts were compared. In Table 7, the quantity of maize stored by level of maize production (district) and storage types are presented.

Table 7: Distribution of quantity of maize stored by district (N=270)

		Tukey's HSD		*p-value*
District	**Mean (Kg)**	**District**	**P>t**	
High (Iganga)	657	Katakwi vs Iganga	0.321	**0.042**
Medium (Manafwa)	916	Manafwa vs Iganga	0.523	
Low (Katakwi)	313	Manafwa vs Katakwi	0.032	
Overall			**629**	

Source: Primary data

The overall mean stored quantity was 629 kg. The *p-value* of 0.042 shows that there is a significant difference between the three sample districts in the means stored. Smallholder maize farmers in

Manafwa stored the highest quantity of maize (916 kg) compared to Iganga and Katakwi with 657 kg and 313 kg respectively. Post-hoc analysis was performed to establish the actual groups causing these significant differences. Applying the Tukey test established that the significant difference resulted from the difference between Manafwa and Katakwi districts (*p-value*=0.032), while the other two contrasts between districts were not significant (*p-value*>0.05).

The average amount of maize stored was 719kg (standard deviation = 1756) among male respondents, and 512kg (standard deviation =1403) among female respondents. Based on ANOVA (p=0.406), it is concluded that this difference between genders in relation to the amount stored is not significant.

Table 8 summarizes the results concerning average quantities stored in the various storage types as described below.

Table 8: Distribution of quantity of maize stored by storage type (N=270)

Storage Type	Sample (n)	Mean Kilograms (kg)[1]
Granary	29	479(761)
Crib(open)	6	263(373)
Crib(closed)	6	2,033(1,936)
Basket	1	20(0)
Above fire	1	2(0)
House corner	24	1,408(4,040)
House roof	2	51(69)
Sacks	201	538(1,134)
Overall	**270**	**629(1,612)**

Source: primary data

1. Standard deviations in brackets

The results tabulated above demonstrate how the quantity of maize stored varied between the storage types used. The usage of storage types was not uniform: as noted, the majority of households used sacks, followed distantly by granary and house corner storage. Because of these variations in the use of storage types, the study chose to compare quantities without testing their significances. Overall, household maize storage was 629 kg (standard deviation =1,612). Of the

three most popular storage types, sacks were used for an average of 538 kg (standard deviation =1,134), granaries for 479 kg (standard deviation =761) and house corners for 1,408 kg (standard deviation =4,040). These relatively high standard deviations indicate how wide was the spread of variations in quantity between households employing same storage type, and for this reason the researcher decided – given the unknown distributions of quantities stored – that further tests of significance would not yield relevant results.

4.6 Factors impacting on storage choices

For this part of the investigation, storage types were categorized into in-house based and non-house based types. The in-house-based storage types comprised sacks, baskets, house corner and above fire; the non-house types comprised granaries, cribs (open and closed) and house roof. The chi-square, as explained by Allan (1980), was used to test for any association between the storage type categories and the different household characteristics assumed to affect the choice of storage type.

4.6.1 Testing for association between storage type category and location (district)

Table 9 summarizes the results of the association, using Fisher's exact test, given that some cells had less than 5 percent counts for association between storage type category and location (district).

Table 9: Testing for association between district and storage type

District	Storage type used		Total (%)	n	*p-value*
	In-house (Sacks/house/baskets)	Non-house Granary/crib			
	%	%			
Iganga	39	2	33	90	0.000
Manafwa	35	26	33	90	
Katakwi	26	72	33	90	
Overall	84	16	100	270	

Source: primary data

The *p-value* of 0.000 shows a significant association between the choice of in-house or non-house storage type by smallholder maize farmers, and their location (represented by district). Although in-house storage types were used in all districts, they were most commonly used in Iganga district (39 percent) and Manafwa district (35 percent). Across all districts, they were used by 84 percent of the smallholder maize farmers in 2014/2015. The non-house storage types, such as open and

closed cribs, house roof and granary, accounted for only 16 percent of usage, mainly in Katakwi district (72 percent).

4.6.2 Testing for association between storage type category and gender

The hypothesis that there is an association between the use of these two storage categories and gender was explored. Table 10 summarizes the results of the chi-square test for association between storage type category and gender.

Table 10: Testing for association between gender and storage type used

Gender	Storage type used		Total (%)	n	*p-value*
	In-house (Sacks/house/baskets) (%)	Non-house Granary/crib (%)			
Male	53	74	56	152	0.009
Female	47	26	44	118	
Overall	100	100	100	270	

Source: primary data

The findings in Table 10 demonstrate that there is a significant association between storage type category and gender. Women in SSA constitute the majority of smallholder farmers (Midegi *et al*., 2016) and they need to make careful decisions about where to store their maize. Male smallholder maize farmers formed the majority (74 percent) of users of the non-house storage type.

The smaller percentage of women making use of the non-house storage category was, in part, attributable to the risks involved, such as theft, and to the cost of storage. Particularly at night, women could not easily guard their maize and preferred to use in-house storage. However, more men than women (53 percent) also used in-house storage. The overall dominance of male farmers in both categories of maize storage may be because, besides being a food crop, maize is also a

commercial crop, and men tend to dominate commercial activities as earlier mentioned. Support for, and detail about, these observations are presented in the FGD contributions (Chapter Five).

In terms of gender differences between districts, the results demonstrate that the majority (66 percent) of those using non-house types in Katakwi were male, compared to 34 percent in Manafwa and none in Iganga. Non-house storage may be more prevalent in Katakwi because of the nature of houses, which are small and round and may allow insufficient room for in-house storage.

4.6.3 Testing for association between storage type category and storage acquisition method

Table 11 summarizes the results of the chi-square test for association between storage type category and storage acquisition method.

Table 11: Testing for association between acquisition methods and storage category used

Acquisition of storage type	Storage type used		Total (%)	n	*p-value*
	In-house (Sacks/house/baskets)	Non-house Granary/crib			
Constructed it	21	84	31	84	0.000
Purchased	77	14	67	181	
Others	2	2	2	5	
Overall	100	100	100	270	

Source: Primary data

The *p-value* of 0.000 shows that there is a significant relationship between how a storage type was acquired and its use. The majority, 67 percent of smallholder maize farmers in all three districts, had purchased the type of storage they used, across all types, while 31 percent had built their own during the second season of 2014/2015. Only two percent had either inherited or been gifted the storage types. Storage at household level is either purchased or made locally. For in-house storage types the pattern is the same: the majority, 77 percent of respondents, using in-house storage types,

had purchased them. Most non-house storage types (84 percent) had been constructed by the smallholders who used them.

4.6.4 Association between storage types and the use of storage over multiple seasons

Table 12 summarizes the results of the chi-square test for association between storage type category and multiple seasonal use of storage.

Table 12: Testing for relationship between use of storage over time and storage category

Seasonal use of storage type	Storage type used		Total (%)	n	*p-value*
	In-house (Sacks/house/baskets)	Non-house Granary/crib			
Last season	7	7	7	19	0.032
Last 2 seasons	4	14	6	15	
Every season	89	79	87	236	

Source: Primary data

The *p-value* of 0.032 shows that there is a robust association between storage type category and the use of the same storage type over several seasons. Eighty seven percent of the smallholder maize farmers in the sample districts reported using the same storage types in "each season" (defined as every time they harvest). Six percent reported using the storage type for one year (the past two seasons) and seven percent reported using the storage type for the last season of 2014/2015. This demonstrates that there was limited innovation around storage types among smallholder maize farmers: the majority adhered to the same storage types.

4.6.5 Testing for association between storage type category and the decision-maker in using a particular storage type

Table 13summarizes the results of the chi-square test for association between storage type category and the decision maker to use a particular storage type.

Table 13: Testing the decision-maker in using a storage type against a given storage category

Decision maker to use storage type	Storage type used		Total (%)	n	*p-value*
	In-house (Sacks/house/baskets)	Non-house Granary/crib			
Household head	50	47	50	134	0.100
Household spouse	10	21	12	31	
Both household head and spouse	40	33	38	105	
Overall	100	100	100	270	

Source: primary data

Although the findings demonstrate that household heads were the major decision-makers regarding which storage type to use, a p-value of 0.100. Findings in Table 13 reveal that there is not sufficient evidence to reject the hypothesis that storage type used does not differ by the sex of the decision maker. In addition, there is no significant association between the decision maker and the storage type used, implying that using in-house or non-house storage does not differ based on the whether the household head or the spouse takes the decision. Maize storage was the concern of the person who produced the crop – not necessarily the household head – and related to his or her reason for producing it. In households where husband, wife and children each produced individually, even storing it would be an individual decision (See Chapter Five).

4.6.6. Testing for association between storage type category and education of the household head

Table 14 summarizes the results of the chi-square test for association between storage type category and the education of the household head.

Table 14: Association between education level and storage type used

Level of education	Storage type used		Total (%)	n	*p-value*
	In-house (Sacks/house/baskets)	Non-house Granary/crib			
No school	11	2	9	25	0.152
Primary level	54	47	53	142	
Secondary level	27	40	29	79	
Tertiary level	8	12	9	24	

Source: Primary data

There was no significant association between the highest level of education of the household head and the storage type category used (*p-value*>0.05). This result seems counterintuitive. However, it may relate to the absence of any significant association between the decision maker and the storage type category shown in Table 13 above. Given that finding, it is possible the education of the decision-maker – rather than of the household head –should have been tested against the storage type category, since it was not always the household head who made the decision. Thus the need to investigate this important relationship is further discussed at 7.4.

In summary therefore, this study showed significant relationships between storage type and four farmer characteristics: location (district), gender, acquisition of storage type and continued use of storage type. No association was found between storage type and two other characteristics: education, and the identity of the decision-maker on storage type.

4.7 Characteristics of smallholder farmers who sold maize.

Since maize is stored for both home consumption and sale, the characteristics of the farmers who sold maize were explored. Smallholder maize farmers were asked whether they sold and/or purchased maize in the second harvest season of 2014/2015. The analysis of different household market characteristics by storage type for the smallholder maize farmers is presented in subsequent sections.

4.7.1 Testing for association between maize selling characteristics and storage type

Table 15 summarizes the results of the chi-square test for association between the maize selling characteristics and storage type of the smallholder farmer.

Table 15: Relationship between maize sales pattern and storage type

Market characteristics	Storage type used		Total (%)	n	*p-value*
	In-house Sacks/house/basket (%)	Non-house Granary/crib (%)			
Sold maize	69	31	68	183	0.263
Sold immediately after harvest	46	42	45	83	0.736

Source: Primary data

Sixty eight percent of all smallholder maize farmers sold maize. Sixty nine percent of those who sold used the in-house storage category while 31 percent used the non-house storage category. However, the findings presented in Table 15 indicate that there is no sufficient evidence to reject the hypotheses that storage type used varies by amount of maize sold, and by whether such maize was sold immediately after harvest or stored and sold later. The act of selling maize was not associated with the farmer's storage category. For example, in all the sample districts farmers indicated that whether a smallholder stored in-house or non-house he or she faced the prospect of either incurring a loss or selling immediately (less than one month) after harvest, because both storage categories were equally unsafe. However, the in-house category was preferred because at least the risk of theft was reduced (See Chapter Five). These findings are also explored in more detail in the table below.

4.7.2 Testing for association between time of sale and storage type

Table 16 summarizes the results of the chi-square test for association between the time after harvest at which a smallholder chose to sell, and the storage type employed.

Table 16: Association between time of sell and storage type

Market characteristics	Storage type used		Total (%)	n	*p-value*
	In-house (Sacks/house/basket)	Non-house Granary/crib			
Time period of sell after harvest	(%)	(%)			
Immediately after harvest	46	39	45	82	0.734
One month	10	15	10	19	
Two months	18	15	18	32	
Three months	9	4	8	15	
Four months	8	12	9	16	
Five months	10	15	10	19	

Source: Primary data

The findings show that the time when the farmers sold their maize was not significantly associated with the storage category (*p-value* of 0.734). Drawing a summary observation from the chi-square test results in both Table 15 and Table 16, there is no significant association between storage category and a smallholder maize farmer's market pattern, sale of maize or timing of the sale after harvest.

4.8 Household characteristics and storage length

This section reports on testing for any association between household characteristics (storage type and category, gender, age, district, household size, hectarage under maize and level of education) and the length of time for which smallholder maize farmers stored maize. The testing employed one-way analysis of variance (ANOVA). Table 17 summarizes the results.

Table 17: Relationship between farmer characteristics and storage length (n=270)

Farmer characteristics	F-value	*p-value*	Mean length of storage (months)
Gender	0.06	0.80	1.31(0.55)
Age	1.92	0.15	1.35(0.49)
District (Location)	2.50	0.08	1.31(0.54)
Number of people in the household	2.71	0.07	1.35(0.50)
Land used for maize growing	4.29	0.01	1.32(0.52)
Level of education	0.52	0.67	1.34(0.51)
Storage type	2.46	0.12	1.36(0.46)
Overall			1.31(0.55)

Source: Primary data 1. Standard deviation in brackets

Table 17 shows that the mean storage length for those who sold maize in the second harvest season of 2014/2015 was 1.31 (standard deviation = 0.55) months. Although maize storage is important, the majority of the smallholder maize farmers do not store for long, underscoring the findings above about selling immediately after harvest.

The findings show no significant association between gender, age, district, education level, household size and storage type and the storage length in months of the smallholder maize farmers (*p-value*> 0.05). The only household characteristic significantly associated with storage length was the hectarage under maize (p=0.01). The more land allocated to maize farming, the greater the likelihood that maize is stored for longer. A larger-scale farmer can produce more maize and has the financial resources to invest in better storage types that can preserve maize for a longer period.

Using land size classification categories of 0.10-1.50; 1.51-3.00; 3.10-5.00; 5.10 and above (in hectare), post-hoc testing using Tukey was done to test for the differences in storage lengths and land area allocated to maize farming in the three sample districts. Table 18 summarizes the results.

Table 18: Contrasts among categories of land allocated to maize farming using the Tukey test

Maize land (hectare)	Contrast	Tukey				
		SE	t	p>t	(95% Conf. Interval)	
1.51-3.00 vs. 0-1.50	0.07	0.09	0.79	0.86	-0.16	0.29
3.10-5.00 vs. 0-1.50	0.18	0.10	1.91	0.23	-0.07	0.43
5.1-Above vs. 0-1.50	0.32	0.09	3.35	0.01	0.07	0.56
3.10-5.00 vs. 1.51-3.00	0.12	0.09	1.22	0.61	-0.13	0.36
5.1-Above vs. 1.51-3.00	0.25	0.09	2.68	0.04	0.01	0.49
5.1-Above vs. 3.10-5.00	0.13	0.10	1.30	0.56	-0.13	0.39

Source: primary data

Further analysis of land allocated to maize farming by the farmer, using the Tukey test, indicates that the significant differences in terms length of storage arises mainly from two categories of land size: 1.5 ha and below, versus 5.1 ha or more; and 1.51 to 3.00 ha versus 5.1 ha or more (*p-value* =0.01).

4.8.1 Current smallholder farmer market behaviour

The average period in month from storage to sale of maize produce varied among the three districts. In Iganga it was (Mean = 2.3; Standard deviation =1.6), in Manafwa (Mean = 2.2; Standard deviation =1.5) and Katakwi Mean = 3.1; Standard deviation =2.0). Using only the proportion of the sample who sold maize, Table 19 shows that 44 percent of those who sold maize, sold immediately after harvest (in less than one month).

Table 19: Distribution of farmers who sold maize at different times (n=183)

Time period of sell	Percentage of farmer who sold at different times
Less than a month after harvest	44
One month after harvest	10
Two months after harvest	18
Three months after harvest	9
Four months after harvest	9
Five months after harvest	10
Total	**100**

Source: Primary data

Eighteen percent of smallholder farmers sold their maize two months after harvest and very few (10 percent) sold after five month. Fifty four percent of those who sold maize, sold two months after harvest. At that time, prices are usually low because that is the time of highest (glut) supply. As a result, these farmers realize only a small share of the marketing margin. Some of the farmers who sell immediately after harvest later face consumption challenges and have to re-purchase maize from the market. However, the fact that there are farmers who attempt to store to sell later (that is, to realize a greater proportion of the maize marketing margin) demonstrates that smallholder maize farmers have some appreciation of the theory of storage.

Additionally, immediately after harvest (less than a month), farmers who have consumed resources while waiting for the maize harvest to mature will face a high demand for cash. This makes it more likely that many, if not all, farmers will sell a portion of their maize immediately after harvest (see Chapter Five).

In addition to establishing what proportion of farmers stored for longer, it thus becomes important to establish what proportion of farmers would have liked to store for longer, what periods they would have wanted to store for, and what constraints precluded them from doing so. It is equally important to establish whether those who stored for longer succeeded in storing for time they

desired. If not, what constraints precluded them from doing so? These are all areas for further study and noted in Section 7.4.

4.8.2.1 Variation in maize selling prices by period of storage

Given that some farmers did store maize and sold later in the season during the second season of 2014/2015, it is important to establish whether the prices realized by that group are higher than the prices realized by those who sold immediately after harvest. Did those who stored maize and sold it later realize a higher share of the maize marketing margin through storage? Figure 6 shows the price variations at different time periods of sale.

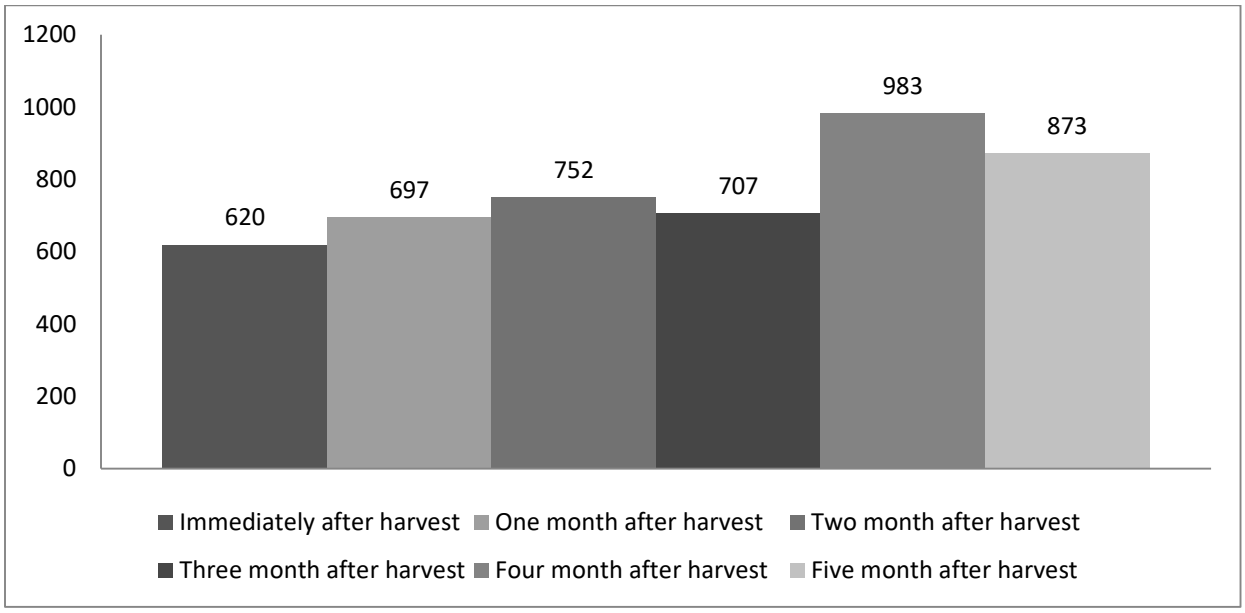


Figure 6: Maize price variation with period of storage 1Price in UGX is per kilogram

Figure 6 shows that when smallholder maize farmers sell immediately after harvest, they get UGX 620 per kilogram. If they store and sell later – for example, after two months – they get UGX 752, and when they store for longer and sell, for example, after four months, they receive a higher price of UGX 983. Farmers who stored and sold later realized a higher price (and therefore a higher

share of the maize marketing margin) and that price increased over the duration of the storage period. This demonstrates the potential for smallholder maize farmers to increase their share of the maize marketing margin through longer storage.

However, because the smallholder farmers themselves often cannot store, due to constraints (including poor storage performance and high storage costs), this potential margin is instead enjoyed by the traders, who buy at low prices from the smallholders immediately after harvest and store only to sell to (some of the same) smallholders later at a higher price, when the smallholders need maize for consumption. The fall in price after five months shown in Figure 6 is a result of the expectation of the new harvest at that point in time.

From this price analysis, it can be argued that if the ability of smallholder maize farmers to store efficiently is improved, then they can increase their share of the maize marketing margin by storing and selling later at a higher price. Since smallholder maize farmers who purchased maize on average paid UGX 938 per kilogram, this shows the potential maize marketing margin farmers could realize if they did not sell immediately after harvest for a price of UGX 620. In addition, if smallholder farmers' storage was improved, their ability to store maize securely for longer would obviate the need to purchase maize in later months at higher prices. It is therefore essential to understand what factors may influence both the period of sale and the storage length.

4.8.2.2 Testing for association between period of sale and smallholder farmer's characteristics

Table 20 summarizes the results of the chi-square test for association between period of sale and farmers characteristics.

Table 20: Association between periods of sell and farmer characteristics (n=183)

Characteristic	Time of sale of maize after harvest					
	Immediately (%)	One month (%)	Two months (%)	Three months (%)	Four months (%)	Five months (%)
Age in years						
16 - 29	40.2	47.4	40.6	33.3	37.5	36.8
30 - 49	56.1	47.4	46.9	60.0	50.0	31.6
50 and above	3.7	5.3	12.5	6.7	12.5	31.6
Chi-square=16.66; *p-value*=0.082						
Gender						
Male	56.1	68.4	59.4	60.0	68.8	73.7
Female	43.9	31.6	40.6	40.0	31.3	26.3
Chi-square=3.00; *p-value*=0.700						
District/Location						
Iganga	37.8	31.6	37.5	46.7	6.3	26.3
Katakwi	32.9	21.1	25.0	33.3	43.8	0.0
Manafwa	29.3	47.4	37.5	20.0	50.0	73.7
Chi-square=23.51; *p-value*=0.009						
Number of people in the household						
Small	32.9	26.3	25.0	26.7	62.5	31.6
Medium	56.1	63.2	53.1	60.0	31.3	36.8
Large	11.0	10.5	21.9	13.3	6.3	31.6
Chi-square=14.94; *p-value*=0.580						
Amount of land used for maize production (hectare)						
Less than 1.5 ha	31.7	26.3	15.6	6.7	18.8	21.1
1.51 - 3 ha	34.1	36.8	25.0	40.0	18.8	36.8
3.1 - 5 ha	14.6	21.1	25.0	20.0	25.0	10.5
5 ha and above	19.5	15.8	34.4	33.3	37.5	31.6
Chi-square=14.06; *p-value*=0.001						
Level of education						
None	4.9	0.0	3.1	6.7	0.0	0.0
Primary	61.0	52.6	53.1	46.7	56.3	52.6
Secondary	28.0	36.8	31.3	40.0	18.8	36.8
Tertiary	6.1	10.5	12.5	6.7	25.0	10.5
Chi-square=10.79; *p-value*=0.767						
Storage types						
In-house	87.8	78.9	87.5	93.3	81.3	78.9
Non-house	12.2	21.1	12.5	6.7	18.8	21.1
Chi-square=2.78; *p-value*=0.339						

Source: Primary data

The *p-value* of 0.009 shows a significant relationship between when the farmer sells his/her maize and where s/he is located. Farmers near towns sold their maize earlier than those who were distant from the town markets, thus making location an important factor in the transaction. Another factor significantly associated with time of sale (*p-value* 0.001) is the amount of land under maize production. As earlier noted, land is often rented for maize production. Those smallholder maize farmers who rent land are often compelled to sell immediately after harvest to pay rent to the landowners, and this may be one component of the association.

The one-way ANOVA *p-value* of 0.000 shows another significant relationship: between land allocated to maize and time of sale. Post-hoc analysis shows that the more land allocated to maize farming generated more maize production and subsequently more storage length and time of sale. Other characteristics – gender, storage type used, education level and household size – were not significantly associated with time of sale.

4.8.2.3 Analysis of storage types by time of sale.

Since some farmers store for sale later, it is important to find out if there are any differences in the storage types used by those who store maize for different lengths of periods for sale at different times. Table 21 summarizes the results.

Table 21: Storage types by time of sale

Storage type used	Time of sale after harvest							Total N=270	Total (%)
	Did not sell n=87	Immediately n=82	One month n=19	Two months n=32	Three months n=15	Four months n=16	Five months n=19		
Granary	11	7	4	3	1	1	2	29	11
Crib(open)	3	2	0	1	0	0	0	6	2
Crib(closed)	1	1	0	0	0	2	2	6	2
Basket	1	0	0	0	0	0	0	1	0.4
Above fire	1	0	0	0	0	0	0	1	0.4
House corner	5	9	1	4	1	1	3	24	9
House roof	2	0	0	0	0	0	0	2	0.7
Sacks	63	63	14	24	13	12	12	201	74
Total	87	82	19	32	15	16	19	270	
% of total	32	30	7	12	6	6	7		100

Source: Primary data

The smallholder farmers who did not sell used all the storage types listed in table 21. However, the farmers who sold maize did not use baskets, above fire or house roof storage. Farmers who store for increased periods do not use these three types because they are less efficient storage options.

Farmers who stored for sale mainly used house corner, sacks, granaries and cribs, as shown in Table 21, with sacks once more the most prevalent storage type. Farmers who stored for three to five months used granaries and open or closed cribs. This finding warrants further investigation to discover which characteristics of these storage types make them preferable for longer storage (discussed in Section 7.4).

The question arises of whether and how storage types (both preferred and non-preferred) could be improved to increase the storage options for smallholder maize farmers seeking to increase their share of the marketing margin. As Table 20 shows, few farmers store for the more extended periods of time. The chi-square was used to test for association between time of sale and storage

type and the finding (*p-value* = 0.360) indicates that there is no significant association between time of sale and the storage type used. This suggests that most farmers may already be optimizing their choice of storage, taking into account factors other than time of sale, such as consumption needs and the need to conserve seeds for planting. This warrants further investigation (Section 7.4).

4.8.2.4 Analysis of costs by storage type and time of sale

Three types of costs were computed: mean maintenance costs (the costs of maintaining the grain in the storage – for example, chemical costs and repair costs); mean amount lost in storage (an estimate of the grain equivalent lost during the storage period estimated in kg and converted to a cost by multiplying it by the price of selling maize at harvest time: a measure of the effectiveness of the storage); and mean acquisition cost (the cost of acquiring the storage). These three values were computed for the whole sample (those who sold maize, and those who did not), and for the six different times of sale. Figure 7 is a stacked bar graph summarizing the results.

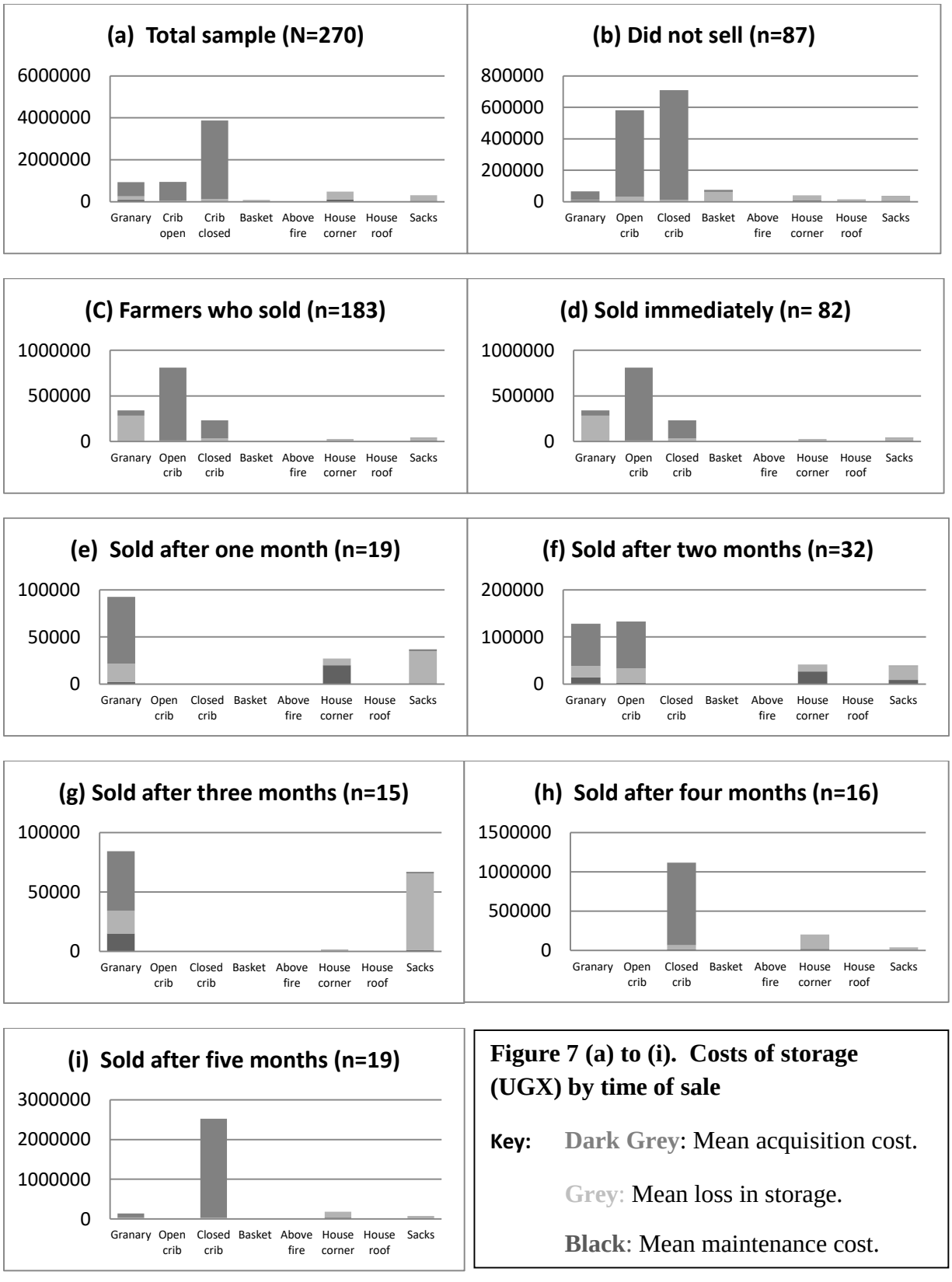


Figure 7 (a) to (i). Costs of storage (UGX) by time of sale

Key: **Dark Grey**: Mean acquisition cost.

Grey: Mean loss in storage.

Black: Mean maintenance cost.

Figure 7: Costs of storage (UGX) by time of sale

Figure 7 shows that the mean maintenance cost was highest (UGX 99,775) among smallholder maize farmers using the house corner storage type. This is because in the open environment of the house more pesticides need to be used. The mean maintenance cost for granaries was UGX 87,545, for sacks UGX 44,260, for closed cribs UGX 23,250, for open cribs UGX 5,500 and for baskets UGX 5,000 with no cost incurred in above the fire and house roof storage. The low maintenance costs of cribs are one aspect of their higher storage effectiveness.

The mean amount of money lost was highest (UGX 379,110) in the house corner storage type, followed by sacks (UGX 249,794**)** and granaries (UGX 172,528), compared to cribs which incurred losses of UGX 102,800 for closed cribs and UGX 37,050 for open cribs. From this data, the house corner emerges as the least effective storage type, while cribs appear to be the most effective.

Figure 7 shows that the acquisition costs are highest for closed cribs (UGX 3,750,000), open cribs (UGX 900,000) and granaries (UGX 677,440) while the lowest cost of acquisition is incurred for baskets (UGX 12,000). Figure 7 also shows the different costs incurred for the different storage types against the time of sale or length of storage. The farmers who stored for longest used granaries, open or closed cribs, house corners and sacks. It is surprising that even given its high maintenance cost, the house corner is still used for long storage periods, but it is probable the zero acquisition costs of this storage type present a strong counterbalancing attraction.

This analysis suggests that when considering improvement in storage types, the focus should be on granaries, open or closed cribs, house corners and sacks, all of which are used by those who store the longest. Given that the closed crib is one of the most effective storage types – but has

the highest acquisition cost – one direction of improvement could be towards making the closed cribs more affordable for resource-constrained smallholder farmers.

Currently, farmers find sacks an attractive storage option. Sacks combine a low acquisition cost (low outlay) and effective storage. However, sacks need to be purchased every year. If the costs of the other types of storage used by farmers are compared to sacks on an annual depreciation cost basis, then they may compare favourably to sacks. Given that, for instance, the closed crib is more effective at storing grain than sacks, as long as the initial outlay can be afforded, the closed crib appears attractive. Thus the affordability and storage effectiveness relationships need to be further explored for the five storage types used by those who stored the longest: granaries, open or closed cribs, house corner and sacks.

4.9 Analysis of costs by storage category

The acquisition cost, mean amount lost, and maintenance cost were compared for the storage categories of in-house and non-house. The results are summarized in Table 22.

Table 22: Mean loss by storage category

Type of costs incurred	In-house Mean (SD)	Non-house Mean (SD)
Mean maintenance cost	7,564 (13964)	8,063 (10247)
Mean money lost	34,530 (51351)	25,305 (22397)
Mean acquisition cost	34,200 (109335)	329,000 (584746)

Source: Primary data [1. SD=Standard deviation 2. Units are in Uganda Shillings (UGX)]

Table 22 shows that the mean acquisition cost was higher for non-house storage types than for in-house. This may provide additional contextual explanation for the earlier observed preference of women for in-house storage types. Where women have lower incomes or earning, as in all sample

districts, the cash outlay for a non-house storage type, even if it might be more effective, is unaffordable (See Chapter Five).

The mean maintenance cost was almost equal for the in-house and non-house storage categories. Table 23 summarizes the analysis of the association between costs and household characteristics of gender, age, education level and location.

Table 23: Test for association between costs and gender, age, education and location

Characteristic		**Average maintenance cost (UGX)**	**Average money lost (UGX)**	**Average acquisition cost (UGX)**
Gender	Male	9,144 (14,294)	33,902 (51,078)	93,370 (338,173)
	Female	8,934 (14,082)	32,840 (44,392)	66,235 (160,098)
		F-test 0.006 *P-value*0.938	F-test 0.621 *P-value*0.431	F-test 0.004 *P-value*0.947
Age	16 - 29	7,551 (10,682)	34,999 (43,326)	91,859 (346,567)
	30 - 49	9,834 (16,444)	30,629 (46,858)	71,015 (222,040)
	50 & above	11,129 (13,592)	40,141 (67,364)	91,055 (182,607)
		F-test 0.871 *P-value*0.420	F-test 0.181 *P-value*0.835	F-test 0.626 *P-value*0.535
Level of education	None	76,43 (21,242)	22,285 (20,418)	49,355 (141,300)
	Primary	94,09 (12,719)	29,574 (41,516)	71,485 (170,244)
	Secondary	94,83 (15,830)	39,672 (44,874)	57,762 (191,864)
	Tertiary	7,057 (5,491)	47,277 (93,088)	251,012 (723,153)
		F-test 0.226 *P-value*0.879	F-test 3.545 *P-value*0.015	F-test 1.879 *P-value*0.133
Location/ District	Iganga	7,286 (13,825)	27,346 (26,754)	38,772 (112,582)
	Katakwi	7,208 (8,685)	35,389 (58,159)	93,598 (192,310)
	Manafwa	12,204 (17,519)	37,562 (53,403)	11,2164 (418,091)
		F-test 5.033 *P-value*0.007	F-test 1.739 *P-value*0.178	F-test 1.107 *P-value*0.332

Source: Primary data [1. Standard deviation in brackets 2.UGX=Uganda shillings]

Table 22 shows significant associations (p=0.007) between location and maintenance costs and between (p=0.015) education level and acquisition cost.

Further analysis was done to compare mean maintenance costs by area. The mean maintenance cost was high in Manafwa UGX 12,204 (Standard deviation =17,519) a medium-producing district compared to Iganga UGX 7,286 (Standard deviation =13,825) a high-producing area and Katakwi UGX 7,208 (Standard deviation =8,685) a low-producing area. A de-motivating high maintenance cost may contribute to smallholder farmers' decision to sell immediately after harvest, reducing their food and income security.

It is important to establish why maintenance costs differ by region. Regional climates differ, and this could be a function of those climates that foster pests and diseases. This area requires further exploration and is listed in section 7.4 below.

A comparison of acquisition costs by level of education was also performed. Acquisition costs were found to be higher among farmers with a tertiary level of education UGX 25,1012 (Standard deviation =723,153) than among those with no education UGX 49,356 (Standard deviation =141,300); primary education UGX 71,485 (Standard deviation =170,243); and secondary education UGX 57,762 (Standard deviation =191,864). The more educated appear to invest in storage more than the less educated. It was observed that household heads with tertiary education were able to acquire good storage and hence were slightly more food and income secure. This is seen as demonstrating their better understanding of the theory of storage (See Chapter Five).

No significant association was found with gender, which is surprising given the preference of women for in-house storage types discussed earlier. However, one explanation may be provided by the low representation of non-house storage types in the sample: 84 percent of storage types were in-house and only 16% were non-house. This area requires further investigation (see section 7.4 below).

4.10 Conclusion

These findings demonstrate the importance to smallholder maize farmers of having good, safe storage at household level. Analysis of the data revealed some significant associations between household characteristics and storage choices and practices. Although younger farmers formed the majority of the sample surveyed (the average age was 41 years) most had, at best, primary level education, which limited their access to information about, and ability to implement, innovation. The majority of smallholder maize farmers hardly changed their storage types; the same type was reported as being used over multiple seasons. As well as age and education, gender had a significant relationship with storage choices. This is an aspect this study was not designed to explore, but clearly one of major significance for future work.

One key factor was the hectarage under maize. The smallholder, who had more land and could produce more maize, was slightly wealthier, had better storage and would strive by all means to keep his grain for longer to sell at a higher price. Where smallholders were situated (and the access this location gave them to markets or additional employment), as well as their relationship to their land (owned or rented) were all factors in their storage decisions.

However, the major factors limiting smallholder maize farmers in acquiring better storage were acquisition and maintenance costs. Maintenance costs in particular greatly influenced when the maize would be sold, because smallholders feared losses during storage.

All these findings are important both at policy level and in refining the extension of the theory of storage. The qualitative data in Chapter Five below add granular detail about farmers' situations

from the statements of the smallholders themselves, illustrating, for example, the often-fraught relationship with traders who benefit from potential transfer payments by buying from farmers at a low price, storing the maize, and re-selling when demand and prices are high. Chapter Six then goes on to explore the adjustments in theory assumptions both qualitative and quantitative results point towards, and Chapter Seven to detail both policy implications and the fruitful areas for further study these findings open up.

CHAPTER FIVE: Farmers' perception of storage business framework

5. Introduction

This research employed a phased, mixed-method approach to provide explanatory data about the phenomena being investigated. The results of the initial quantitative phase have been discussed in Chapter Four. However, because the quantitative inquiry offered respondents limited opportunities to communicate their perceptions and experiences, findings from the qualitative enquiry were equally important, and these are presented in this chapter to provide both description and interpretation of smallholder maize farmers' perceptions of maize storage as a business strategy to increase their share of the maize marketing margin. These findings present significant new information; no such data have previously appeared in the literature.

The findings were derived from focus group discussions (FGDs) and key informant (KI) interviews, both designed to access the subjective meanings of the study phenomena for respondents in the context of their understanding of their own social realities. The data was coded to categorize raw data in manageable sections through processes previously detailed in Chapter Three. Themes and sub-themes were developed to represent the various meanings of participants' experiences as these recurred in responses; these were then categorized in relation to the research questions and objectives.

All FGD participants had grown maize in the second harvest season of 2014/2015 and none had participated in the quantitative survey. Respondents for the KI interviews (sub-county agricultural extension officers) were chosen because of their experience in working with smallholder farmers; every sub-county surveyed has such an officer.

5.1 Ethics, consent and permissions of the study

Qualitative research findings rely on the trustworthiness of the researcher and the respondents. Thus, in accordance with the ethical requirements discussed, and processes detailed, in Chapter Three, participants in the qualitative survey – like their counterparts in the quantitative survey – were required to complete an Informed Consent Form (Appendix A and B) after discussion of its implications with the researcher. FGD participants were identified during discussion by the initials of their surnames, which were written on a label they wore during discussion. However, to maintain anonymity as promised in the consent form, their initials were not used in reporting the findings. KI participants' bio-data per case is presented in Table 24.

Table 24: Key informant interviewee Bio-data casebook and extension services given

Case code	Date	Sub-county/ District	Tenure of respondent	Primary function	Small holders per sub-county	Storage type used	Description provided of extension services offered
Case1	May 16th 2016	Bulamagi Iganga	Half a year	To improve on the agricultural productivity through advisory services.	44000	Sacks, house corner, tins, baskets Jerry-cans, drums	Advise smallholder maize farmers on planting, Accessing seeds, weeding, fertilizer uses, pest identification and control.
Case2	May 16th 2016	Ibulanku Iganga	Five month	Train, advise farmers on how to produce and market the produce.	23000	Sacks, buckets, house corners above fire jerry-cans	Advise them on agronomy practices i.e. on how to plant maize, to plant in lines, two seeds per hole, weed in time and also spray if possible
Case3	May 17th 2016	Makuutu Iganga	Eight years	Advise smallholders on farming practices	7000	Sacks, cribs, metal and plastic silos, triple bags, house corner, tins, basket	Introduce and explain to smallholder farmers' new and improved seeds, storage chemicals to use, how to store, and mixing of the enterprises for success.
Case4	May 18th 2016	Bubutu Manafwa	Over ten years	Advise on agriculture production	200	Sacks, cribs, house corner, above the fire and granaries	Provide demonstration services on planting, weeding, harvesting, drying and storing.
Case5	May 19th 2016	Ngariam Katakwi	Six month	Sensitize community on agricultural best practices. Dialogue on civic problems	600	Sacks, house corner, pots, sauce pan, granaries, tins, above the fire, cribs, hang the maize on trees outside the houses.	Give information on planting methods and seed accessibility, new weeding methods, fertilizer usage, pest identification and control, agronomy where plants and animals are mixed.
Case6	May 20th 2016	Omodoi Katakwi	Close to one year	Help farmers in the production, storage and selling. Provide inputs such as seeds	17000	Sacks, house corner, granaries, above the fire, pots, tin and very few used cribs	Introduce new improved seeds. Give institutions to schools that receive new seeds. Equip demonstration centres to provide guidance. Alert farmers on pests control

Source: Primary data

The KIs role in sub-counties is primarily to provide extension services, working closely with smallholder maize farmers. However, of the six KIs interviewed, four (67 percent) – although not necessarily new to their roles – had worked for less than a year in theses specific sub-counties. Bulamagi sub-county in Iganga District had the highest (44,000) number of smallholder maize farmers, followed by Omodoi sub-county in Katakwi district with (17,000) smallholders maize farmers.

The researcher's target was nine KIs. However, only six were available for the interviews: from Iganga, Manafwa, and Katakwi districts of the Eastern Region of Uganda. Their responses are described in Table 24. The KIs targeted but unavailable for interview were from Katakwi, (Katakwi sub-county), and Manafwa (Butiru and Khabutoola sub-counties).

Although this study focused mainly on storage and share of the maize marketing margin, responses demonstrate that the services provided by the KIs to smallholder maize farmers extend far beyond this to include the provision of market information, the distribution of seeds, demonstrations, and meeting other requirements related to maize production. The extension workers also mentioned training and advising farmers on seed selection, planting, storage, marketing and enterprise selection.

The cases reveal that various storage types were used to keep maize for consumption, sale or future planting, indicating the implicit role of storage as part of a business strategy. The fact that farmers used many different storage types suggests a lack of consensus on a single optimal storage method. It was possible to add detail and nuance to these broad indications through data gathered from farmers in the FGDs, whose organization and distribution are summarized in Table 25 below.

Table 25: Focus group discussion information casebook

FGD Code	FGD Date	District	FGD Sub-county
FGD 1	5/16/2016	Iganga	Bulamagi
FGD 2	5/16/2016	Iganga	Ibulanku
FGD 3	5/17/2016	Iganga	Makuutu
FGD 4	5/18/2016	Manafwa	Bubutu
FGD 5	5/18/2016	Manafwa	Butiru
FGD 6	5/18/2016	Manafwa	Khabutoola
FGD 7	5/19/2016	Katakwi	Omodoi
FGD 8	5/19/2016	Katakwi	Ngariam
FGD 9	5/16/2016	Katakwi	Katakwi

Source: Primary data n=108

The FGDS were conducted in three districts, and nine sub-counties of the eastern region. They were conducted to elicit information from respondents in a more relaxed and naturalistic manner by stimulating their participation. Table 26 indicates how themes were coded, in accordance with the process described in Chapter Three.

Table 26: Theme creation

Research questions	Theme (Parent node)	Sub theme (Child node)	Explanation
What is the effect of household characteristics on the choice of maize storage types and length of storage?	Storage types	Traditional	Methods locally used by farmers to store grains. They are learned from their ancestors.
		Modern	Scientifically proven methods that can prevent grains from pests and mould. They are learned through interactions with agricultural extension workers.
	Benefits and challenges of storage types used	Benefits of traditional	The advantages that accrue to farmer as a result of using the traditional storage type
		Challenges of traditional	The inconveniences that smallholder maize farmers experienced as a result of using traditional storage types
		Modern storage benefits	All the advantages that the farmer enjoys when they adopt modern storage types
		Modern storage Challenges	The costs incurred in order to acquire and use modern storage types
What are the experiences and perceptions of smallholder maize farmers in adopting and using a storage business framework to increase their share of maize marketing margin?	Storage decision making	Household head	The decision of how and where to store maize was made by the household head.
		Spouse	The spouse made the decision alone irrespective of whether the head was male or female.
		All household members	All household members were involved in the storage decision making.
		Reasons for immediate sale	To identify the reasons why they sold at a given time.
	Storage cost	Fixed costs	Costs related to acquisition of the storage types
		Operational costs	Costs incurred in maintaining the storage type
	Perception of storage as a business strategy	Supporting the view	The majority (over 80%) supported the view of using storage as a business strategy.
		Opposing the view	Those opposing the view were very few.
	Perception of factors influencing marketing margin share	Storage costs, time of sale, length of storage, age, gender (see section 5.8)	The factors that influenced smallholder maize farmers' marketing margin and which emerged through the discussion. These factors are discussed in section 5.8

Source: Primary data

The themes generated and listed in Table 26 appear as the headings of the sections that follow. Narrative passages discuss the results of the analysis, with tables and figures employed as adjuncts to the discussion.

5.2 Storage types at household level

Maize that has been properly stored to remain clean and dry commands a higher sale price and increases smallholders' share of the marketing margin. George (2011), has found that inadequate proper storage contributes to significant maize loss in Africa. For this reason storage is an important aspect of maize production and marketing. *"As smallholder maize farmers we must store to sell at a high price. That is to say, without good storage one may never sell maize at a high price and will therefore receive a low price, leading to low share of the marketing margin especially because maize is a crop which tends to get damaged so fast… if not properly stored. But we lack good stores"* (Male farmer, Bualamagi sub-county, Iganga district).

Smallholder maize farmers have traditionally adopted various storage methods to deal with environmental factors that can affect the quality and quantity of their maize while in store. The storage methods reported as used in the second harvest season of 2014/2015 were sacks, granaries, above the fire, pots, drums, baskets, house corner, house roof, cement bags, cribs. More specifically, respondents often used tins and old jerry-cans (because these metal and plastic containers are not easily penetrated by rats and termites), and above the fire storage (because maize infused with smoke is less vulnerable to pests and is known to germinate quickly). Smoked maize is not kept for consumption; tins, jerry-cans and above the fire storage types hold only limited quantities of maize, mainly for planting.

Although some farmers continue to use granaries outside their homes as storage facilities, this practice is declining because of the vulnerability of granaries to thieves. Those few farmers who still use granaries have bought dogs to help chase the thieves.

Smallholder maize farmers view storage as an effective remedy for many of the problems in their maize business. In the discussion, many recounted how they desired to store for longer so they could enjoy the high prices which develop during the later planting season and increase significantly closer to the next season's harvest.

A participant stated that "*There is a lot of price differences among districts and time of sell. For example farmers who sold immediately after harvest sold at lower price than those who sold say after three to five months. This is the biggest challenge facing the farmers' marketing margin share of price. The inability to store safely increases the risk of loss and reduces our ability as farmers to sell at high prices so as to earn higher marketing margin share"* (Male farmer, Balamagi sub-county, Iganga District). Similar findings were obtained in the quantitative study described in Figure 6, Chapter Four. Other participants argued that having good, safe storage is important in keeping maize for a longer period, not only for sale but also for consumption. Storing for longer and selling at higher prices would enable them to benefit more from their maize production. Participants in the FGDs stressed that it was strenuous to produce maize and lose it during storage, while many people have nothing to eat.

Participants explained that the maize business would only benefit smallholder maize farmers if they had better storage facilities, which would reduce the reasons for selling immediately after harvest. As it is, poor storage limits smallholders from taking advantages of seasonal maize price variations and encourages early selling of maize. To avoid experiencing these kinds of losses, some well-to-do smallholder maize farmers have adopted modern, expensive storage types affordable only by a few. However, the expensive nature of these modern storage types makes them

ineffective for smallholder maize farmers. Once a storage type is too expensive for the user, it is considered ineffective. Jones *et al*. (2014) argue that for storage to be effective for smallholder maize farmers, it must be within their financial reach.

One participant noted: *"Few farmers in Iganga who joined farmers' groups got an opportunity to buy 'triple bags' and 'metal silos'. The triple bags and the silos have an advantage that they limit air from entering which kills the pest that could have entered. Also the maize kept in triple bags or silos can be protected from the rats as well as pests because the bag and silo cannot be eaten by rats. The silos can store up to 500 kilograms of maize but they are expensive to buy. A silo that keeps 500 kilos of maize is bought at UGX 198,000/=, while a triple bag of 100 kilograms is bought at UGX 7000/="* (Male farmer, Ibulanku sub-county, Iganga District).

The two quotes below are some of the most striking responses from the smallholder maize farmers.

Coding quotes: *"During the last season the yield was low and I stored in one of the corners of my house. My house is cemented. I kept maize for two months and we kept sun-drying it. I do not use the sacks because rats eat the sacks so you have to buy sacks often. Sometimes I keep maize grain in the used/old jerry-cans that can no longer fetch water and continue to sun-dry. When maize is kept in the jerry-cans, the rats think it is water and so the jerry-cans are not attacked. I keep my maize for long but continue sun-drying it as a way of protecting it from mould, rot and pest. I sold my maize when many of my fellow farmers had sold off their maize, for fear that they would resort to begging maize from me* (Female farmer, Makuutu sub-county, Iganga district)*."*

Coding quotes: *"I got a chance and joined Difansubira Farmers Group as members of one family (team). This has helped us to acquire modern storage types. I use the metal silos and triple bags. I bought these from an NGO. One of my silos keeps 500 kilograms and another 300 kilograms. The triple bag keeps 90 kilograms. I also have a thresher, so I do not beat my maize to thresh. I acquired the thresher from USAID because of the farmers' groups that we formed in this area. With the use of silos and triple bags my maize is protected from rats and other pest. More so I do not have to sun-dry regularly because the silos and triple bags were designed with technology that does not allow oxygen to enter once they are closed" (*Male farmer, Makuutu sub-county, Iganga district).

However another participant noted that *"the majority of the farmers in this area uses sacks because the triple bags are expensive but also work as individuals and oppose the idea of forming groups"*

(Female farmer, Makuutu sub-county, Iganga district).

These two cases illustrate important differences in storage, and show the potential of using storage as a business strategy. The first-quoted smallholder maize farmer who uses traditional storage, incurs losses in storage, stores for a short time and has to repeatedly sun-dry to ensure that the maize does not get damaged. However, in the second case, because of the modern storage he has adopted, the farmer can store for longer and with less fear of pest damage. These findings concur with those of Kimenju and DeGroot (2010) whose Kenyan study of alternative maize storage technologies found that longer storage in larger storage types offers the most benefits to smallholder farmers.

With modern storage, the assumption is that smallholders can keep more maize, more safely, and for longer periods, making these types more efficient compared to traditional storage. One participant reported *"We the smallholder maize farmers may never gain much from maize due to storage problems. This is because costs associated with storage stop us from storing and makes it impossible for us to store and benefit from long storage. Costs of acquisition and maintenance are greatly influencing farmers' ability to store and benefit from high prices. However, I am aware and excited about using storage as a strategy to increase my earning but because I cannot afford to have better storage it limits me from utilising storage to the maximum"* (Female farmer, Ngariam sub-county, Katakwi district). However, the high costs of modern storage referred to above provide only one explanation of why smallholder maize farmers have continued to use traditional storage despite its comparative inefficiency.

Smallholder maize farmers revealed a wider range of additional reasons for their continued use of

traditional storage types, although they were all interested in keeping maize for longer to benefit from the convenience yield (benefits that accrue to the holder of inventory: Kaldor, 1939). Yet they are constrained by a plethora of challenges. The FGD finding shows there are many impediments to effective maize storage at household level. Respondents cited their immediate need for money to solve household challenges as one of the reasons why they do not store grain for longer. Other reasons included the inadequate quantity produced and price fluctuations, as well as poor storage facilities that increase the costs of storage. The majority (about 70 percent) of these smallholder maize farmers would have preferred to store and sell later, but were unable to do so because of all these challenges.

When asked whether they were interested in storing outside their home in communal storage facilities, respondents quickly said "no". One participant mentioned: *"We do not trust the store owners and those stores have limitations on quantity and quality requirement. More so, the maize would lose weight to the extent that, if you store 100 kilograms you would get less than that, which is sometimes decided using manager's eyes"* (Female farmer, Bulamagi sub-county, Iganga District). Thus even where such facilities exist, smallholder maize farmers are unwilling to utilize them. The issue of weight loss in storage greatly discourages communal storage and precipitate conflict between store managers and farmers, because estimating the weight loss is challenging, and some farmers do not want to bear such losses. Consequently, the majority of smallholder maize farmers continue to prefer storing their maize in household storage because they can watch over it and will not have to blame anybody else for any weight loss. These discussions illuminate why the majority of smallholder maize farmers continue to opt for household storage despite the challenges.

Yet while some remain wedded to diverse traditional storage types (as shown in Figure 8 below), others are switching to modern storage types (in Figure 9). This transition from traditional to modern is not smooth, as it requires technical and financial resources on the part of the farmer concerned. Storing in either way brings differing benefits to the holder of the maize. Study participants also conceptualize the benefits of maize storage as being multi-facetted: stored maize contributes not only to the marketing margin but also to consumption, sale and planting (which were mentioned throughout the FGDs) as well as prestige – large maize stocks create a perception of wealth – and brewing local beer.

All farmers (108/108) reported an interest in deriving convenience yield from the storage of maize. However, the nature of the storage types that many households use jeopardizes the expected convenience. Convenience varies with the effectiveness of the storage they can access, which places many smallholder maize farmers in a predicament, even though they are aware of the right time to sell at a higher price and the need to store until then. However, most are unable to store effectively due to their poor storage facilities. This, in turn, raises the cost of storage for those who opt to store and sell later.

The modern storage types recommended by many scientists as a way to improve household storage have not created a significant change, and are less widely adopted because they are expensive for the majority of smallholder maize farmers. Consequently, smallholders have continued to use their traditional storage types, even when holding stock to sell later is known to be a profitable practice (Geman & Tanaru, 2013).

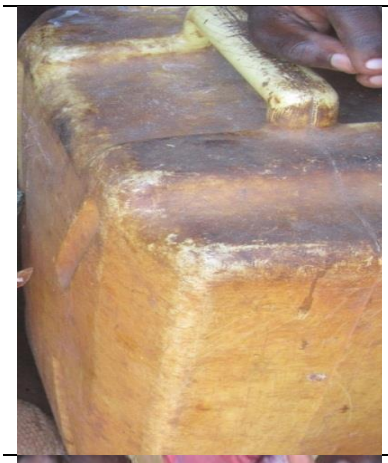
Respondents from the sample explained that many smallholder maize farmers desire a storage type

whose cost does not put them in financial difficulties, and this partly explains why they have continued to use traditional storage types. One participant stated *"(...) our ability as farmers to adapt to modern storage is still difficult due to cost of purchase for example the purchase costs are very expensive for the majority of smallholder maize farmers to afford"* (Female farmer, Bubutu sub-county, Manafwa District). Yet despite this, for all the FGD participants (108/108) consensus was evident that storage could be used as a business strategy to increase smallholders' share of the maize marketing margin.

Smallholder maize farmers expressed willingness to improve their storage for business purposes. A constant theme in the FGDs was how poor storage is jeopardizing farmers' food and income security, and that if they could be helped to have better storage they could become more income and food secure. This is consonant with Tefera *et al.* (2011) whose study conducted in Nairobi Kenya found that safe storage is crucial for food and income security, poverty alleviation and prosperity for smallholders.

5.3 Benefits and challenges of traditional storage type vs. the modern ones

Figures 8 and 9 below present field photographs taken to show some of the storage type used. It also indicates the challenges, benefits and coping mechanism of smallholders. Figure 8 shows traditional storage types and Figure 9 some of the modern storage types that farmers are adopting. Below the figures, farmers' challenges and adoption strategies are explained.

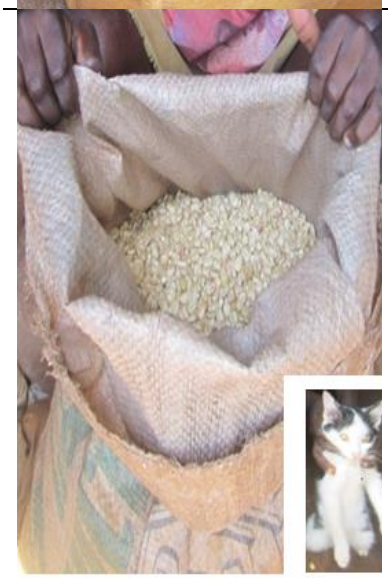


Usage of old Jerry-can

"Using the jerry-can is the best way to keep my maize because it cannot easily be attacked by rats" (Female farmer, Bulamagi sub-county, Iganga district). Farmers use old jerry-cans which can no longer fetch water. Sometimes they buy new ones at a cost of UGX 5,000/=. A jerry-can can be used for 3-4 years if nothing happens to it.

Benefits: Maize cannot be attacked by rats quickly: "*Rats think the jerry-can is carrying water"* (Female farmer, Bulamagi sub-county, Iganga district). You can easily lift the jerry-can in case of sun-drying. It enables the farmer to tell his quantity of maize easily.

Challenges: Maize can still be damaged by pests, and the closed container can encourage mould growth if the grain is not sun-dried **Coping mechanism:** Farmers regularly sun-dry the maize



Usage of Sacks

Most farmers have used sacks for over ten years. They buy them from the nearby markets or shops at a cost between UGX 1,300/= and UGX 1,500/=.

Benefits: "*Sacks are accessible and affordable. Sack may be used to store maize for six months to one year before replacing it. You can keep maize in a sack and put it inside the house, unlike using the granary. Hence, no one can steal your maize since it is kept inside the house apart from the household members"* (Female farmer, Omodoi sub-county, Katakwi District).

Challenges: One has to keep sun-drying the maize every after a few days or else it rots, and sacks are also highly attacked by rats and pests. During the process of drying, the farmer can lose some kilograms as the maize is eaten by birds.

Coping mechanism: Many farmers buy cats to eat rats, use neem tree leaves, ash mixed with water, red pepper and pesticides to prevent pest damage.

Usage of Closed crib made of poles

"*A crib of this kind is built using poles, nails and iron sheets. Poles are more accessible compared to wire mesh because they can be obtained at no cost from the forest, or bought more cheaply than wire mesh. Such a crib can last for 5 years without major renovations. However, it is more expensive to construct than a granary"* (Male farmer, Bubutu sub-county, Manafwa District).

Benefits: You can store many kilograms of maize in the crib and you do not need to carry maize for drying on a regular basis because it enables continued drying.

Challenges: It can be attacked by termites and thieves because it is outside the house, but it is also very hard to control pests through use of pesticides in the crib.

Coping mechanism: Farmers continually add pesticide to prevent termites and rats; some buy dogs to alert them in case of thieves, and cats to eat the rats.

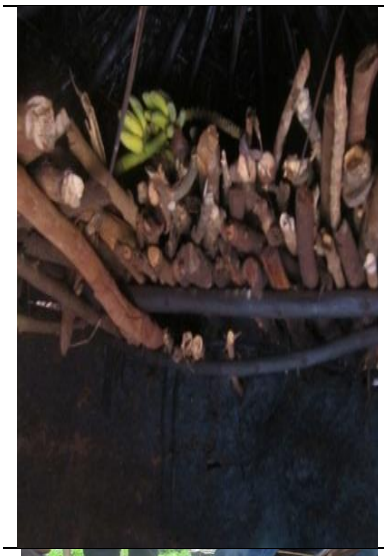
	**Above the fire** Farmers discovered that maize for planting can be kept above the fire for a very long period of time. Some farmers have therefore constructed platforms above the cooking place to keep their maize, so that rising smoke and heat keeps drying the maize. They use poles and nails or sisal to create a table-like platform. This platform is multi-purpose as it can be used to keep other items such as firewood when there is no other storage space. It costs about UGX 30000/= (depending on the size) to construct. **Benefits:** *"When maize is kept above the fire, it does not get attacked by insect or pests and it germinates quickly when it is planted"* (Male farmer, Omodoi sub-county, Katakwi Distict). **Challenges:** Maize loses its original colour due to smoke and can only be used for planting. **Coping mechanism:** Building a better cooking place to enable the construction of a bigger platform**.**
	**Usage of pots** The use of pots to store maize is an ancestral technology that has been adopted by some smallholder maize famers. "*The pot's mouth is closed with a smaller pot and is usually smeared with cow dung to keep away pests and deter rat penetration"* (Female farmer, Katakwi sub-county, Katakwi district). The pots are placed on short logs or put on stones to raise them above the ground. A pot like the one in the picture sells for UGX 20,000/= from the market. The biggest pots sell at UGX 40,000/= **Benefits:** Pots are safe and can keep the maize clean and free from rats and pest damage. **Challenges:** Pots need to be handled carefully because they are fragile and can easily break. However, when properly handled, a pot can last for over 10 years. **Coping mechanism:** Pots are used by adults only and kept away from children.
	**Usage of Granaries** Granaries are also used to store maize. They are made of local materials such as grass, reeds or small sticks, poles, stones, mud, clay and water. Some farmers smear granaries with cow dung. "*A well-constructed granary can last for 3 to 5 years"* (Male farmer, Ngariam sub-county, Katakwi District). A granary costs about UGX 250000 depending on the size and use. **Benefits:** Granaries allow for the continuous drying of maize without taking it out of the granary. "*If you have many granaries, you can store a lot of maize"* (Female farmer, Omodi sub-county, Katakwi District). **Challenges:** Maize can be stolen by thieves because the granary is never locked and is constructed outside the house. A granary offers easy access to termites, pests and rats. **Coping mechanism:** Buy cats to eat rats and dogs to scare thieves.

Figure 8: Traditional Storage types

When smallholder maize farmers were asked why they continue to use the traditional storage types despite the losses incurred, one typical answer was: *"For me the storage types used are the ones I know and have seen my parents use while growing up. It is very difficult to start using other storage types because I am not sure if they can protect my maize well. On the other hand those other storage types are quite expensive and very hard to find. For the pot, granary and house corner these storage types are within our community and you do not struggle to get any of them. Therefore, because of their accessibility and ancestral attachment for the case of pot, it motivates me to use them in-spite their problems. I also want to continue the storage types that were used by my great grandparents so that my children can know about them. Although they do not protect the maize for long and indeed cause losses, I continue using them because alternative storage types are hard to find and expensive. In my case I have used these storage types ever since I started growing maize and will use them even in the next season" (*Male farmer, Omodoi sub-county, Katakwi district).

Of the many storage challenges of traditional types illustrated in Figure 8, smallholder maize farmers explained that rats were the major causes of maize loss in store: they may eat up to 20 kilogram per sack if the maize is not protected. As a result of rat attacks on the stored maize, one participant explained: *"I have tried to innovate against rats by tying white papers with a hanging string towards the maize heap in the room where the maize is stored so that when the wind blows the papers make noise and chases the rats away but all these are not helping much and so my maize is eaten by rats"* (Female farmer, Ngariam sub-county, Katakwi district).

The second most significant cause of loss mentioned by the majority of the participants was pests. Although there were other causes, such as pilferage, mould, rot, termites and birds, their impact was not as great as that of rats and pests. These observations concur with Kimatu *et al*. (2013) who also observed that smallholder farmers lost five kilos in every 100 stored to pests.

Smallholder maize farmers thus continue to lose their maize, thereby reducing the quantity and quality they have available for sale, lowers the price they can command, and reduces their share of the maize marketing margin. The findings of this study concur with Gorton *et al*. (2012) and Symeonidis *et al*. (2012) in their arguments that holding stock is risky. These scholars further argue that the inventory holder must be willing to bear the risk. However, in the case of the respondents in this study, a key factor is Ugandan farmers' lack of resources for risk-bearing. In SSA, studies show that prohibitive costs of acquisition are among the challenges precluding the adoption of modern storage types (Midega *et al*., 2016).

In Figure 9, the photographs portray the storage types smallholder maize farmers regard as modern. These were relatively expensive and offered better protection to the stored maize than the traditional storage types; these challenges and benefits are detailed below.

Usage of Metal silo

Only one farmer was found using metal silos, and he had bought them from USAID through a World Food Programme scheme. This farmer has two metallic silos of different sizes, holding a total of 800 kilos of maize per harvest.

Benefits: *"A metal silo can keep the maize safe from pests, rats and termites for a long period of time"* (Male farmer, Makuutu sub-county, Iganga District. It is guaranteed for 10 years and if it is malfunctioning can be returned to the vendor for exchange. It is effective in protecting the maize and once the maize is well dried it is protected from moisture or any other environmental contamination.

Challenges: The price of silos is UGX 198,000/= which was considered to be very expensive for the farmer.

Coping mechanism: Farmers use traditional storage facilities while a few were saving money to acquire silos in future.

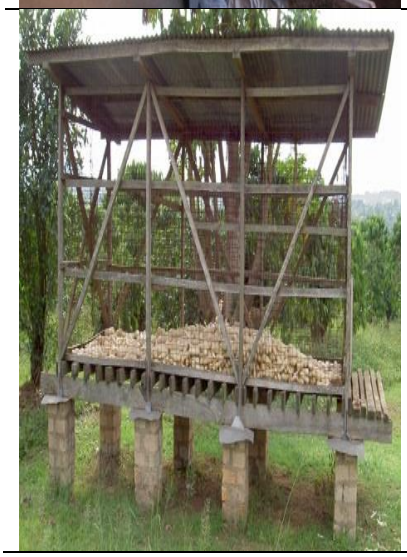
Usage of 'Super Bag' – sometimes called triple bag

This storage technology is still new in the region: it was introduced by a non-governmental organization that supports farmers in 2015. Each super bag is bought at UGX 7,000/= it keep 90 kilos and can last for 5 years.

Benefits: The super bag technology is very safe in storing maize. No pest can enter the sack and even rats cannot destroy it. You can keep the bags in the house to avoid thieves; it is not intended for storage outside the house.

Challenges: Super bags are expensive and not easily accessible. You cannot find them in shops around the villages and they are only found in big towns.

Coping mechanism: Farmers instead continue to use other traditional storage sacks **Coping mechanism:** Farmers instead continue to use other traditional storage sacks



Usage of closed cribs made of wire mesh

Smallholder farmers who grow a lot of maize use cribs made of wire mesh to store the maize. To construct the crib, the farmer needs iron sheets, stones, poles, nails, bricks, wire mesh, rat guards, sand and cement. A well-constructed crib can last for over 10 years. It costs about UXG 1,000,000/= depending on the size.

Benefits: It stores a lot of maize and enables continuous drying. Maize is protected from rats and birds. Due to the good air flow, maize is also protected from mould. You can store maize throughout the dry season and wait to sell when prices increase

Challenges: The crib is expensive to construct. It cannot be used during the rainy season. Maize can be stolen by thieves at night since the crib is constructed outside the house. It is used by those farmers who can produce a lot of maize.

Coping mechanism: Buy dogs to scare the thieves and install 'rat guards' (downward-pointing collars around poles to inhibit climbing).

Figure 9: Modern storage types

5.4 Challenges encountered and consequences for quality and selling price

Although smallholder farmers would prefer to store their maize and sell when the price rises, this poses several challenges, especially since the majority use traditional storage types such as sacks, granaries and jerry-cans, which do not protect the quality of stored maize well and hence lower the selling price. When maize is stored in a sack placed on the ground or floor without any protection underneath, it wicks moisture from the ground and can attract mould.

In some cases maize placed on the floor is eaten by termites. Smallholders therefore often prepare a platform made up of logs or big stones to protect the grain from moisture and termites. When maize is kept for a long time without drying, it can be spoilt by weevils. Farmers therefore have to sun-dry the maize every three to four days. However, if the maize is over-dried it loses weight, resulting in fewer kilos available for sale.

All these many challenges led participants to say, as this one did: *"The storage types I used affected the quality and quantity of my maize and this reduced the price of maize to be sold. These generally reduce the market share because poor quality maize is purchased at low price but also some quantity is lost in the poor storage which reduced the amount available for sale"* (Male farmer, Khabutoola sub-county, Manafwa Distict). This quote is again consonant with Tefera *et al's*. (2011) Kenyan finding that storage at household level remains problematic and affects both the quality and the quantity of the produce.

As has been noted, when maize is stored in sacks, over 20 kilos of maize per sack can be eaten by rats, thus reducing what the farmers would have sold or consumed. However, dealing with rats poses its own problems. It is difficult to eliminate rats and although some farmers use cats or traps, their third option, poisons, carries significant risks.

Prolonged use of pesticides poses a serious health risk for smallholder maize farmers and their families. In addition, some effective pesticides are scarce and expensive, or may be adulterated by traders to stretch them further. All this forces farmers to improvise with locally available protections such as the relatively newly-introduced neem tree leaves, red pepper or ash mixed with water. None of these arduous measures would be necessary if secure storage were accessible and used. In a parallel study conducted in Uganda, poor household storage was found to increase aflatoxin contamination in stored maize grain due to mould, which affects the health of the consumers (Kaaya & Warren, 2005). Consequently some smallholder farmers use pesticides, yet Pingali (2001) in the study conducted in Asia found that the use of chemicals also causes environmental costs through excessive or improper application that eventually affects the health of the farmers.

One participant noted: *"My biggest challenge is losing my maize after harvest when I have struggled all though until when the maize is at home. I wish the government or you people who do research can find options for us to get where to store than waiting to give food when ours is actually damaged by rats, pest, mould or rot. Let them buy for us storage facilities to protect maize"* (Male farmer, Khabutoola sub-county, Manafwa Distict).

Apart from using the traditional storage methods that are more vulnerable to fluctuations in environmental conditions, farmers have the option to contact private agricultural companies that offer to rent modern storage technology for their maize. This could help farmers to keep the maize dry, clean and for a longer period of time. However, the farmers have been skeptical about this method. There is anecdotal evidence – for example, from Iganga – about trusting such companies to provide similar services and being cheated. Others doubt the usefulness of this approach because they believe their production is too small to warrant payment for special storage. Due to their poverty, they prefer to sell their maize immediately.

One participant noted: *"We have storage problems but we do not know how and who can solve it for us. Sometime back a non-governmental organization came to help us but was asking for registration fees. After paying they closed office and took all our money. We now fear to trust anybody because of such thieves. Others want to take a big part of the maize we store with them to take care of the storage costs, making us lose"* (Female farmer, Bulamagi sub-county, Iganga District).

Other farmers simply fear change, because of their own lack of knowledge; one participant said: *"Storing maize using traditional means is cheaper while acquiring modern technology would pose additional costs which are not affordable based on the poverty we are in"* (Female farmer, Bulamagi sub-county, Iganga District).

Such negativity also prevents them from accessing or appreciating information about other alternative technologies that might not be as expensive as, for example, grain silos. Most farmers

choose their storage methods by balancing the amount of maize they harvest against the protection and security that could be offered by a specific storage type, in relation to its accessibility and affordability. This is consonant with the findings of Innes (1993), who argues that storage decisions hinge on storage capacity and protection.

To improve storage quality and eliminate the associated challenges, the farmers in the FGDs suggested that the government should provide technology-based storage materials or build modern storage facilities, where every farmer could keep their maize safe. Government should also provide safe pesticides and preservatives without health related side-effects. Among those who supported this position, one participant argued: *"Farmers need government support if they are to increase on their earning from the maize crop. The support should enable them acquire safe storage facilities to store well so as to bargain for higher price with less fear of loss through storage. The support should be through the agricultural extension workers who directly work with us in our communities"* (Male farmer, Butiru sub-county, Manafwa District). There was, however, vibrant debate between smallholder farmers in the FGDs about the benefits of communal storage versus individual household storage.

Figure 10 provides a comparison between the merits and demerits of modern and traditional storage types. Most smallholder maize farmers argued that modern storage types were relevant only to well-to-do farmers because of their scarcity and cost – the cost of a crib was higher than the cost of the kind of hut many smallholder farmers live in – but they are nevertheless included in this study because a few farmers were found to be using them. FGD participants stressed that their use of different storage types relates directly to differences in financial ability. (For example,

sacks were the most used storage types because they are considerably cheaper than cribs.) Shepherd (2012) argues that storage techniques can differ within a country. Thus any attempt for extension of the theory of storage must take such variations into account.

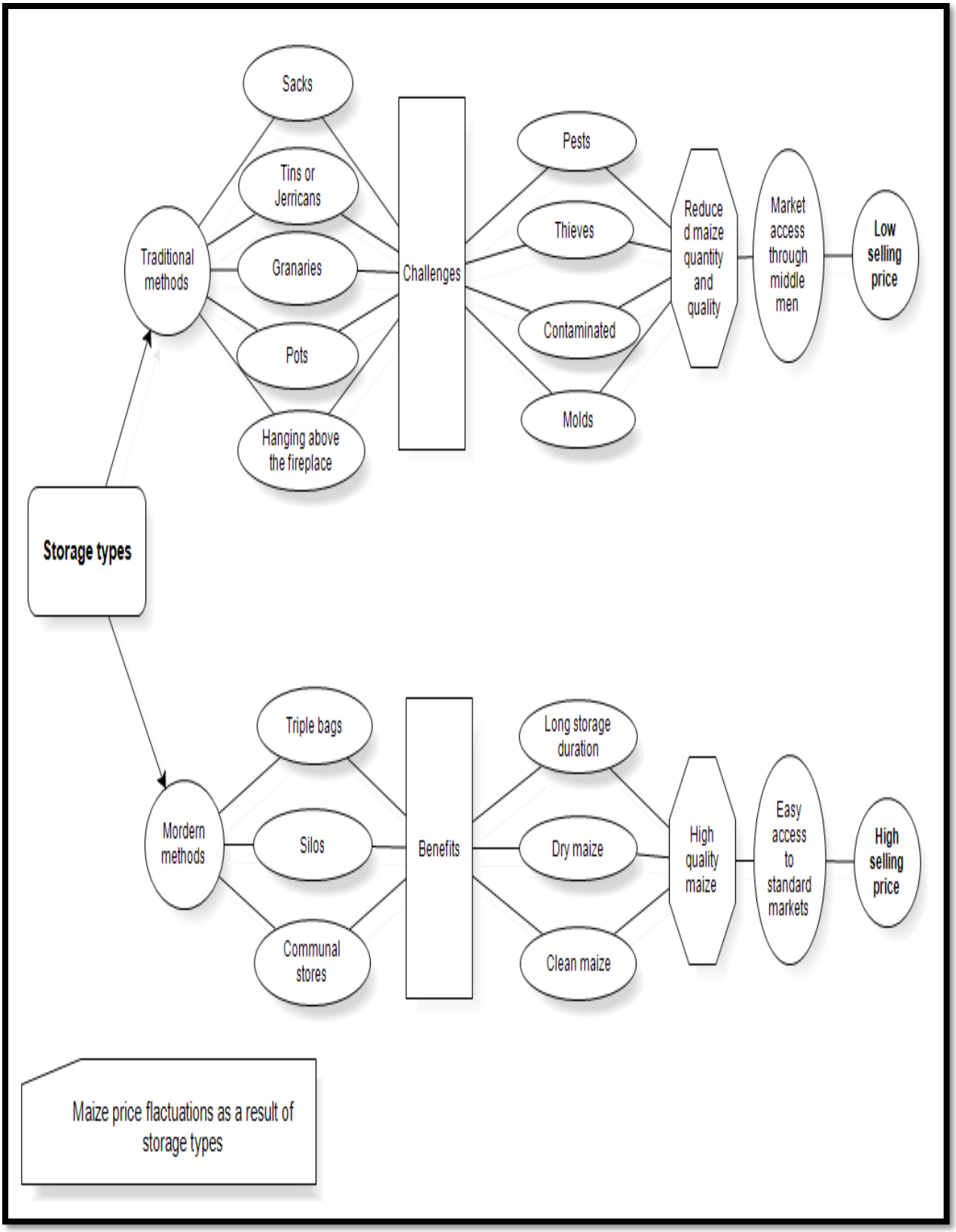


Figure 10: Traditional vs. modern storage types Source: Primary data

The FGD finding that the majority of smallholder maize farmers cannot afford modern storage types signals a need to improve traditional storage to provide the benefits of storage in a way relevant to the social and financial context of these farmers. Smallholder farmers perceive that for them to use storage as part of their business model, they need help in adjusting the ways they store their maize, but their responses in the FGDs provide compelling evidence that the improvement must match their spending capacity and economic situation.

5.5 Maize storage decisions and household decision-making dynamics

Understanding who makes the storage decision helps in understanding the dilemmas around storage smallholder famers face. In a few households, decisions about maize storage are made by both the household head and spouse, because they are both involved in growing the maize. Participants explained that in a few other families, all family members were involved in making the decision, meaning that everyone is obliged to carry the responsibility for storing and/or drying maize. However, in many homes, the household head was considered as the sole decision-maker about both storing and selling maize. One youthful participant explained: *"For us young farmer (the youth) we usually seek advice from our parents on how well to store or sell because we need to acquire experience over time to do it ourselves"* (Youth farmer, Bubutu sub-county, Manafwa District).

However, whoever took the decision, whether to sell immediately or keep maize to sell later depended primarily on the perceived cost of continuous storage. The basic issue was whether the harvest was adequate to meet consumption needs with extra in hand to store and sell later at a high price.

Feeding in to this decision-making was the urgency of a family's financial need. When a household was relatively free from financial constraints, the farmers were likely to store the maize so that it could be sold when the price rose. However, a family could be forced to sell the stored maize at any time if it was faced with an emergency such as the sickness of a family member or the need to pay school fees. Many participants agreed to the view that the storage decision was complicated. One participant reported: *"Maize storage decisions vary from farmer to farmer. There is no one way of reaching such a decision on how to store. Even in households where the husband and wife stay together sometimes everyone will make a decision of where to store and when to sell individually. In my home it is me who make a decision for my maize because I store to eat and sell the balance. My husband also store for selling and planting but when we have no food we can ask him to give"* (Female farmer, Ngariam sub-county, Katakwi District). Generally women kept for consumption while men kept for selling and planting. In the sample males dominated the decision making (over 50%) of the storage type to use. This relates to the earlier findings in chapter four that maize is commercial crop highly attractive to male farmers.

Discussion in the FGDs showed that where decisions were reached collectively by a family, it was often easier to implement those decisions: everyone in the household worked hard to carry it out. However, when different family members enjoyed different levels of authority and status, the power imbalances could produce a final decision that clashed with the wishes of some. Decision-making in households was often very difficult, and sometimes caused chaos in homes. Since maize is a commercial crop, some family members felt that the decision should be made individually if the work of growing maize had been shared equally among them. This caused individual experiences and perceptions about storage, and decision-making about selling and the proceeds of

the sale to differ widely, and prompted both highly individualistic decision-making and even pilferage in some cases. The bargaining power of a seller from such a family may be weakened, to the buyer's advantage. All this may also partly explain some households' reported limited maize availability, poor storage and concealment of market information. These study findings concur with Siaplay *et al*. (2012), whose US study also found that storage decisions were difficult ones. However Siaplay *et al. (ibid.)* situated the cause of the difficulty predominantly in the hard task of matching supply and demand, rather than in these problems of family dynamics and democracy.

Decision-making was most commonly between the options of sell, consume or plant. Among decision-makers, some were market-oriented and others were consumption-oriented. Where the head of a household was male but living with a spouse, the pressure to allocate grain for consumption usually came from female farmer. However, where male farmers lived alone or with young children, they made the decision – and further, in most African settings, household heads are predominantly male. Thus the decision to store for sale may be characterised as more "masculine" (more male-oriented) and to store for consumption more "feminine" (more female-oriented). However, not every smallholder even faced these kinds of market decisions: some sold no maize at all in the second harvest season of 2014/2015.

Almost every participant talked about maize as a perishable that can potentially be stored for a long period (up to five months) if the proper storage technology is used. Households that store maize for a long period are seen as being prestigious, since they can have both maize for food and a balance for sale when the price rises. Table 27 summarizes how decisions for storing maize are

made in households, the reasons for storage, the factors influencing storage decisions and some proposed storage improvement methods that emerged from discussion.

Table 27: Storage decisions, influencing factors and storage improvement methods

Storage decision mode	Reasons for the decision mode	Storage decision influencing factors		Storage improvement methods
		Pro- storage decisions	Counter storage decisions	
Both husband and wife	They both dig together	• When the amount harvested is greater than what the family can consume • When there are no immediate financial needs • To ensure food availability or food security • To ensure availability of seeds during the next season • When the storage space and materials (e.g. tins or sacks) are available • When they are aware of a safe storage type. • For prestige, being known for having food all the time. • To have a continuous maize supply in the home. • It's a business, you can buy and store and then sell when the prices go up.	• When the prices go up • When there are money emergencies • When maize is getting rotten or affected by pests. • Fear of thieves • When the husband demands • When the next season is approaching; to clear the old stock, and prepare for the new harvest	• By constructing good communal stores • Provision of pesticides • Sanitation in the storage facilities • Use of quality preservatives • Use of modern technology such as metal and plastic silos • Constructing safe and permanent cribs • Government to subsidize modern storage materials
The entire family	To make all family members responsible for food security			
Husband only	He is the head of the household			
Wife only	Where a household is headed by a female member			
Farmer makes a decision with parents	Some farmers are young and they need parent's advice			

Source: Primary data

5.6 Perception of the maize market amongst smallholder farmers

The maize market is not regulated in Uganda so the price of maize fluctuates greatly and smallholder farmers who dare to store to wait for higher prices often end up selling at a lower price. These comprise mobile middlemen; local shops/markets; and private maize stores/millers. The most common way of marketing among these smallholders is selling to the mobile traders

who move through communities with bicycles and weighing machines and arrive at the farmers' homes. These mobile traders act as middlemen between the famers and the private maize stores. The sentiments of most participants who sold to middlemen concurred with those of this participant, who stated: *"The advantage of selling to the middlemen is that they find you at your home and save you from the journey of taking your maize to the big maize store or market. However, the associated costs are far beyond the advantages. First, their weighing scales are deliberately fixed to cheat the farmer; if used the farmer is bound to lose some good amount of kilos"* (Male farmer, Butiru sub-county, Manafwa District).

The prices offered by middlemen are lower than those offered by the maize stores and there is no standardized price, because farmers sell individually. Each middleman buys at a different price and the prices can change each time. Farmers who can afford to transport their maize, thus prefer to sell it directly to the major local markets or shops or maize mills, often at a higher price than these farm gate prices.

Seasonality governs maize prices. For example, in January 2016 the prices were lower than in February 2016. Prices increased continuously from April to June, 2016 when everyone had sold off their maize and it was time for planting for the next harvest. Farmers who have been able to store maize up to that time of year often sell at a higher price, although storing for an average period of four months (March, April, May and June) between low and high prices is quite costly. Some smallholder maize farmers prefer to sell cooked or roasted maize in the trading centres, which fetches more money, but has only a limited market. Higher prices per stalk can be obtained when the maize starts drying out during the peak period and fresh maize is scarce. The challenge

of selling raw maize is the limited market available. One participant had this to say about selling raw maize: *"I sell raw maize because it fetches more money than struggling to dry it and sell later. For example each stalk can be sold at UGX 150 to UGX 200 but when it is dried the same stalk cannot generate the same amount of cash because a kilogram of maize grain may be at UGX 400 which requires three stalk and yet if sold raw those same stalk would earn the farmer UGX 600. More so, when you sell raw maize you do not suffer with storage, sun-drying, pesticides which all cost money, time and lead to losses due to pest, rats, bird damage"* (Youth farmer, Makuutu sub-county, Iganga District).

Since maize is grown mainly for income, how the farmer sells is less important to him or her than whether a good price is obtained. To achieve a high return on their maize, farmers need to store when prices are low and sell in periods when prices are high. But the fact that there is exchange of maize for money presents a business opportunity. Farmers know when the prices are high and low, and could therefore use storage to control supply and demand and take advantage of price fluctuations. If the challenges associated with storage could be eliminated, farmers might be more willing to keep maize until a time when they can sell at highest prices. Proper storage at household level also has the potential to benefit farmers at times when variations in harvest occur, because supply and demand are both affected by such variations. When there is over-production the surplus maize can be stored and when there is scarcity the maize can be released from storage to address the surge in demand.

Farmers perceived storage as an important tool for smoothing supply and demand. This implies that with safe storage farmers may rarely run out of maize, which would make them food and

income secure. They explained that they knew when prices were high and would possibly store up to that time but their current storage cannot enable them to do so. If they can store and sell at high prices their share of the maize market share would probably increase. Moreover, safe storage reduces the wastage in store.

Participants explained that the costs of storage – depending on the type used – are known to be a major cause of price variations in agricultural products. If a useful business model for smallholder farmers based on storage is to be developed, attention must be paid to minimising storage costs at the household level including the costs of shrinkage, deterioration and theft. Minimising such costs through safe storage, and thus allowing smallholders to improve the quality and quantity of the maize they store, may ultimately lead them to realise an increased share of the marketing margin, and comments from farmers in the FDGs indicated that they perceived this. Additionally, with good household storage, they saw that they would not only be able to store for sale but also for consumption so that they were not forced to buy at exorbitant prices later in the season.

5.7 Perceptions of selling costs among smallholder maize farmers

A majority (85 percent) of participants reported maize as their major source of income, on which they depend to buy most other household necessities. But because of poor storage facilities, most farmers are forced to sell all the maize they have produced in a given season immediately after harvest, and later buy additional maize for consumption and seeds for the new season. Farmers who try to keep maize for seeds often end up selling or consuming it before the next season because of their need for money.

One participant noted: *"We depend on maize so instead of it getting damaged in store I rather sell at low a price and get the little than [risk] losing it all. Also by the time maize is harvested we already have debts for many things and we have to sell to pay the debts at school, shop and colleagues. How can you keep for selling in future when you are going to struggle with rats, pests and birds?"* (Male farmer, Khabutoola sub-county, Manafwa District).

Another participant said: *"When I keep my maize in the house it attracts people's attention because it is normally in the sitting room. They will ask me for some and may come to steal it. It also occupies space and makes it inconvenient for household and each time they are passing they may take some out, also my hens will keep eating besides getting duty. Therefore, without a separate store it quite hard to keep maize for long"* (Female farmer, Khabutoola sub-county, Manafwa District).

The production level of some households was also too low to satisfy both cash and consumption needs. Due to the scarcity of income in these households, some families end up selling all the maize to deal with the immediate cash challenges and then have to buy more later when the need arises. Several farmers reported that in some homes the harvest is less than the family consumption level. Such households will certainly have to buy maize for consumption. For some farmers the logic is that one is better off selling and then buying later because poor storage does not allow maize to be preserved intact and undamaged.

Participants reported that poor storage facilities force smallholder maize farmers to sell immediately after harvest because they want to avoid losses caused by pests, rats, and pilferage.

Due to poor storage farmers, also do not keep for their home consumption and hence buy from the market later at high price compared to the selling price.

Several farmers reported that in some homes, what is harvested is less than the family consumption level. Such households will certainly have to buy maize for consumption. To some farmers the logic is that one is better off selling and then buying later, because of the poor storage types used that cause maize to rot, get spoiled by pests, or contaminated by domestic animals and birds.

Most farmers complained about the bad state of their storage facilities and noted that not only did this cause losses, but it also denied them the ability to keep maize for food. The reduced quantity means lower potential earnings; reduced quality exacerbates this because of the quality price discount. This situation forces smallholder maize farmers to sell their maize early and buy afresh when the new planting season starts. However, buying later for either consumption or planting adds more costs, as prices rise when supply becomes scarce. Figure 11 illustrates smallholder maize farmers' selling and buying situations.

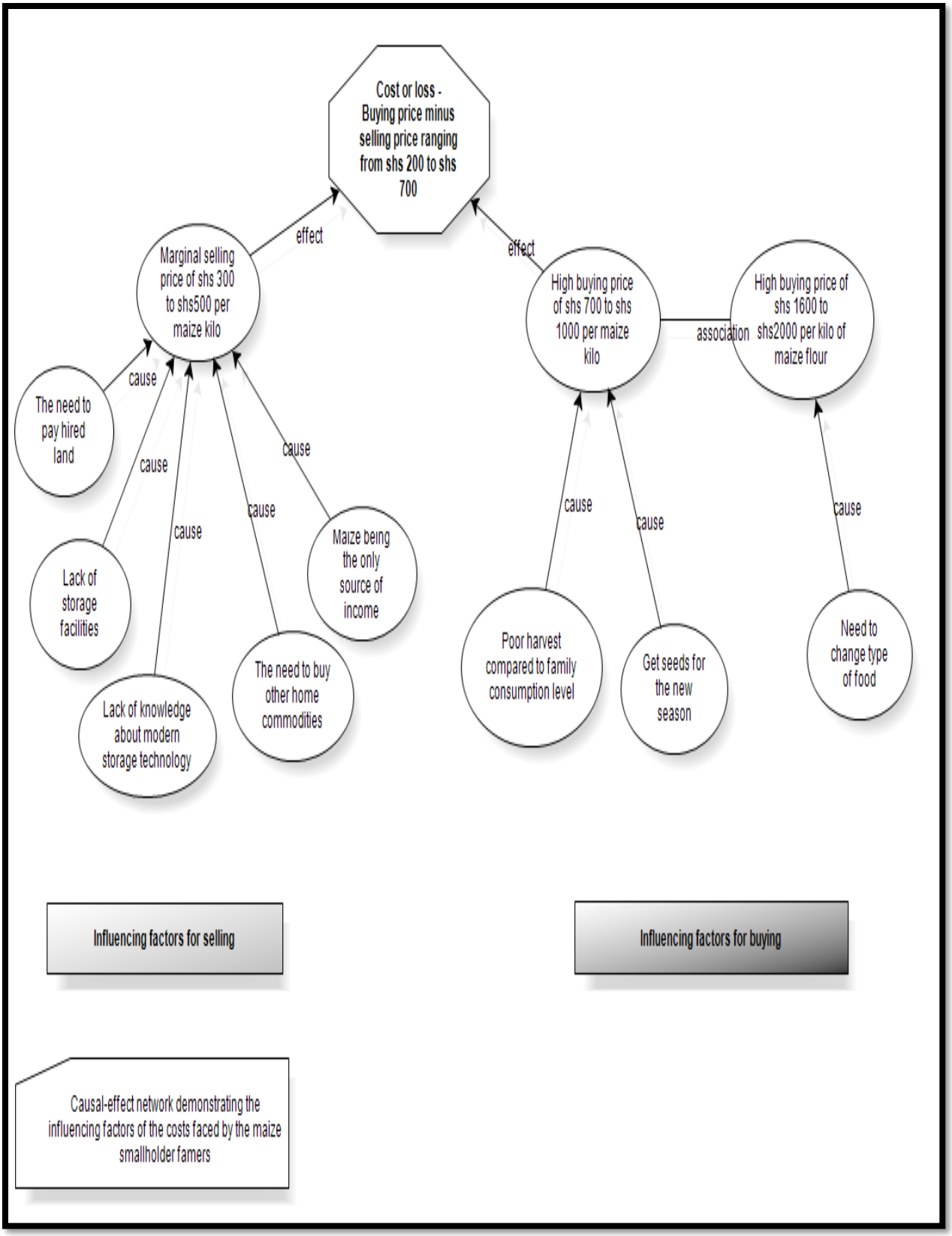


Figure 11: Cyclical selling and buying of maize Source: Primary data

Even when maize is in demand, it is difficult for farmers to know about prevailing market conditions. As a result farmers will sell at any price if their circumstances demand it. Figure 11 below also illustrates the multiplicity of factors exerting pressure on farmers to sell at low prices.

5.8 Farmers' perception of the factors influencing smallholder maize farmers' share of the marketing margin (MM).

Agricultural commodity exchange emphasizes the need for safe storage systems. The findings of this study illustrate how and why safe systems are not available for smallholder maize farmers. Thus the smallholders are exposed to many challenges as they struggle to store their grain and wait for increased selling prices. In the FGDs, farmers reported that multiple factors impede their share of the maize marketing margin. Because these reports resulted from the qualitative phase phase of the study, however, it was not possible to measure the relative significance of each of these factors on farmers' maize marketing margin share and this topic is therefore recommended for future study in section 7.5.

MM =fx (age, gender, storage cost, literacy level, time of sale, sources of other income, distance to the market, storage length)

5.8.1 Smallholder maize farmers' age and share of the maize marketing margin

In this study the maximum age of a respondent was 90 years. Elderly farmers complained that they suffered injustices from the middlemen and traders who buy their maize. A smallholder maize farmer expressing her frustrations with middlemen and traders stated: *"They cheat us because of*

our inability to look for better prices in other markets due to old age. We are paid little money for our maize compared to the youthful farmers. They cheat us with their faulty weighing machines, take more maize in a kilogram than what it ought to be and pay for less. The weighing machines are deliberately tampered with because they know that the elderly have no choice since they are unable to go look for maize markets elsewhere" (Male farmer, Omodoi sub-county, Katakwi District).

Another participant noted: *"I cannot have a good store as you see my age it not possible to build a good store so what even I harvest it is used for eating with my grandchildren and the balance is sold to whoever come to buy from me because it is hard for me to keep. It will be eaten by rats, pest and it can be stolen from me"* (Female farmer, Buturu sub-county, Manafwa Distict).

It was noted that the absence of effective systems and standards for grading and measurement gave an opportunity to middlemen and traders to cheat the elderly. Sometimes measurement was conducted by sight alone: a highly subjective practice that increases the risk of cheating on weight and quality.

5.8.2 Distance to big markets and smallholder farmers' share of the marketing margin

Smallholder farmers sell their maize at the farm gate because they are unable to transport the maize to big markets in nearby towns or to a central market. Transport infrastructure connecting markets is problematic in many parts of Uganda and the markets are not close to farmers' homes: the mean distance to the nearest market in the survey was four kilometres. Transport also carries a cost, which the majority of smallholders would not wish to incur. Hence they prefer to sell at the farm gate. Thus smallholder farmers who cannot transport their maize to the main market usually have

to sell at a low price largely determined by the buyer. This lowers farmers' share of the maize marketing margin because those who buy from them sell to others later at a higher price. Even when the smallholder farmers buy from traders for home consumption they pay almost twice the price they themselves previously received. Thus distance to market clearly influences the share of the maize marketing margin.

A smallholder farmer stated that: *"Since markets are far and you have to carry the maize and spend transport it is easy for me to sell to the middle men because you do not struggle to carry to market but I know they buy at low price and also cheat us with the weighing machines it never correct they take much than a kilo"* (Female farmer, Butiru sub-county, Manafwa District).

5.8.3 Gender and smallholder farmers' share of the maize marketing margin

The gender of a smallholder maize farmer also affected his or her share of the maize marketing margin. The majority of women (60 percent) sold their maize hastily, due to fear of losing it to thieves – some of them within the household. One female respondent stated: *"If I store my maize for long my husband will steal and sell it to buy alcohol besides the risks of pests" (*Female farmer, Ngariam sub-county, Katakwi District)."

This was said to happen immediately the husband's maize was finished. To avoid losing the maize to partners who would spend the proceeds on alcohol, women ended up selling it at a lower price immediately after harvest, which intensely impacts on their share of the maize market. This reinforces the quantitative findings (Chapter Four) that women prefer to store maize in the house, and predominantly for consumption.

5.8.4 Education and smallholder farmers' maize marketing margin share

Given that 53 percent of smallholder maize farmers were educated only up to primary level, this inadequate education limits their ability to seek markets for their produce – for example they greatly depend on middlemen who in many cases are said to cheat them. A female respondent farmer stated: *"Middlemen and traders deceive us on maize prices so as to pay low prices. Sometimes they tell us that the prices will continuously lower and that if we do not sell now we will instead get less than what is being offered"* (Female farmer, Katakwi sub-county, Katkwi District).

As this respondent indicates, the only way this information asymmetry gap can be bridged is by relying on middlemen. However, this increases the opportunities for middlemen to cheat, using their powers of persuasion. Smallholders sell to middlemen and traders because it is convenient (Abebe *et al*., 2016).

5.8.5 Costs of storage and smallholder farmers' maize marketing margin share

As has already been discussed, the costs caused by the deterioration or shrinkage of the maize crop as a result of poor storage are partly responsible for the low prices which affect the market share of smallholder maize farmers. In the FGDs, one smallholder argued that *"instead of losing their maize to pests it is better to sell it off at low price and get something little than wasting it all"* (Male farmer, Ngariam sub-county, Katakwi District). Because maize is a perishable good, vulnerable to poor storage, farmers who lack safe storage are better off selling their maize at the farm gate price. Indeed, even those farmers using apparently more effective storage types were affected by the scarcity and cost of non-harmful pesticides

5.8.6 Sources of income and smallholder farmers' maize marketing margin share

Additional sources of income besides grain sales that could help meet household expenses would reduce the "sell low buy high" pattern noted by Stephen and Barrett, (2011), which was very apparent in this survey, where 31 percent of respondents sold their maize within a month after harvest: the time when supply is abundant and prices low. Farmers asserted they sold their maize immediately after harvest to meet urgent household financial needs that cannot wait for prices to increase.

One participant stated: "If *one of my children is sick the only thing to sell to treat my child is maize. Also when children are chased from school for school fees we sell maize to pay so at that time you have to accept the price the middlemen are giving"* (Female farmer, Bulamgi sub-county, Iganga Distict).

5.8.7 Time of sale and smallholder farmers' maize marketing margin share

Time of sale was found to have a strong influence on the share of the maize marketing margin realized by smallholder farmers. Those who sold immediately after harvest sold at a lower price than those who sold, say, two to three months after harvest. As one example, a respondent noted "*Some of us the farmers' who sold immediately after harvest were being paid as little as UGX 250, while the highest price closer to the next harvest rose to UGX 1,000 per kilogram"* (Male farmer, Bulamagi sub-county Iganga District).

5.8.8 Length of storage and smallholder farmers' maize marketing margin share

Long storage is associated with securing increased prices for maize. Participants explained that the prices of maize are usually high in the months April - June because during that period few or even no smallholder farmers will have maize in their stores. This scarcity is the main cause of the price increase. Thus, farmers who can store to sell at that time are certain to command higher prices and a higher share of the maize marketing margin. But, as has previously been discussed, the immediate need for money and the costs of storage mean most farmers cannot do this. However, an additional factor emerged from the FGDs: harvest expectations. One farmer noted that "*If the coming season's harvest is expected to be a bumper one, farmers will sell maize earlier to prepare for the new harvest"* (Male farmer, Makuutu sub-county, Iganga District).

5.9 Farmers' perception of storage as a business framework

Yet despite all these factors pushing smallholder maize farmers to sell, they still need to store some grain for consumption, planting and later sale in the event of other household emergencies. FGD participants described how in situations of sickness, death or school fees, selling maize is one way to solve the problem. A male farmer stated: "*Maize is our problem solving crop for many of the money needs in the home once I have my maize them I will find someone to buy easily when there is a problem. The bad thing is it very difficult to store for long and also because of money needs we sell easily sometimes at very low prices"* (Male farmer, Khabutoola sub-county, Manafwa District).

For this reason many farmers perceived household storage as indispensable: storing for sale was a central part of their business framework. One participant stated that: *"Prices of maize fluctuate regularly and we are aware of when prices are high but we cannot keep our maize to the time when prices increase. Even when we want to protect our maize by sun-drying, the maize is eaten by birds in the process. However, if I was able to store for long I would keep mine and probably buy from other smallholder farmers in the community and sell to traders' which may increase my earning but also reduce the cost of buying maize for home consumption"* (Male farmer, Ibulanku sub-county, Iganga District).

There was implicit understanding that a longer-term business framework was necessary because consumption is continuous (and needs to be addressed off-season) while supply is only seasonal. These findings are consonant with those of Odegard and van der Voet (2014) in the Netherlands, which even in that very different context emphasise the importance of storing agricultural produce for future use.

Over 80 percent of FGD participants agreed with the view that storage helps them manage their business at household level provided the grain can be kept free from damage. One male respondent said: *"Our challenge for long has been finding safe stores, the reasons we sell immediately is because of poor storage that becomes an inconvenience. Just imagine one has to put 1000 kilograms of maize out every week to sun-dry it is limiting because we have other things to do and we do not get the time. Also, you are not sure if the price will increase to your expectation therefore some who sell are sometimes better off and that is why me I sold off all mine immediately after harvest"* (Male farmer, Bubutu sub-county, Manafwa District).

Smallholder maize farmers' business perceptions extended beyond this household perspective, however. They were also sharply aware that maize storage can be a lucrative business because the demand for maize is ubiquitous. Given that they produce maize every season, they could bargain for a bigger share of the maize marketing margin if their maize could be better stored. In one FGD there was strong agreement with the participant who stated: *"having a safe store may reduce the cost of storage significantly and is a form of quality management which may result into selling when the prices are high and in the long-run increase the marketing margin share"* (Female farmer, Makuutu sub-county, Iganga District).

However, farmers need guidance because they are not aware of how this can be done efficiently and effectively. One FGD participant asserted: *"We wish to be guided on how to protect and possibly reduce costs of storage, to store for long so as to take advantage of increase in price* (Female farmer, Ngariam sub-county, Katakwi District)*."* One solution would be organizing producers to create a more formal market for maize at village level: one way of counteracting the previously-discussed information asymmetry which forces smallholders to sell at the price offered by middle men and traders. However, one participant noted that: "*using storage as a business strategy requires training to teach us smallholder farmers on the best storage practices, pests control and how and where we can sell our maize at high price"* (Female farmer, Katakwi sub-county, Katakwi District).

Smallholder farmers explained that they need to be organized to work collectively to achieve a common goal (increase share of the maize market). Participants explained that they sold their maize individually which denies them the potential of collective bargaining and this weakens their

bargaining power. Also, they cannot agree on the same price since each will be approached individually by the buyers.

FDG participants said that if farmers agreed to cooperate they could build a communal store for collective storage within their communities. Working together would lead, they felt, to increased yields of maize, access to better seed varieties and fertilizers to boost their production, and shared information to improve marketing. Such co-operation, however, would require continuous training and sensitization on how to manage such facilities. One farmer stated that: "*Many of us here work individually but if we work collectively we can agree on price for our maize and refuse to sell at low price. However we have a problem of trust and also maybe we should be trained and given the advantages of working together. This will encourage other farmers to join the teams working as groups the moment they see it is good"* (Male farmer, Makuutu sub-county, Iganga district).

Another participant noted that: *"We need to be trained because sometimes when we struggle and store the price go down and make loss. So it is very difficult to time price and when to sell at high price. Also, we think differently so it is hard to work together and agree on a price because our needs are different. Maybe the government should buy from all the farmers. This is because the market is unpredictable and prices follow market changes"* (Male farmer, Bulamagi sub-county, Iganga district).

FDG participants were conscious that ignorance of better storage types and markets for their maize constrained their potential to earn a bigger share of the maize marketing margin, and that it related

to their limited education. Training is therefore an important component of any strategy to increase their earnings as an avenue to poverty reduction.

One participant noted: *"We the farmers are not helped much because we hardly get the advice from anybody to tell us about storage and markets for our maize. Once my maize is harvested then it must be sold so that I can get money. After all, even storing for long is costly because much of the maize is lost or damaged and when traders come they buy the damaged maize at low prices. Therefore, I find selling immediately as an option to avoid storage loss"* (Male farmer, Makuutu sub-county, Iganga District).

Figure 12 below illustrates the perceptions farmers have of improved maize storage as a business strategy to reduce household poverty, despite the challenges.

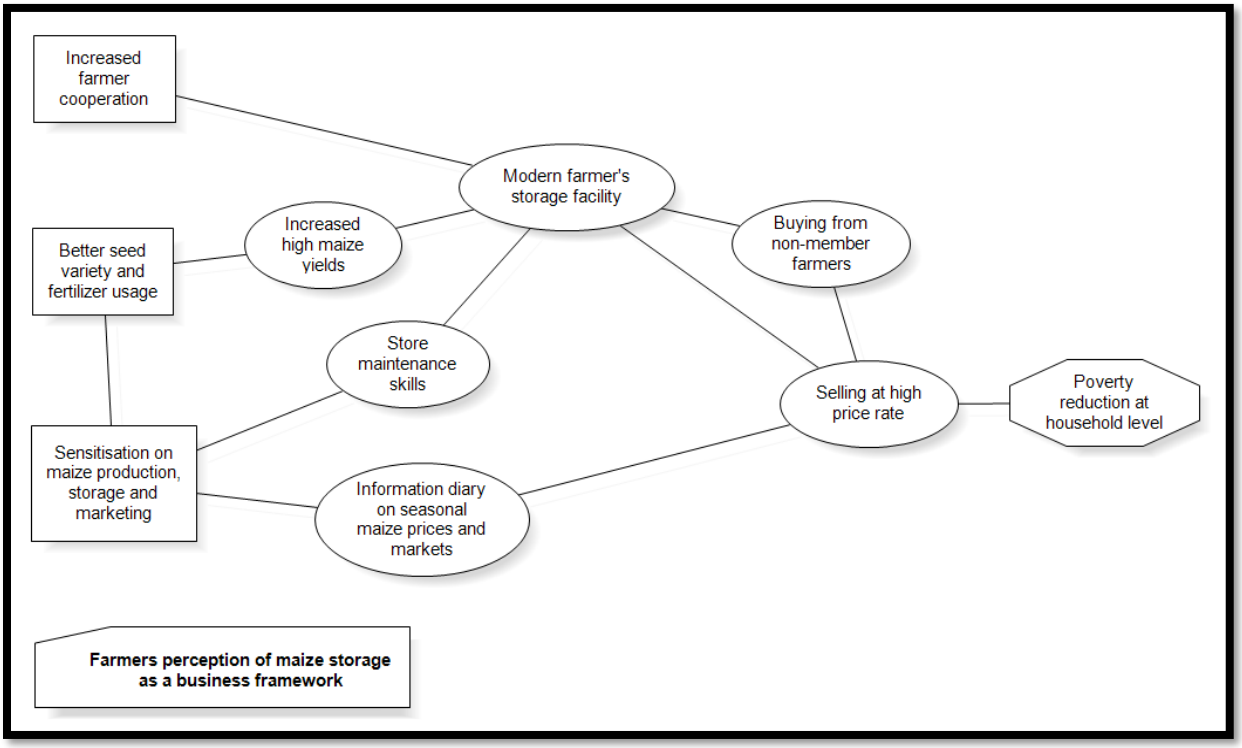


Figure 12: Maize storage business framework Source: Primary data

Participants perceived that storage can be used as a business strategy to increase their share of the maize marketing margin, because you can buy maize at a lower price during the harvesting season and sell it at a higher price later during the planting season provided you have a good and safe store. Farmers who can either grow and store or buy and store will be in a position to sell to those many farmers who have nothing in store yet still need to consume.

Other than using storage to keep maize for selling, farmers can keep maize for home use and so would not spend money to buy maize for their household consumption. This saves the money that would otherwise be spent on maize purchases, which can thus be put to other household financial uses. In addition, a household assured of food is better able to concentrate on other economic activities without stress. This finding is consonant with the findings of Tefera *et al*. (2011) that safe household storage directly affects food and income security, and also provides robust support for the view that marketing margin and smallholder storage are closely connected.

In conclusion, the qualitative data provided by FGDs and KI interviews, and the information about the various storage types that smallholder maize farmers use, makes it clear that they are in no position to increase their share of the maize marketing margin at present. Participants expressed relative satisfaction with their current storage arrangements, but nevertheless stressed the need for upgrade to enable them to keep maize for longer. Such an upgrade will make two important contributions: firstly, farmers' income will increase and therefore reduce household poverty; secondly, smallholder farmers – and, by extension, their communities and regions – will become more food secure.

However, some important additional questions also emerged from the FGDs. It is not clear how far smallholder farmers will be able to store and wait for higher prices – even if they access improved storage – when poverty and family emergencies still provide pressing additional reasons to sell. In the long-run, as more income is built at household level, their immediate need for money may slowly be ameliorated. Another key question relates to the changing market conditions greater access to improved storage may create. If all smallholder maize farmers are able to store safely and for long periods, far fewer will be willing to sell immediately after harvest. This will create shortages and price surges, followed by later price falls when many farmers put their maize on the market later. Market fluctuations will persist; only the calendar for these fluctuations will have been changed. In addition, farmers with access to better storage may be discouraged from growing their own maize, preferring instead to buy for storage from those farmers who still cannot store well at harvest time. These important questions emanating from the focus group discussion should be further explored and are thus noted at section 7.4.

Table 28 below provides a summary of the findings of the qualitative investigation, offering to readers a ‘snapshot’ linking the findings to the reasons the study was undertaken.

Table 28: Summary of the findings

Research questions	***Research objectives***	*Findings and Conclusion*
RQ1: *Can the theory of storage be extended to underdeveloped maize markets of smallholder maize farmers in Uganda?*	***OB1:*** *Develop a framework for an extended theory of storage applicable to the underdeveloped markets in which smallholder maize farmers in Uganda participate.*	*Developed the framework for the theory of storage extension. With some adjustments, the theory of storage can be extended to underdeveloped markets.*
RQ2: *Can the storage types of smallholder maize farmers in Uganda be identified and characterized? And if so, do these characteristics affect choice of storage and the maize marketing margin realized by the smallholder farmers?*	***OB2:*** *Identify and characterize the storage types used by smallholder maize farmers in Uganda.*	*Different storage types were identified and characterized Figure 8 and 9. Some Characteristics of Smallholder maize farmers affected the choice of storage, the length and therefore their share of the marketing margin realized.*
RQ3: *What are the costs (quantity, quality and financial) associated with the identified storage types? Do the associated costs affect the share of the maize marketing margin realized by smallholder farmers in Uganda?*	***QB3:*** *Assess the costs associated with the identified storage types.*	*Acquisition and maintenance costs were found critical to farmers' decision to store and storage types to use. Costs of storage affects smallholder maize farmers' share of the marketing margin realized. The storage types that cost more appear to the more effective types. Farmers have a preference for sacks which cost less but result in high losses (quantity and quality) in storage. This impacts the marketing margin realized by farmers.*
RQ4: *What is the effect of household characteristics on the choice of maize storage types and length of storage?*	***QB4****: Assess the effect of farmers' household characteristics on choice of maize storage types and storage length.*	*Smallholder characteristics such as: gender (0.009), district/location (0.000), method of acquisition (0.000), seasonality in use (0.032) were significantly associated with storage types used. (The figures in brackets are p-values). Land used for maize crop as a smallholder farmers' characteristic was also significantly associated with storage length at p-value 0.01.*
RQ5: *What are the experiences and perceptions of smallholder maize farmers in adopting and using a storage business framework to increase their share of maize marketing margin?*	***OB5:*** *Explore smallholder farmers' experiences and perceptions on developing maize storage business framework to increase their share of the marketing margin.*	*Qualitative findings show a positive perception of farmers on the development of the business framework to increase their share of the marketing margin.*

Source: Primary data

CHAPTER SIX: Integrating guidelines and framework for the theory extension

6. Introduction

In this chapter the findings of chapter and five is brought together. The guidelines are premised on the research questions and objectives of the study as outlined in chapter one sub-section 1.5 and 1.6. The chapter is organized as follows: background; storage in underdeveloped market; socio-demographic implications of storage; storage types used in Uganda; the effects of household characteristics and storage type; household storage and associated costs; factors associated with share of marketing margin; theory extension framework; assumptions of the theory of storage extension; and the model.

6.1 Background to the guidelines for the theory extension

The study set out to assess the extension of the theory of storage to an underdeveloped market, via surveys conducted among smallholder maize farmers. The literature reviewed illustrates that the theory is applied efficiently in developed markets, and this discussion appears in Chapter Two. However, it is necessary to investigate the assumptions on which the theory of storage is based in both developed and underdeveloped market contexts, because extending the theory requires the existence of a relevant basis of comparison. In this chapter, therefore, the underdeveloped market context is discussed, using the case of Uganda.

6.1.1 Storage in underdeveloped market

Because production and consumption often do not match neatly, the storage of agricultural commodities has been a subject of interest to social scientists in both developed and underdeveloped markets.

In all markets, holders of commodities derive benefit from keeping inventory, because in this way they can buffer supply and demand variations (Cifarelli & Paesani, 2012): pulling stocks from storage to address shortages, and storing for future use when there is a surplus. The benefit thus accruing is called the convenience yield (Kaldor, 1939; Brennan, 1958; Fama & French, 1987).

6.1.2 Socio-demographic implications of storage

In line with international concerns over shortages, market fluctuations, and storage, maize storage has similarly been a widespread concern in Uganda, particularly among smallholders, for the majority of whom maize is both a staple food crop and an income generator (Omotilewa *et al*., 2016). The findings summarised in Table 3 demonstrated that more men than women are involved in maize growing. This offers an exception to the findings of Onubuogu *et al*. (2014) that agribusiness in SSA is a female-dominated activity. The smallholder maize farmers surveyed had an average age of 41. The average highest level of education attained was primary schooling and this low level of education limits storage innovation and the use of information. Onubuogu *et al*., (2014) and Phiiri, Egeru and Ekwamu (2016) both found that higher levels of education impact strongly on how well farmers are aware of the innovations and technology around them.

The findings show that the smallholder maize farmers surveyed had an average household size of six persons. The demand for maize for consumption in such households would certainly be high.

This provides one reason why the greater part of the survey population is engaged in agriculture, with very few involved in trading. However, this family demand imperative towards agriculture as the main source of income also limits farmers' options for accessing alternative sources of income generation.

Smallholder maize farmers are the major producers of maize in Uganda (Okoboi, Muwanga & Mwebaze, 2012), with the average land allocated to agriculture across the sample being 1.7 ha; a similar allocation to that found by Onubuogu *et al*. (2014) in a study conducted in Owerri Agricultural Zone, Imo State, Nigeria.

The maize hectarage varied within districts, with Katakwi – a low maize producer – having the highest hectarage (1.9 ha) allocated to maize growing. In terms of maize yield per ha, Manafwa, the medium maize producer, harvested more maize than either Iganga or Katakwi. However, Iganga allocated more land to maize growing than Manafwa. Land was found to be very expensive to rent in Manafwa at UGX 163,000 compared to Katakwi (UGX 94,400), and Iganga (UGX 77,800) and this may be due to the Manafwa's high productivity.

Moreover, smallholder maize farmers in the sample predominantly rented land for agricultural production and this gave them a reason additional to family demand for selling maize immediately after harvest: the need to pay rent.

6.1.3 The storage types used in Uganda

The study indicates that the majority of the smallholder maize farmers still use traditional storage types (Figure 8) although some farmers are slowly adopting modern storage (Figure 9). Table 5 provides the quantitative data for this finding and Figures 8 and 9 the qualitative evidence. Across all sample districts, sacks were the major storage type used: a storage type inefficient for long storage and highly vulnerable to pests and rats.

This desperate situation makes it easier for unscrupulous traders to take advantage of the smallholders, paying the lowest prices possible for their maize at harvest time, and later selling to them at exploitatively high prices as also observed in Sitko & Jayne (2014). Figure 6 illustrates price variations over a period to demonstrate the margin that smallholder maize farmers could gain if they stored.

The findings show that storage length varied across the sample districts, with Manafwa storing for a long period compared to Iganga and Katakwi. The *p-value* of 0.01 shows a significant relationship between land allocated to maize farming and length of storage. A more detailed analysis within categories shows a significant relationship *p-value* of 0.01 Table 17. The reasons farmers advanced for not storing maize for long (considered as determinants of storage in this study) were inadequate storage types, high storage costs, immediate need for money to meet household demand, and prevailing high prices at harvest time motivating them to sell.

6.1.4 Effect of household characteristics and storage type

The findings demonstrate a relationship between household characteristics and storage type used. There is a significant association between household characteristics and choice of storage type at ($p<0.05$). The following characteristics demonstrated the most significant associations: district (location) *p-value* of 0.000, the finding implies that location (district) dictated the type of storage to be used mainly because that given storage type was customary and understood in the area, or easily accessible there. Storage challenges were exacerbated where knowledge and access were inadequate. Gender (*p-value* of 0.0090 was also influential on the storage category to be used: for example, women mainly preferred in-house storage, but houses were generally small causing space pressure. The mode of acquisition (*p-value* of 0.000) was another important factor that precluded access to safe storage because the majority of smallholders used the purchase mode yet prices for good and safe storage were very high. Other modes of acquisition as shown in Chapter Four, Table 11, also did not provide good storage and were less utilised compared to purchase. Seasonal use, with a *p-value* of 0.032, indicated that farmers tend to use the storage types with which they are familiar, and hardly changed because of what the qualitative responses revealed: the fear of the risk involved in changing and the associated costs. If storage is to be upgraded, these aspects need to be understood. Each characteristic impacted on or added to the challenges faced in storing grain for longer periods.

6.1.5 Household storage and cost associated

Household storage for any period of time – from a day to months – attracts costs which impact negatively on the share of the maize marketing margin realized by smallholder farmers. The high costs of acquiring and maintaining certain types of storage discussed during the FGDs impel farmers towards cheaper storage options and faster sales after harvest (Figure 7). Keeping crops intact in storage, these farmers noted, involved using pesticides that are expensive, inaccessible, sometimes counterfeited or adulterated and often hazardous – another factor impacting negatively on the earnings from maize sales and smallholders' share of the marketing margin. Other anti-pest and anti-theft costs (such as the cost of buying guard dogs or cats for ratting) may also be added. Thus these results provide no support at all for the view that the costs of storage do not affect the share of the marketing margin (Kadjo *et al*., 2015).

The findings further demonstrate that storage costs are far more useful in identifying an optimal storage category than an optimal storage type (Table 21), and support the hypothesis that storage costs cannot be used to pinpoint one optimal storage type. The optimal storage category reported by farmers in this study was in-house storage, which had a mean maintenance cost of UGX 7,564 compared to UGX 8,063 for non-house storage, and a mean acquisition cost of UGX 34,200 compared to UGX 32,900 for non-house.

6.1.6 Factors associated with share of marketing margin

Discussion in the FGDs allowed smallholder maize farmers to identify multiple factors affecting their share of the maize marketing margin. These included their age, gender and literacy levels, their access to other sources of income, the costs of storage, time of sale, distance to the nearest

market, and length of storage. Each of these factors impacted very differently on different individuals or households but collectively they posed a significant challenge to smallholder maize farming.

6.1.7 Farmers perception of storage as a business framework

As data underlining the importance of storage to smallholder maize farmers accumulated, it became increasingly important to explore their experiences and perceptions of the function, in order to design a framework that could help increase their share of the marketing margin. Participants were generally supportive of using storage an important element of their business framework to increase their share of the maize marketing margin. However, they urged the need for accompanying initiatives to improve household storage to maintain the quality and quantity of stored maize.

The research was able to develop a framework, based on the findings in Chapters Four and Five and the assumptions discussed in Chapter Two, to extend the theory of storage.

6.2 The business framework description

This study aimed to develop a framework that provides a basis for extending the theory of storage to an underdeveloped market. It has already been argued that the relationship between storable commodities such as maize is guided by the theory of storage (Geman & Smith, 2013). The theory is premised on various assumptions which have worked well in the developed market context (Gorton *et al*., 2012).

However, in this research, which uncovered granular detail about the traditional storage types used by smallholder maize farmers, the focus was on discovering whether and how theory extension to an underdeveloped market was possible. This extension necessitated examining the developed-market assumptions in relations to smallholder maize farmers' characteristics.

6.3 Assumptions of the theory of storage extension

In Table 29 a framework for the extension of the theory is provided. This presents the context of developed and underdeveloped markets, related to selected scholars' assumptions about the theory of storage.

Table 29: Framework for the theory of storage extension

Theory assumption clusters, by main author	Developed market context	Underdeveloped market context	
	Theory assumptions applicable in the developed market	**Characteristics of underdeveloped market**	**Necessary but not sufficient conditions for theory extension**
Kaldor (1939), Telser (1958)	Stock-holders' behaviour; Holders of inventory derive a benefit referred to as convenience yield. It accrues to those who can store and sell later when the prices are high. The essence is to hold stock when price is low and sell it when price is high. It is applied to hard and soft products (metal)	Smallholders sell their maize immediately after harvest due to: • Immediate need for money • high cost of storage • inadequate storage or • prevailing high prices.	Reduce storage costs so that smallholder maize farmers can hold on their maize without fear of the loss emanating from pest and bird damaged, pilferage, mould and rats.
Smith *et al.* (2012), Omotilewa *et al.* (2016)	Inventory-holding: Storage buffer against uneven supply and demand. The products are kept safe, with no pest damage in store.	Thirty percent of maize is damaged in storage.	Build stores that can keep the maize safe for future use.
Gorton *et al.* (2012), Brooks *et al.* (2013), Cifarelli & Paesani 2012	Nature of product stored: The theory is applicable to hard and soft products. The producers of maize are also agents and have safe stores.	The theory is applied to soft products. Producers are not necessarily agents.	Calibrate products. Encourage producer to become agent by equipping them with safe storage facilities
Fortenbery (2004), Fama and French(1987)	Market characteristics: Market has efficient characteristics Stock-holders have various income sources.	It is difficult to match consumption with supply. (Inefficient market characteristics).	Improve market characteristics. Reduce information asymmetry. Provision of safe storage.
Brennan (1958), Fama & French (1987)	Scale of production: Mass production	Limited production	Increase amount of maize produced
Gorton *et al.* (2012)	Hedging: Stock-holders hedge against future price risk by keeping inventory.	Smallholders cannot keep maize for hedging. Farmers incur losses because they sell low due to storage inadequacy & limited production	Create adequate storage to encourage maize storage in times of abundance and sell during scarcity at high prices.
Geman and Smith (2013)	Speculative behaviour: The theory of storage brings about speculative behaviours that lead smallholders farmers to believe they will benefit in future if they store their produce.	Speculative behaviours are limited by the inability to store safely and impel immediate sale at low prices caused by glut.	Improve efficiency of farmers' storage
Working (1949), Omotilewa *et al.* (2016)	Producers' income sources: Commodity price increases in times of low inventory and decreases in times of abundance. So producers must use other income to wait for better prices	Smallholders have limited sources of income and mainly depend on maize so they cannot wait for price increase.	Encourage smallholder farmers to find other income sources. Diversify income sources.

Source: Primary data

6.3.1 First theory assumption cluster

This first cluster of assumptions relates to stock-holders' behaviour in different conditions of supply and demand: that the holders of inventory (maize) receive implicit benefit referred to as the convenience yield; that storage keeps inventories safe and maintains continuous flow (demand and supply shocks are absorbed by the stored inventory); These assumptions do not necessarily apply to underdeveloped markets. Kaldor (1939) argues that storage can reduce the inconvenience of looking for a product when one wants to consume it. Although, as already noted, holding maize in stores would enable smallholder maize farmers to immediately respond to needs that arising in the off-season, when smallholder farmers store their maize it gets spoiled, and so they end up still being inconvenienced by having to buy from the market later. In addition, inventory itself can become an inconvenience. If maize is stored in-house, it competes for space with the storage needs of other household members in a small dwelling. These findings thus demonstrate that the convenience assumption cannot hold in the context of underdeveloped market without changes in the current storage types. A number of important differences exist. The assumption that holders of inventory receive benefits is over-emphasized for underdeveloped markets, and particularly for smallholder maize farmers.

In the developed world, it is the accrual of convenience yield that motivates storage – yet for smallholder maize producers, storage plays some role in consumption but does not yet play a key role in the accrual of convenience yield. Additionally, in the developed world inventories can be kept safe with limited or no deterioration in quality and quantity; this, as has already been noted, is difficult for smallholder maize farmers in the developing world. Thus if the theory is to be extended with a good fit for underdeveloped markets, storage types need to be brought closer in efficiency to those used in developed markets.

6.3.2 Second theory assumption cluster

This cluster relates to the benefits of holding inventory and the ways that it is held. Smith *et al*. (2012) contend that storage buffers against the uneven supply and demand that exists for agricultural products due to seasonality. This assumption holds in developed markets, but not for underdeveloped markets with poor storage infrastructure.

The storage types used also differ widely in the two contexts. In the developing world smallholders use traditional storage types (Chapter 5, Figure 8) which are vulnerable to high losses. Omotilewa *et al*. (2016), in another recent study conducted in Uganda, argued that concerns about effective storage at household level led to the immediate sale of maize after harvest in SSA. Similarly, in this research, smallholder farmers in the FGDs revealed that expectation of losses had a negative impact on the volume of maize they stored. Thus I argue that the theory of storage may not be extended to the context of underdeveloped market until the storage types currently used are improved.

6.3.3 Third theory assumption cluster

This cluster of assumptions relates to the nature of the products under storage. Historically, in developing the assumptions of the theory of storage, hard products such as precious metals were used (Kaldor 1939; Brennan 1958; Telser 1958; Geman & Smith 2013; Cifarelli & Paesani 2012; Geman & Tunaru 2013 and Brooks, Prokopczuk & Wu 2013). Unlike ‘hard’ (non-perishable) products, agricultural products such as the maize produced by smallholder farmers can be quickly destroyed by environmental conditions. This presents a very different picture for the developing world: perishable commodities kept in insecure traditional storage types. In these conditions, the fear of losing maize in storage is reported as one strong motive for immediate sale after harvest

(Omotilewa *et al*., 2016), which does not happen in the developed world. Thus the theory can be extended only if farmers either deal with other, non-perishable, commodities or have access to secure, efficient storage.

6.3.4 Fourth theory assumption cluster

This cluster deals with market characteristics. The market characteristics of the developed world are quite different from those of underdeveloped countries. In the developed market, buy/sell decisions can be based on, for example, stock exchange market information, while underdeveloped markets have access to only limited information, together with poor infrastructure and no price legislation. Thus extending the theory of storage requires major market characteristic adjustments, such as making market information more easily available to sellers and buyers.

6.3.5 Fifth theory assumption cluster

This cluster relates to production. The theory of storage currently assumes mass production of the product(s) stored, but in underdeveloped markets inventory may be small, as the production figured cited in the results chapter indicate. The theory cannot be extended to a new, underdeveloped context if smallholder farmers' production capacities are not increased. On the other hand, the inventory stored and demarcated by smallholders for consumption may not be in the market so its quantity and price may not directly respond to increases or decreases (fluctuations) in maize inventory. Furthermore, the reasons why inventory increases or decreases may not be the same in the developed as among smallholders in the developing world. Inventory costs have been found to deter storage (Fama & French, 1987), thus smallholder farmers who incur

high costs in storage (because of the storage types they use) were not willing to store, but rather preferred to sell and later buy from those who could afford to store.

6.3.6 Sixth theory assumption cluster

This cluster relates to hedging and future prices. The price of maize is determined by supply and demand; hedging requires knowledge of when to sell in future. Future delivery dates are known in developed markets for many non-seasonal products. This is not the case for agricultural products in underdeveloped markets. First, the producers of maize in underdeveloped markets are semi-literate (the majority surveyed were of primary level) and this deprives them of the skills to process complex price information even when it is available. Secondly, these smallholders are not in a position to store and wait for a future they cannot predict amidst other are much harder to predict in underdeveloped markets than in developed markets.

The conventional storage-theory view is that stock can always be released to meet demand, but in underdeveloped markets there is a consistent mismatch between production and demand. Multiple bottlenecks in production can occur, such as changes in weather conditions, poor seeds or limited land. All of these raise the costs of production, and are especially perilous for the many farmers who rent rather than own their maize lands. Renting also occurs in developed markets, but in underdeveloped markets smallholders find land rents unaffordable even in good years. In addition, smallholder maize farmers in the developing world often have large households (6-10 people, as noted in the survey results) that require food for consumption at a rate slightly above their production. Their production is thus dominated by subsistence needs, rather than the commercial purposes that dominate grain production in developed markets. The research findings thus support

the contention that the theory of storage cannot be extended to underdeveloped markets until farmers understand and are enabled to embark on commercial production, which will offer larger financial benefits from storage.

6.3.7 Seventh theory assumption cluster

This cluster relates to speculative behaviour. The speculative behaviour exhibited in the developed world where the theory of storage works well is supported by the efficient information systems in place to forecast demand and supply. Underdeveloped markets lack these, and thus the theory of storage cannot be extended to an underdeveloped context without creating good information systems to support speculative behaviour. For seasonal products like maize in the underdeveloped market, supply depends on several factors such as weather conditions, what variety of seeds is planted and what fertilizers are used, to mention but a few. Thus, whereas farmers may predict a satisfactory yield, they may reap a low yield or find themselves part of a glut. In either case, their behaviour is certainly affected. Consequently, the supply and demand conditions for maize produce and its implications on behaviour are harder to predict in underdeveloped markets than in developed markets.

The ‘traditional’ storage theory view is that stock is always available. However in underdeveloped markets there is a consistent demand for maize but inconsistent supply and stocks. This results from several potential bottlenecks in the production process, such as changes in weather conditions, poor seeds and limited land. This has made the cost of production expensive. Some farmers have to rent land to produce enough – or indeed any – maize. Although in developed

markets farmers may also rent land, in underdeveloped markets producers are often too poor to afford rents.

6.3.8 Eighth theory assumption cluster

This relates to maize producers' sources of income. The theory of storage assumes that producers of the stored commodity have other sources of income, and so can retain their produce while utilizing other income sources to solve immediate financial needs and wait for prices to increase. In underdeveloped markets, particularly among smallholder maize farmers, this is not the situation. Without additional income sources, many smallholder maize farmers need to sell their maize less than one month after harvest; Omotilewa *et al*. (2016) argue that in SSA smallholder farmers exhaust their inventory before the next harvest season. If smallholder maize farmers continue to have maize as their sole or major source of income, the theory of storage cannot be extended to an underdeveloped context.

6.4 Framework contribution

The framework makes both a theoretical and an empirical contribution, as delineated below

6.4.1 Theoretical contribution

From this research, original insights useful to extending the theory of storage to an underdeveloped context emerge. The research offers an innovative analytical approach to smallholder maize storage and storage types by triangulating results from both qualitative and quantitative research, including an extremely rich dataset reflecting the voices of farmers themselves. The assumptions of the theory of storage in a developed-world context are interrogated in a way that illuminates

how the theory of storage can be extended to explain maize storage (a perishable commodity) in Uganda (an underdeveloped market) – a context in which it has not previously been studied. This adds to existing knowledge. Additionally, the development of a framework (Table 29) for extending the theory of storage to underdeveloped markets in which smallholder maize farmers operate also contributes to the existing body of knowledge.

The boundary conditions of the theory – for example, the modern storage types assumed in studies of developed markets – are extended by discussion and analysis of traditional storage types. Further, evidence from the research demonstrated that certain predictions (hedging and speculation) based on the theory of storage in developed markets were unrealistic for underdeveloped markets.

The framework developed on the basis of this research makes a critical contribution to the existing body of literature on farmer behaviour regarding the storage of maize crops in SSA. The framework has utility as a basis for policies to stimulate incomes at smallholder level, and alleviate food insecurity. If used properly, it can support policy innovations to transform the subsistence agriculture of smallholder maize farmers into larger-scale, commercial farming. It proposes interventions to reduce the price disparities affecting smallholders' share of the maize marketing margin, increase their incomes and alleviate their poverty.

It has already been noted that few studies of smallholder maize storage and the marketing margin for smallholder maize farmers in SSA had previously been undertaken. There is a dearth of research describing smallholder storage practices, despite perishable and seasonal crops that require storage being a key aspect of their activities, and indeed the argument concerning the need to extend the theory of storage to underdeveloped markets is premised on the dearth of theorists

explicitly focusing on contextual limitations in existing theory (Whetten, 1989). This study therefore adds a new dimension to a complex phenomenon. The findings provide a solid foundation for further theoretical analysis of the storage challenges facing smallholder maize farmers, and these are discussed at 7.4 below.

6.4.2 Empirical contributions

This study offers research results derived from the experiences and perceptions of smallholder maize farmers themselves about maize storage at household level. Such information is critical in guiding decision-makers on solving the challenges of household storage. Although incorporating many individual perceptions and experiences, the common ground revealed by analysis provides information useful in studying smallholders in many developing countries and dealing with a variety of crops that exhibit similar storage characteristics. Given that many underdeveloped markets are grappling with grain storage challenges, extending the theory to their context is urgent and relevant. Farmers' own voices provide compelling evidence of the problems created by poor storage, their belief that household storage yields convenience, and their need for improvement and support in dealing with storage challenges.

Because commodity prices are notoriously difficult to predict, effective storage is key for smallholders. It is through inventory management that price variations can best be controlled. The adjustments required to make household storage more reliable for smallholder farmers in underdeveloped markets – and thus bring these kinds of farmers into the ambit of the theory – are clearly indicated in the framework developed.

The framework provides the necessary information to enable smallholder farmers to have more maize at their disposal. The inventories they hold can buffer against supply and demand disequilibrium in a situation where consumption is continuous, supply is seasonal, and the crop is perishable.

Creating conditions in which the theory of storage can be extended to this context will assist in addressing this mismatch and enhancing income and food security for smallholder farmers. If food is available at household level because farmers' own production is better stored, money previously spent on grain for consumption can be saved. If the amount of grain held is surplus to household consumption needs, it may be sold at a higher price to generate income.

This improvement in storage, however, can have a broader impact. If the maize is sold for export, foreign exchange will be earned – or saved, because less grain needs to be imported. Increased earnings at household level may allow the government to broaden the tax base and earn additional revenue for infrastructure development. Improved infrastructure, in turn, can facilitate the easier movement of produce to markets and improved dissemination of the market information smallholder farmers in SSA currently find so difficult to access.

The implementation of the measures in the framework at producer/smallholder level will augment the supply chain transaction processes needed for effective agribusiness market operations. All maize that reaches the market through the supply chain has, at one point or another, had to be stored. Storage needs to be of a standard that compromises neither the quantity nor the quality of

maize. Storage improvement measures as recommended in the framework will serve this purpose in a significant way for smallholders, who are the majority maize producers in SSA.

The framework offers details both of essential storage remediation for smallholder maize farmers and of the drawbacks of the theory of storage relevant to maize marketing transactions in this context. The improved climate for commercial transactions that implementation of the measures aims towards may encourage smallholder maize farmers towards more enthusiastic and informed participation in the market, in the realistic expectation of improving their share of the marketing margin.

These findings thus provide information that will enable the extension of the theory of storage underdeveloped markets. What is novel is that the findings demonstrate the potential for transforming smallholder farmers from (as currently) residual sellers making consumption-driven storage decisions to residual consumers making sales-driven storage condition. In addition, the study has provided rich and nuanced findings that demonstrate foundational potential for extending the theory of storage to the kinds of underdeveloped markets in which smallholder maize farmers operate.

6.5 Framework limitation

The users of models require examples robust enough that they can be applied to similar challenges across different environments. If the framework is too specific it runs a risk of not being widely replicable. The major limitation of this framework is that it may be applicable to only those crops with similar characteristics to maize, while some smallholder farmers may grow multiple crops.

In addition, while the framework suggests adjustments in current storage types, many smallholder maize famers may be in no position to change their storage types due to financial and other constraints. These farmers already use storage types they know to be less than ideal, because these are all that can be afforded.

The framework is limited by approximation, in that it assumes all smallholder maize farmers in underdeveloped markets have similar storage characteristics. This may not be the case. The study was conducted with a sample from three districts in eastern Uganda, and generalizing from these to all underdeveloped markets may be an over-simplification neglecting nuances in storage needs, types and approaches. Even within the districts surveyed, differences between, for example, sack, raised platform and drum storage were recorded.

The framework assumes that smallholder farmers are able to produce enough maize for both consumption and sale. However, even within the sample surveyed, some farmers were producing so little that even with access to effective storage they would not be able to store until prices became more advantageous. Maize is a seasonal crop, and unreliable weather can additionally reduce the amount a household has to store.

The framework is also not fully able to accommodate the multiplicity of motives developing-world farmers have for their store/sell decisions. In the developed world farmers predominantly store for

price arbitrage. Participants in the research, however, indicated that they produce maize for consumption, sale and planting, with consumption the priority. Emphasizing improved storage mainly as a way to have maize to sell later is taking the priority of selling as a one size-fits-all explanation. This is a mistake too easily committed when making recommendations.

Further, in the developing world, farmers' sell/store decisions can be rapidly overturned if a pressing household financial emergency arises. Smallholder farmers storing to plant will not sell even when prices are high, because they need seed for the new season. If they store for consumption – the majority of smallholder farmers – even higher prices may not tempt them to sell; price arbitrage is not their priority. Thus smallholder farmers often ration their maize between selling, planting and consumption, and may, according to changes in circumstances, alter the quantity in each category. In underdeveloped markets, contingency needs play a far larger role in sell/store decisions than in the developed world.

The theory does not consider risk aversion, which is a common attitude among smallholder maize farmers in underdeveloped markets. The findings in Chapter Five indicate that farmers will only store when they are sure of not losing their maize in storage, because maize is a much-needed commodity that touches all the important aspects of a smallholder's life, including income and food. Thus it is suggested that farmers' motivations – extensively explored in this research – should be kept in mind as an important moderating factor on the application of the model.

Having provided a theoretical foundation for the extension of the theory of storage in Chapter Two, and a methodological explanation in Chapter Three of how evidence was gathered, Chapters Four and Five laid out the evidence, qualitative and quantitative, on which the conditions for

extension can be based. Table 29 summarized the extension framework developed. Section 6.6 below presents the extension model.

6.6 Extending the theory of storage to a perishable commodity in an underdeveloped market

Smith's (1992) definition of marketing margin as the difference between the value of a product at one stage in the marketing process and its value at another stage is used as the basis for this discussion, with the marketing margin in business taken as the difference between the purchase price and the selling price in the same or different markets. Therefore:

$MM = P_s - P_p$……..Equation 1.

Where:

1. MM = Marketing margin
2. P_p = Purchase price
3. P_s = Selling price.

In this study, however, smallholders are not buying and selling "in the same or different markets". They are producing, selling and then sometimes later buying back the same product (maize), which they sold earlier because of lack of effective storage. Thus in this case the per unit production cost is considered as their imputed initial price (P_i): the price at which the farmers purchase the maize). If the smallholder maize farmers sell their maize immediately after harvest and realise a price P_h then their marketing margin can be computed as:

$MM_f = P_h - P_i$.....Equation 2.

Where:

MM_f = Marketing margin realised by smallholder maize farmers who sell immediately after harvest.

P_h = Price realised by farmers when they sell immediately after harvest.

P_i = Imputed purchase price of farmers.

There are traders who buy maize from the farmers, store it and then sell it at a higher price. Since farmers do not have similar adequate and efficient storage to that of traders, they later buy back maize from the traders who bought from them immediately after harvest. The marketing margin realised by traders can be expressed as:

$MM_t = P_t - P_h$……Equation 3.

Where:

MM_t = Marketing margin realised by traders.

P_t = Price at which traders sell to the farmers.

P_h = Price realised by smallholder maize farmers when they sell immediately after harvest (the purchase price of traders).

In this market the total marketing margin is:

$MM_T = P_t - P_i$……Equation 4.

The share of the maize marketing margin realised by farmers is:

$MM_{SF} = MM_f/MM_T$……..Equation 5.

Where MM_{SF} is the share of the marketing margin accruing to the farmers by selling immediately after harvest.

The share of the marketing margin realised by traders is:

$MM_{ST} = MM_t/MM_T$…….Equation 6.

Where MM_{ST} is the share of the marketing margin accruing to the traders by selling to the farmers after storing the maize for a period. This is margin which the farmers fail to achieve due to poor storage.

It therefore follows that:

$MM_{SF} + MM_{ST} = 1$…….Equation 7.

The thesis of this study is that, if farmers improve their storage, they can increase their share of the maize marketing margin (MM_{SF}) by holding the maize and then selling at a higher price. If farmers succeed in doing this, they reduce the share of the maize marketing margin (MM_{ST}) currently being realised by traders. This is represented in the equation: $MM_{SF} + MM_{ST} = 1$.

From a systems perspective, the share of the marketing margin gained by farmers as a result of improving their storage is a transfer payment, with the farmers gaining and the traders losing. However, this transfer payment may be justifiable. Because the transfer goes to more farmers than traders, and because the farmers are poorer than the traders, the increase in their income is likely to go directly into consumption, thus better stimulating the economy than if it accrued to traders. Some of these parameters in equations 1 to 7 have been estimated in this study. For instance P_i=620 amid P_t=938. Therefore:

$MM_{SF} = (620-P_i)/(938-P_i)$.

The only parameter to be estimate is P_i.

It is important to realise that when more farmers invest in storage and sell later, the prices realised at that later time may fall. However, since the gain by farmers is, for the most part, a transfer

payment, this effect is likely to be minimal. The established parameters will also vary by season, because they are a function of maize supply and demand. For instance after a drought, both P_h and P_t increase, while there may be minimal effect on P_i resulting in increased marketing margins for both farmers and traders.

In this way the theory of storage is extended to a perishable commodity in an underdeveloped market.

CHAPTER SEVEN: Conclusion and recommendations

7. Introduction

This chapter aims to provide readers with a summarized understanding of the study and how its findings relate to the following recommendations for action. The main findings relating to the research questions are presented, the general conclusions and recommendations of the study are described, and its limitations and directions for future study discussed.

In this research, the primary aim was to examine the impact of the storage types they used in influencing smallholder maize farmers' share of the marketing margin, and to explore how they perceived the role of storage in their business strategy to increase this share. A secondary aim was to evaluate whether and under what conditions the theory of storage could be extended to an underdeveloped market, using smallholder maize farmers in Eastern Uganda as the case study.

7.1 Conclusion

The conclusion is structured according to the research questions that were investigated in this study.

7.1.1 Can the theory of storage be extended to underdeveloped maize markets of smallholder maize farmers in Uganda? (RQ1)

The findings demonstrate that in principle the theory of storage can be extended to underdeveloped market, list certain assumptions – relating to stock-holder behaviour in terms of inventory-holding and speculation; the nature of the products stored; the characteristics of the market; the scale of production; and producers' motivations and income sources – are adjusted. While the fine detail

of these adjustments may vary with local conditions in different underdeveloped countries, the broad categories will be similar.

7.1.2 Can the storage types of smallholder maize farmers in Uganda be identified and characterized? If so, do these characteristics affect choice of storage and the maize marketing margin realized by the smallholder farmers? (RQ2)

The findings provided both general and specific descriptions of the storage types used by smallholder maize farmers. Many different storage types were used, including granaries, cribs (open and closed), sacks, house corner, house roof, above-the-fire, baskets, pots, jerry-cans and tins. However, the results indicated that the most significant differences in impact were related not to a single individual type, but to two broader divisions: in-house and outside the house storage types. Which of these categories was employed had a clear impact on the share of the maize marketing margin realized: farmers preferred in-house storage (for reasons detailed in the sections below), but the more modern external storage types such as cribs facilitated better, longer storage and thus could realize higher, late-season, prices and an improved share of the marketing margin.

7.1.3 What are the costs (quantity, quality and financial) associated with the identified storage types? Do the associated costs affect the share of the maize marketing margin realized by smallholder farmers in Uganda? (RQ3)

The costs of acquisition and maintenance were found to be significant for smallholder farmers in identifying the storage types to use at household level. The majority of the smallholder maize farmers surveyed preferred in-house storage, specifically sacks, which were much cheaper to acquire than cribs or granaries. The greatest cost (in terms of loss to the farmer) was incurred through damage and deterioration of the grain in storage from pests and rats, with house-corner

storage being the most costly in this context. Some farmers surveyed described losing almost all their maize to pests or rats, a finding parallel to that of Suleiman and Rosentrater's (2015) in Tanzania, where loss of maize at household level was often between 20 - 30 percent of the harvested amount. The loss is a huge challenge among farmers in East Africa; another study conducted in Kenya by Midega *et al*. (2016) also reported a similar percentage loss.

Household storage costs are exacerbated by the costs of maintaining quality during storage (Hell *et al*., 2000). Keeping maize safe and in good condition is expensive – sometimes more so than acquiring the storage type – and this is one explanation for why farmers prefer to sell their maize immediately after harvest. Farmers have devised various protective measures, which are outlined in Chapter Five, and some farmers employ pesticides (Actellic Super was mentioned) but these are expensive, sometimes hard to find, and often adulterated or counterfeited, while some respondents were also aware of the dangers of poisoning or food contamination when using them in-house.

All these storage costs inhibit smallholders from selling at the higher prices experienced later in the season and often force them to sell immediately after harvest: 44 percent of those surveyed sold their maize less than one month after harvest, impacting negatively on their share of the maize marketing margin.

7.1.4 What is the effect of household characteristics on the choice of maize storage types and length of storage? (RQ4)

The household characteristics of location (district), gender, the ways storage types were acquired, and the seasonal patterns in households' use of storage, were all found to be positively associated with smallholder maize farmers' choice of storage types. Neither the education levels of household

heads, nor who the decision-maker on storage was (household head and decision-maker were categories that did not always neatly coincide), showed a significant association with specific storage decisions, although low education levels (the majority of those surveyed were at or below primary level) were important in both hampering access to information and reducing innovation related to storage. However, higher education levels were associated with smallholders reporting they invested more in storage, as was having access to a greater area of land for maize cultivation. Anecdotal discussion indicated that these results are affordability-related: better-educated householders can command the higher incomes that make these practices more feasible.

7.1.5 What are the experiences and perceptions of smallholder maize farmers in adopting and using a storage business framework to increase their share of maize marketing margin? (RQ5)

Most smallholder maize farmers participating in focus group discussions expressed positive support for using storage in their framework for building a better business strategy to increase their share of the maize marketing margin. They explained that despite the poor storage options to which they currently had access, they still base some business on stored grain. If their storage were to improve, this might become a more meaningful component of their business strategy. In their view, storage can be used as a basis for a business framework for farmers in their situation – increasing, for example, their capacity to store from the current two months to the six months during which prices rise to maximum before the next harvest. In this way, they see the potential to increase their incomes. Although they are aware of the impact of storage on their food and income security, however, these smallholder farmers expressed themselves as unable, unaided, to change the situation. Lack of resources, education and information were all cited as contributing to this, providing granular evidence about the factors underlying Shepherd's (2012) finding that

innovation among smallholder farmers in SSA remains low. However, resistance to innovation is not the only underlying factor: not only the skills to innovate but also the materials for improving storage are scarce and expensive in some areas. For this reason, even in different parts of the same eastern region, some storage types have completely disappeared (for example, granaries are no long used in Iganga).

7.1.6 General implications

This research provides compelling evidence that the importance of maize storage for SSA – where smallholder farmers are the major producers – underscores the need for continued research (from scholars, policy-makers and practitioners) to improve storage approaches as a way to augment both income and food security.

Generally, smallholder maize farmers sell at or shortly after harvest and maize storage at household level remains problematic. Despite the various protective measures they have devised, these farmers still face difficulty in keeping maize for long enough to benefit from higher prices. This has continued to cause speedy sale after harvest with its embedded consequences of low prices (Tefera *et al*., 2011). However, the findings of this research provide robust support for the view that longer storage does have the potential to increase the share of the maize marketing margin, because of the tendency of prices to increase over time after harvest. Smallholders who stored for longer and sold later did realize higher prices.

The affordability of better storage was a recurring and serious concern for farmers in the FGDs. If smallholders' share of the maize marketing margin is to increase then there must be a deliberate

effort to reduce the costs of household storage by improving the efficiency of, and access to, current storage types. This is a fundamental condition for extending the theory of storage.

Qualitative findings underlined how strong farmers' preference was for storing their maize at household level. Thus any attempt to help them improve storage should be directed towards household types. As stores are improved, mechanisms and measures for better maintenance need also to be designed, because, without proper maintenance, stores as well as the grain within them, deteriorate (Proctor, 1994; Poole *et al*., 2013). Having a store alone is not enough; maintaining the maize in the store is what creates greater value.

While storage at household level is challenging for maize smallholders, it still plays an essential role: providing not only income, as discussed above, but food for these farmers and their families. It is important to acknowledge these positive benefits. The extent to which storage can be improved will depend on how smallholders perceive it, and on their ability to upgrade. However, the improvement can be expected to have a positive impact on the smallholder commercialization process and smallholder farmers' share of the marketing margin. Interest in this prospect informs the focus of this research on the extensibility of the theory of storage to underdeveloped markets.

7.2 Recommendations

The recommendations made in this section and relating to these aspects derive from the findings of this study, and align with the research questions and objectives. Improving household level storage has the capacity to increase smallholders' earnings from maize because it will afford the opportunity to store and sell later when prices have increased. Better storage will facilitate inter-

seasonal household storage, which increases the benefit to smallholder maize farmers through price arbitrage. Additionally, less money will be spent on purchasing maize for consumption since households will be able to access maize they have grown themselves and stored securely. In the long run, selling to meet immediate cash needs may be reduced or eliminated, thereby reducing poverty among smallholder maize farmers. All these changes can enhance income and food security at all levels. Thus promoting household storage is likely to carry positive economic and social impacts.

7.2.1 Enlarge consideration of household characteristics and farmers' experiences

First, it is recommended that studies on storage at the level of smallholder maize farmers should always consider the household characteristics of this group and their reasons for storing. Storage at household level has three main motives; consumption, sale and planting. Smallholders choose storage types in relation to their household characteristics and circumstances; even when they are aware of alternative storage approaches that could increase their share of the maize marketing margin, it is these factors that will impact most strongly on their actual storage choices and decisions.

Because of this, increasing smallholders' share of the maize marketing margin may not demand introducing completely new storage technologies, but might rather be achieved by improving the storage types households already use, with the aim of bringing improved storage that can reduce losses within farmers' financial reach. Such improvements can not only increase farmers' earning, but also facilitate trade.

Without careful investigation, radically different new storage technologies may prove incompatible with the context in which they are to be used. Studies and innovation programmes carried out with limited knowledge of household storage preferences (as in Cameroon, Zambia, Burundi and Benin) have shown limited or no success, illustrating that simply transplanting technology that works well in very different environments to underdeveloped markets is not the way to solve household storage challenges.

Additionally, including farmers' perceptions in designing a successful strategy for them is paramount. In this study, farmers' views on using storage as a business framework were sought and were found to be positive even among farmers with severely limited financial options. Both the literature and this research suggest that the adoption of new storage technology is quite difficult for smallholder farmers and has been disappointing in some places. Giving farmers agency in the process of storage improvement, and improving existing storage types rather than imposing new types can both build greater buy-in.

It is equally important to consider variations in experiences and attitudes among smallholders. Not all will be willing to accept the improvements suggested and, apart from cost issues, some farmers may simply be resistant to change. This research found that differences in location significantly affect choice of storage, even within one region, and this, too should be considered. However, given an appropriate framework of interactions with smallholder maize farmers, the recommendations of this research offer a greater prospect of successful implementation for smallholder farmers across many developing countries.

7.2.2 Increase the focus on market information access and farmer training

Any improvement in storage needs to be supported by sensitization and good market information dissemination. Discussion in the FGDs indicated that Ugandan farmers share the need of their regional counterparts for information and sales skills, rendering them less likely to benefit from their maize sales. Farmers believe such training is important in equipping them with skills to access information about prevailing price when they want to sell. This information is important in bargaining for better prices at the farm gate (Svensson & Yanagizawa, 2009). Thus farmers need to be equipped with marketing information search skills as well as being trained in good storage management skills.

Such training can also upgrade the quality of maize, which has arguably been poor because of improper handling as well as inadequate storage. Improved storage alone is not a guarantee of economic upliftment, as without knowledge of market conditions and price shifts, uninformed sell/store decisions can even create shortages and price spikes at harvest, and cause market gluts later that may lower prices.

7.2.3 Build on the local knowledge of key informants

Improving storage at household level need to be undertaken in consultation with other knowledgeable local stakeholders including agricultural extension workers, traders (and even health workers, although they were not consulted in this study) because the consequences of maize storage and marketing impact on many people (Omotilewa *et al*., 2016). Health workers are critical in advising on the storage to ensure that the improvement is not infringing on health of the consumers through aflatoxin contamination. In addition, they are a key source on dealing with pesticide dangers during household storage. The involvement of other stakeholder provides not

only contributions on improving storage at the source but also a way of maintaining business relationships along the value chain.

Both farmers and policy makers need to know more about storage utility at household level, in order to devise strategies for improvement so that smallholders can sell their maize for higher prices. This information thus needs to be disseminated more widely to enhance awareness of the need for improved household storage. Additionally – and with due caution about the differences between commercial and subsistence agriculture (Pingali, 2001) – such information may also increase the impetus for greater commercialization at smallholder level, another route to improved earnings from maize. Previous literature has observed that precise information about household level storage and the marketing margin in SSA remains inadequate (Poudel, 2013). The results of this study provide original and rich information to add to existing knowledge, as well as serving as an important stimulus for more research in the area, as indicated in 7.4 below.

7.3 Limitations of the study

Every study encounters some limitations; the responsibility of the researcher is to minimise any distorting impact of these limitations on findings, and to report both the limitations and how they were dealt with fully and honestly. The limitations of this study were methodological and conceptual.

7.3.1 Methodological limitations

This study acknowledges that studying maize storage at the household level optimally requires a longitudinal approach. A longitudinal approach permits investigation at different times in the year,

to take into account the bimodal rains that facilitate two maize seasons per year. However, in this study a cross-sectional approach was employed, because of time constraints. This limited interactions with the farmers over time and in turn limited our ability to track maize storage trends over a long period. The cross-sectional approach had utility in reporting on the situation as it prevailed at one particular time, as opposed to trends, and survey questions as well as the more wide-ranging FGD conversations elicited information from smallholders about their storage practices over multiple seasons.

Additionally, time and financial constraints ruled out a census method where every maize farmer was interviewed. A representative sample of the population was surveyed instead as discussed in Chapter Three. In addition, the quantitative part of the study was supplemented by qualitative data collection, which is less affected by sample size.

The study amassed primary data rich in content. However, the accuracy of the information supplied by farmers depends on their ability to recall and self-report past experiences and practices. The study was conducted between January and May 2016, but asked about the second harvest season of 2014/2015. Given that the majority of the smallholder maize farmers surveyed did not keep written records, probing for precise detail sometimes became difficult. Where the information given seemed uncertain, it was approximated by supplementing it with information from the current season.

Sample control sometimes posed problems. For ease of moderation and recording, FGDs were limited to twelve participants. However, in the Ngariam sub-county of Katakwi District, many more smallholders wanted to participate and in this sub-county the venue for the FGD was changed, to control for extraneous information from non-selected participants.

Using agricultural extension workers to identify respondents for FGDs carries the risk of subjectivity. This was controlled by re-checking participants' maize harvest amounts in the second season of 2014/2015 to ensure they fell within the correct sample category. In addition the lists of farmers obtained initially was checked to ensure they had not participated in the survey.

Some farmers were not fluent in English this could have hampered their ability to express themselves freely. Research assistants with knowledge of the various local languages interpreted the questions in the focus group guide, making it possible to gather the views of those not fluent in English. To control for translation bias, translations, guide text and audio-recorded responses were cross-checked by an independent reader fluent in both English and the local language concerned. However, although the accuracy of meaning of the translations was verified, sometimes the vernacular flavour of conversation was lost.

The research encountered two methodological limitations during the course of its work. The first emerged when investigating the impact on storage of education and decision-making roles in households (where no significant associations emerged). Where both household head and spouse made the decision about storage, the education of the decision-maker – rather than that of the household head –should have been tested against the storage type category. This study had not developed a way to code the education levels of two household members jointly. This issue is noted as meriting further investigation at 7.4 below.

The second limitation arose from the richness of the data gleaned from the qualitative investigation. Farmers in the FGDs reported multiple storage challenges: challenges relating to the personal characteristics of the farmer such as age, gender and literacy level, as well as circumstantial factors such as time of sale, access to other income sources and distance to market.

However, because these were reported in the second phase of research, it was not possible for this study to measure the relative significance of each of these factors. Again, this is noted below.

A further attitudinal constraint on survey methodology is that research respondents are known to behave differently – and sometimes artificially – when they are aware they are being studied. To create confidence and manage respondents' anxiety, subjects were fully informed about the study, given free choice about participation, and enrolled via a carefully-explained consent form. This helped to reduce attrition and selection interaction error.

7.3.2 Conceptual limitations

Conceptually, extending the theory of storage required understanding of both contexts before attempting to extend the theory. Resources of time and finance constrained the ability of this study to analyse both environments *in situ*. Therefore the underdeveloped market context was studied through face-to-face survey and discussion groups, while the developed market was studied via the extensive literature which exists and which gives adequate information concerning historical and prevailing storage-related circumstances there.

An additional conceptual challenge in comparison between the two contexts was the difference in farmers' situations. Farmers in developed markets may store maize for sale as an arbitrage to price; farmers in developing markets store predominantly for subsistence. Farmers in developed markets are likely to make profits across several seasons that can be reinvested to improve their storage; farmers in underdeveloped markets instead make losses. These differences pointed the research towards the adjustments in the theory of storage required for its extension to the underdeveloped context, which were outlined at the beginning of this chapter.

7.4 Areas of further study

Areas for useful and relevant future study emerged both from the review of literature and during the course of research activities. In the literature chapter, several areas relating to maize storage and the theory of storage that remain relatively unexplored or unconsidered have been identified, including cost of storage, farmers' access to credit, which storage type can optimize the costs of storage, and climate and pest control. The findings of this study begin to address some of these; others are discussed below.

7.4.1 Further theoretical study

Chapter Six of this dissertation offers a demonstration of how the theory of storage may be extended to the underdeveloped market context by identifying assumptions that need adjustment for the extension of the theory extension. This extension was not, however, tested. Future studies should test the application of the theory in the context of underdeveloped markets in SSA. In addition, the conceptual model developed in as a result of the review of literature (Figure 3) merits further testing to include more variables and test in business contexts other than agriculture. This is important, because the model is new, was developed for the purposes of this study, and requires validation.

Based on the conceptual model in Chapter Two, and considering the analysis done, further study is required to test the following hypotheses:

H1. The theory of storage cannot be extended to an inefficient market.

H2. The characteristics of smallholder maize farmers do not affect the choice of the storage types used.

H3. The costs of storage do not affect the share of the maize marketing margin realized by smallholder maize farmers.

H4. The costs of maize storage cannot be used to identify storage types that optimize storage to increase the share of the maize marketing margin realized by smallholder maize farmers.

H5. Smallholder maize famers' perception cannot be used to develop a business framework to increase the share of the marketing margin realized.

7.4.2 Further empirical study

Existing literature demonstrates that extending credit to smallholder maize farmer may enable them to access safe storage facilities. In this study, data on credit was not collected, and thus it is recommended that further studies in underdeveloped markets should be conducted to assess credit facility opportunities and their relationship to household storage improvement.

This dissertation examined the theoretical application and extension of the theory of storage to underdeveloped markets, with a specific focus on maize However, further empirical studies based on the theory are required to establish how storage at household level impacts on other crops grown by smallholder farmers which may have different characteristics, such as rice, beans, groundnuts, sunflower seeds .

In the course of the qualitative research, participants described various measures they took to preserve their maize (such as neem tree leaves, red pepper, ash mixed with water, sun drying,

pesticides, and many more). The relative effectiveness, affordability and potential of these methods need to explored further.

The research noted significant differences between the maintenance costs of grain in different districts, with, for example, a medium maize-producing district experiencing higher costs than either high or low-producing districts. These were not explained by any additional data, and this merits further investigation.

This research delineated elements for a maize business framework in an underdeveloped market, and underlined the importance of farmers' perceptions and experiences in driving innovative change. One extremely useful extension of the findings might be a focused investigation of business frameworks and agribusiness strategies in terms of farmers' commercialisation behaviours, perceptions and experiences, to assess the potential for enlivening smallholders' collective maize marketing to enhance their bargaining power, increase their incomes and alleviate household poverty.

A number of issues emerging from the qualitative phase of the study demand further investigation at household level. Farmers in the FGDS reported their need for money as an important influence on immediate maize sale. A more detailed study of the financial resource requirements of smallholder farmers' households, and their impact on sell/store decisions could add granular detail here. At several stages in the study, nuanced gender differences in perceptions and experience emerged, which this study was not shaped to explore. In addition, the FGDs illuminated farmers' experiences, but provoked a number of further questions about goals and aspirations. The discussions did not reveal what proportion of grain farmers would have liked to store or sell, and for how long, as opposed to what they did store and sell. It is within this cluster of intriguing future

household studies that investigation of household decision-making, education, and the relative importance of circumstances on storage decisions, described at 7.4 above, belongs.

A final cluster of interesting implications relate to the issues around changed sales practices and commercialisation. If improvements in storage are implemented, longitudinal studies will be required to explore whether these mitigate price fluctuations, or merely change the seasonal patterns of fluctuations. In addition, only longitudinal studies can ascertain whether improved storage for some farmers encourages others to cease growing maize, because they can now buy it from more stock-holders in their area – and what the impact of this development is on socio-economic development.

The information gathered by the research and presented in this thesis may not change the people who were studied. However, it may be used to change their perceptions about how they store their maize, and in this way help to increase their earning from their maize produce. A detailed examination of maize storage at household level illuminates individual household storage challenges, and this can enable smallholder farmers to become more income and food secure as part of what Adler (2013) called the "science of living together".

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Appendix A: **Consent Form for Focus Group Discussion**

I am conducting research on extending the theory of storage to a perishable commodity in an underdeveloped market. Our discussion is expected to last about two hours, and will help us understand how maize storage costs impact on the share of the maize marketing margin of smallholder farmers and your perception of maize storage as a business. **Your participation is voluntary and you can withdraw at any time without penalty**. Of course, all data will be kept confidential. If you have any concerns, please contact me or my supervisor. Our details are provided below.

Researcher Name Research Supervisor Name Research Supervisor Name
Anthony Tibaingana DR. TUMO KELE PROF. GODSWILL MAKOMBE
Email: atibaingana@gmail.comkelet@gibs.co.zaGodswill.Makombe@ul.ac.za
Phone: +256712884626 +27823445862 +27735383811/0608546155

Signature of participant: _____

Date: _____

Signature of researcher: _____

Date: _____

Appendix B: **Consent form for Key Informants Interview**

I am conducting research on extending the theory of storage to a perishable commodity in an underdeveloped market. Our interview is expected to last about an hour, and will help us understand the services rendered by agriculture extension workers to smallholder maize farmers. **Your participation is voluntary and you can withdraw at any time without penalty**. Of course, all data will be kept confidential. If you have any concerns, please contact me or my supervisor. Our details are provided below.

Researcher Name Research Supervisor Name Research Supervisor Name
Anthony Tibaingana DR. TUMO KELE, PROF. GODSWILL MAKOMBE
Email: atibaingana@gmail.comkelet@gibs.co.zaGodswill.Makombe@ul.ac.za
Phone: +256712884626 +27823445862 +27735383811/0608546155

Signature of participant: _____

Date: _____

Signature of researcher: _____

Date: _____

Appendix C: **Consent Form for survey**

I am doing research on extending the theory of storage to a perishable commodity in an underdeveloped market**.** To that end, you have been identified as a respondent for this study. This will help us better understand smallholder maize storage and marketing margin and should take no more than one hour of your time. **Your participation is voluntary and you can withdraw at any time without penalty.** Of course, all data will be kept confidential. By completing the survey, you indicate that you voluntarily participate in this research. Please note that the survey will be conducted in two waves. The first will look at the demographic characteristics, storage types, storage period, and time of sell or purchase. The second wave will estimate the cost associated with the storage type used by each farmer and will include only those farmers who participate in the first wave. Please note that this consent form is for survey waves. If you have any concerns, please contact me or my supervisor. Our details are provided below.

Researcher Name Research Supervisor Name Research Supervisor Name
Anthony Tibaingana DR. TUMO KELE PROF. GODSWILL MAKOMBE
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Phone: +256712884626 +27823445862 +27735383811/0608546155

Signature of participant: _____

Date: _____

Signature of researcher: _____

Date: _____

Appendix D: **FOCUS GROUP DISCUSSION GUIDE**

Dear focus group members: My name is **Anthony Tibaingana.**I am conducting research on extending the theory of storage to a perishable commodity in an underdeveloped market. Our discussion is expected to last about two hours, and will help us understand how maize storage costs impact on the share of the maize marketing margin of smallholder farmers and your perception of maize storage as a business.Your participation is voluntary and you can withdraw at any time without penalty. Of course, all data will be kept confidential.

Date of focusgroup discussion /__/__/__/__/__/__/__/__/ (dd/mm/yyyy)

Let's do a quick round of introductions.

1. Can each of you tell the group your name?
2. What is the name of this village?
3. What is the name of this sub county?

For maize storage

4. Why did you grow maize in the second season of 2014?
5. Which other crops did you grow during the last season (2^{nd} season of 2014)?
6. Could you please talk about storage experience in general and specifically maize storage experience?
7. What kind of storage types are used to store crops in general and for maize specifically?
8. What cost (s) is associated with the storage types for maize? Are they similar to costs associated with storage of other crops?
9. Where do you sell maize?
10. What is the impact of the cost incurred in storage on the maize price realised?
11. What would be the impact of reducing or eliminating the costs?
12. What would be the impact of storing maize for long (if you could) on the price of maize?
13. Of all the different storage type (s) mentioned above, which ones did you use last season (2^{nd} season of 2014)?
14. Why are the method (s) mentioned above used?
15. Who makes the decision of the storage type to use?
16. How did you make the decision of how much maize to store in the last season (2^{nd} season of 2014)?
17. How do you make the decision of when to sell the maize stored?
18. What methods do you use to protect the stored maize?
19. What factors were considered in making the decision about storage type to use last season?
20. What are the reasons for storing the maize?
21. For how long do you store maize?
22. Would you want to store your maize for more than the period you have indicated above?
23. If yes why? And if no why?
24. How can maize storage be improved?

For maize consumption

25. If someone else paid for technology to improve storage for the maize for your consumption, would you be willing to accept such improved storage?
26. If you were to pay for such improved storage for your consumption, would you be willing to accept it?
27. How often do you buy maize for home consumption?
28. Why do you buy yet you produce maize?
29. Where do you buy?
30. What prices do you pay?

Business framework

31. If someone (say the government) were to pay for improved storage so that you do not have to sell immediately after harvest but sell later when prices increase would you be willing to accept such storage?
32. If you were to pay for improved storage so that you do not have to sell immediately after harvest but sell later when prices increase would you be willing to accept such storage?
33. When do you sell your maize?
34. Why do you sell at that time?
35. Whom do you sell to?
36. What prices do they get?
37. When are the lowest prices of maize experienced?
38. When are the highest prices of maize realised?
39. Do you think that maize storage can be used in a business framework for smallholder maize farmers' to sell maize when prices have increased?
40. If yes why?
41. If no why?
42. Is there anything else we haven't discussed yet that you think is important for us to know about?

This is the end of our discussion any question?

Appendix E: **FOCUS GROUP DISCUSSION GUIDE**

Dear focus group members: My name is **Anthony Tibaingana.** I am conducting research on extending the theory of storage to a perishable commodity in an underdeveloped market. Our discussion is expected to last about two hours, and will help us understand how maize storage costs impact on the share of the maize marketing margin of smallholder farmers and your perception of maize storage as a business.Your participation is voluntary and you can withdraw at any time without penalty. Of course, all data will be kept confidential.

Date of focusgroup discussion /__/__/__/__/__/__/__/__/ (dd/mm/yyyy)

Let's do a quick round of introductions.

43. Can each of you tell the group your name?
44. What is the name of this village?
45. What is the name of this sub county?

For maize storage

46. Why did you grow maize in the second season of 2014?
47. Which other crops did you grow during the last season (2^{nd} season of 2014)?
48. Could you please talk about storage experience in general and specifically maize storage experience?
49. What kind of storage types are used to store crops in general and for maize specifically?
50. What cost (s) is associated with the storage types for maize? Are they similar to costs associated with storage of other crops?
51. Where do you sell maize?
52. What is the impact of the cost incurred in storage on the maize price realised?
53. What would be the impact of reducing or eliminating the costs?
54. What would be the impact of storing maize for long (if you could) on the price of maize?
55. Of all the different storage type (s) mentioned above, which ones did you use last season (2^{nd} season of 2014)?
56. Why are the method (s) mentioned above used?
57. Who makes the decision of the storage type to use?
58. How did you make the decision of how much maize to store in the last season (2^{nd} season of 2014)?
59. How do you make the decision of when to sell the maize stored?
60. What methods do you use to protect the stored maize?
61. What factors were considered in making the decision about storage type to use last season?
62. What are the reasons for storing the maize?
63. For how long do you store maize?
64. Would you want to store your maize for more than the period you have indicated above?
65. If yes why? And if no why?
66. How can maize storage be improved?

For maize consumption

67. If someone else paid for technology to improve storage for the maize for your consumption, would you be willing to accept such improved storage?
68. If you were to pay for such improved storage for your consumption, would you be willing to accept it?
69. How often do you buy maize for home consumption?
70. Why do you buy yet you produce maize?
71. Where do you buy?
72. What prices do you pay?

Business framework

73. If someone (say the government) were to pay for improved storage so that you do not have to sell immediately after harvest but sell later when prices increase would you be willing to accept such storage?
74. If you were to pay for improved storage so that you do not have to sell immediately after harvest but sell later when prices increase would you be willing to accept such storage?
75. When do you sell your maize?
76. Why do you sell at that time?
77. Whom do you sell to?
78. What prices do they get?
79. When are the lowest prices of maize experienced?
80. When are the highest prices of maize realised?
81. Do you think that maize storage can be used in a business framework for smallholder maize farmers' to sell maize when prices have increased?
82. If yes why?
83. If no why?
84. Is there anything else we haven't discussed yet that you think is important for us to know about?

This is the end of our discussion any question?

Appendix F:**Questionnaire for the first phase**

I am doing research on extending the theory of storage to a perishable commodity in an underdeveloped market. To that end, you have been identified as a respondent for this study. This survey will help us better understand the concept of maize storage and share of the marketing margin of smallholder maize farmers. The survey should take no more than one hour of your time. Your participation is voluntary and you can withdraw at any time without penalty. Of course, all data will be kept confidential. By completing the survey, you indicate that you voluntarily participate in this research. If you have any concerns, please contact me or my supervisor. Our details are provided below.

Researcher Name Research Supervisor NameResearch Supervisor Name
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IDENTIFIERS **Starting time……**

Name of household head: _____

Name of respondent: _____

Phone Contact: _____

Name of District: _____

Name of Sub-County: _____

Name of Village: _____

Interviewer's name: _____

Interview date: /__/__/__/__/__/__/__/__/ (ddmmyyyy)

Section A (smallholder maize farmers' demographic information)

Dear respondent we are going to talk about your household demographic characteristics

Q 1. How many people live in this household.....?

I will now ask about the composition of your household. Can you provide the following information for each household member? (Use the table below)

Q2.Household member (List the name of the household members beginning with Respondent)	Q3.Gender of household member (1= male 2 =female)	Q4.Age of household member in years.	Q5.Highest level of education attained by household member (Note please indicate as P1,P2,P3,P4,P5,P6 and P7., S1,S2,S3,S4,S5 and S6, Diploma, Degree, No school=0)	Q6.Occupation of household member (1=farmer 2=salary earner 3=Trader 4=Student 5=Child not student 6=other Specify)	Q7.Relationship to the household head (1=Head 2=Spouse 3= Child 4=Grand child 5=Other (specify))
Respondent					

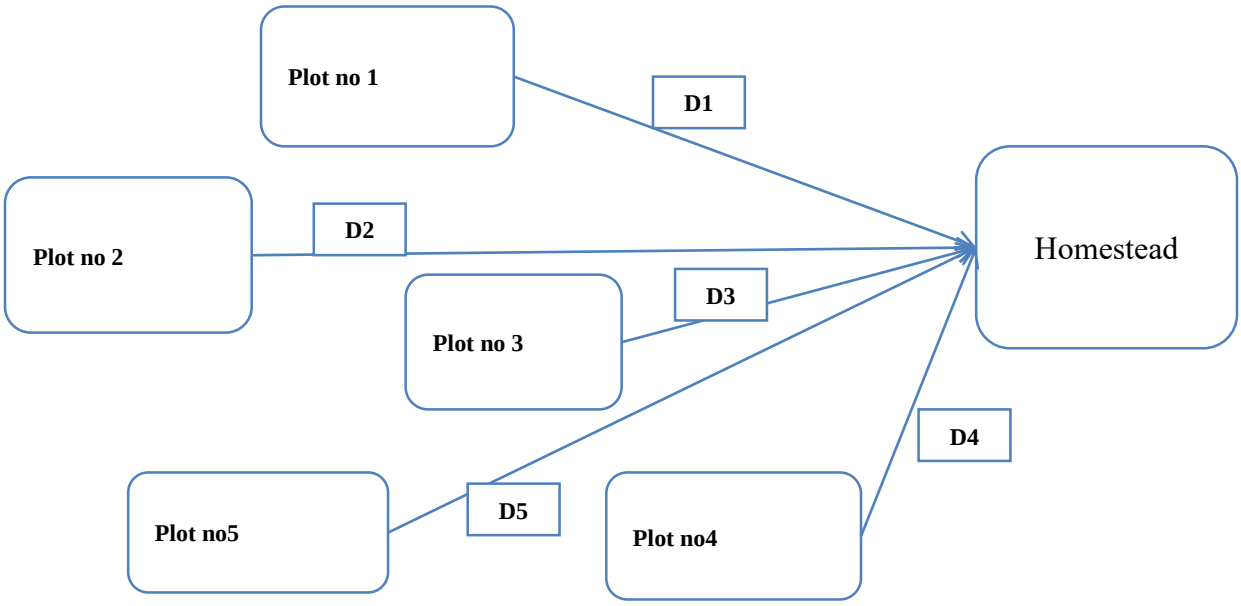
Section B (maize growing characteristics)

Note: <u>The growing season considered in this study is the second season of 2014 from the month of August to November, Harvest season is from December, 2014 to March, 2015 while storage period is December 2014 to June, 2015).</u>

We are now going to talk about the characteristics of maize growing in your household for the second growing season of 2014 which is from August to November. Please, may you respond to the following questions in the figure below?

Where necessary we shall draw a sketch of all your fields, indicating where all your land is located and what you grew on it during the 2nd growing season of 2014. We have pre assigned a plot number to each plot. Each crop will constitute a different plot. If a crop was planted at different times (staggered planting), each planting is treated as a separate plot even if they may be on the same piece of land. Let us also indicate the size each of the plots in acres. Subsequently in the table preceding the figure, we will also indicate on the sketch how the plot was acquired by using the codes: 1=Purchased, 2=Inherited, 3=A gift, 4=Rent and 5=other specify.

Q 8. Use the sketch to answer the questions, the arrow indicates distance between plots and homestead, the size and crop grown in the respective plots will be inserted in the figure. What is the size of the land used for farming……..



D=distance

Plot number	Q9. Area (Acres)	Q10. Crop grown	Q11. How did you acquire this plot (1=Own it 2=Purchased 3=Inherited 4=A gift 5=Rent 6=other specify)	Q12If rented what is the rental amount in Uganda Shillings.	Q13. How much of each crop did you harvest from each plot in the second growing season of 2014? (Specify the unit e.g. cups, tins, sacks, basket or basin)
1					
2					
3					
4					
5					

Section C (Maize storage characteristics)

In this section we are going to talk about maize storage for the second harvest season of 2014 that is from December to June, 2015 by your household.

Q 14. By the time you harvested maize in the second season of 2014, how much was in store from the first harvest season of 2014 that is from April to November.....?

Q15. What was the **mainreason** for storing maize harvested in the second season of 2014 that is from December to March 2015? (Circle all that apply to you)

Reason	Circle
a) Food for the household	1
b) To sell later at a higher price	2
c) Seed for planting	3
d) Others please specify.....	4

Let us talk about the storage type (s) you used for the maize harvested during the second season of 2014 that is from December, 2014 to July, 2015.

SN	Storage type	Q 16. Circle all the storage type you used in the second harvest season of 2014	Q 17. What quantity in units did you store in different storage types? (1=cups 2=tins 3=sacks 4=Basket 5=basin 6= others, specify)	Q 18. For how long (in weeks) did you store? (1=less than one week, 2=two weeks, 3=three weeks, 4=one month, 5=more than a month)	Q 19. In which month(s) did you use [the storage type]? (1=December 2=January 3=February 4=March 5=April 6= May 7= June)	Q 20. What was the main reason for using the storage type? 1=Transitory storage, 2=Sale, 3=Consumption 4=Other, specify				Q 21. How long have you used [the storage type]? (1=last season only, 2=last two seasons only 3=Every season)	Q 22. For [the storage type used] who made the decision? (1=household head 2=household spouse) 3=both 1and 2, 4=Other specify)
a)	Granary	1				1	2	3	4		
b)	Crib (Open)	2				1	2	3	4		
c)	Crib (Closed)	3				1	2	3	4		
d)	Basket	4				1	2	3	4		
e)	Above fire	5				1	2	3	4		
f)	House Corner	6				1	2	3	4		
g)	House Roof	7				1	2	3	4		
h)	Sacks	8				1	2	3	4		
i)	Tin	9				1	2	3	4		
j)	Other (specify)	10				1	2	3	4		

Let us talk about storage types in relation to safety, acquisition and maintenance of storage for the maize stored during second harvesting season of 2014 that is, from December to June, 2015.

SN	Storage type	Q 23. Is the storage type used safe for your maize? (1=Strongly Agree, 2=Agree,3=some what agree, 4=disagree and 5= strongly disagree)	Q 24a. How did you acquire the storage type (1=Constructed it 2=paid for construction 3=Purchased it 4=It was donated 5=Inherited it 6=Other (specify))	Q 24b If in Q23 the answer is **4** or **5** give reasons for your answer; 1=it increased maize wastage 2=it susceptible to damage 3=more prone to theft of maize 4=others please specify.	Q 25. Main method used for maintenance of maize in the different store; (1=Fumigation 2=Smoking 3=Replacement of parts 4=Sun drying 5=None

					6=other specify)
a)	Granary				
b)	Crib (Open)				
c)	Crib (Closed)				
d)	Basket				
e)	Above fire				
f)	House Corner				
g)	House Roof				
h)	Sacks				
i)	Tin				
j)	Other (specify)				

Q 26. Which of the storage types used above was for transitional storage (waiting to take the maize to the market or long term store) circle all that apply.

a) Granary b) Crib (Open) c) Crib (Closed) d) Basket e) Above fire f) House Corner g) House Roof h) Sacks i) Tin j) other specify……..

Section D (Maize marketing)

Let us talk about maize sales and marketing

Q 27. Did you sell any of the maize from the second harvest season of 2014 that is, from December to June, 2015? ☐ 1=Yes ☐ 2=No

Q 28. How much maize did you sell in the second harvest season of 2014 (give the amount, specifying the units either in Kgs, cups, tins, sacks, baskets or basins.....?

Q 29. Did you sell your maize immediately after harvest in the second season of 2014 that is from December to March 205? ☐ 1=Yes ☐ 2=No.

Q 30 a. If yes to question 29, what was the main reason for selling maize immediately after harvest in the second harvest season of 2014 that is from December to March, 2015?

☐ 1= Inadequate storage
☐ 2= Immediate need for money
☐ 3= High storage costs
☐ 4= Other (specify).....

Q 30 b. If no to question 29, what was the major reason for not selling immediately after harvest in the second harvest season of 2014 that is from December to March, 2015?

.....
.....

Let us talk about the details of maize sales. During the second harvest season of 2014 that is from December to March, 2015 who bought your maize? At what time period (s) was the maize sold? How much quantity did you sell to each buyer? How much did you charge for your maize at the different time period (s)? (Use the table below to provide response).

Q 31. At what time period did you sell your maize harvested in the second season of 2014?	Q32. What motivated your decision to sell? (Circle all that apply) (1=no safe storage, 2=high cost of storage, 3=meet other demands such as school fees, medical, buy other food stuff, 4=pay land rent, 5=other specify)					Q33. Who bought your maize? 1=Traders 2=Consumers 3=Both traders and consumers			Q34.What quantity (in Kgs, cups, tins, sacks, baskets or basins) of maize did you sell at those different time period (s)	Q35. What was the unit price (Kgs, cup, sack, tin, basket or basin) in (UGX)	Q 36. From what storage type did the maize come? (1=Granary 2= Crib (Open) 3=Crib (Closed) 4= Basket 5=Above the fire 6=House Corner 7=House roof 8= Sacks 9=tins) Circle all that apply									Q 37. Estimate the distance (in kilometre or miles) from your homestead to the market where the maize was sold?
1=Immediately after harvest	1	2	3	4	5	1	2	3			1	2	3	4	5	6	7	8	9	
2= One months after harvest	1	2	3	4	5	1	2	3												
3= Two months after harvest	1	2	3	4	5	1	2	3												
4= Three months after harvest	1	2	3	4	5	1	2	3												
5= Four months after harvest	1	2	3	4	5	1	2	3												
6= Five months after harvest	1	2	3	4	5	1	2	3												
7=Other (specify)	1	2	3	4	5	1	2	3												

Q 38. Did you try to get the best price for maize harvested in the second season of 2014 that is, from December to March, 2015? ☐ =1 Yes ☐ =2 No

Q 39. If yes how.....?

Q 40. If no why not.....?

Q 41. Did you buy maize for household use during the second harvest season of 2014 that is from December to March, 2015? ☐ =1 Yes ☐ =2 No

If yes to question 43, then let us discuss how much you bought, from where and the price at which you bought. Use the table below to record the responses.

Q 42. When did you buy maize for household use during the second harvest season of 2014?	Q43.Where did you buy the maize? (1= From market 2=Fellow farmers 3=Other specify) Circle all that apply			Q44.The main reason for buying in each time period (1=Consumption 2=Resale 3=Planting 4=Other (specify)) Circle all that apply				Q45. How much maize (in Kgs, cups, tins, sacks, basket, basin) did you buy at the different time period (s)	Q46. How much did you pay per cup, tin, basin, sack, and basket in Uganda Shillings?	Q 47. Estimate the distance in km or miles from the market where you bought the maize to your homestead?
1=Immediately after harvest	1	2	3	1	2	3	4			
2= One months after harvest	1	2	3							
3= Two months after harvest	1	2	3							
4= Three months after harvest	1	2	3							
5= Four months after harvest	1	2	3							
6= Five months after harvest	1	2	3							
7=Other (specify)	1	2	3							

Q 48. Do you have any other comment (s) about the storage type used by smallholder maize farmers in this community not covered in the questionnaire?

.....

.....

End of the questionnaire, any question? **End time……..**

Appendix G: **Questionnaire on cost of storage (Second phase)**

I am doing research on extending the theory of storage to a perishable commodity in an underdeveloped market**.** To that end, this is continuation survey which will help us better understand maize storage costs estimation and marketing margin share of smallholder maize farmers. The survey should take no more than one hour of your time. Your participation is voluntary and you can withdraw at any time without penalty. Of course, all data will be kept confidential. By completing the survey, you indicate that you voluntarily participate in this research. If you have any concerns, please contact me or my supervisor. Our details are provided below

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IDENTIFIERS **Start time…….**

Name of household head _____

Name of respondent _____

Name of District: _____

Name of Sub-County: _____

Name of Village: _____

Interviewer's name: _____

Interview date: /__/__/__/__/__/__/__/__/ (dd/mm/yyyy)

Note1: <u>The storage period considered for the study is from December 2014 to June 2015</u>
Note 2 :(This questionnaire will be redesigned to include only the specific storage types used by the smallholder maize farmers)

Q 1. Did you incur any loss in storage for the maize you harvested and stored during the second season of 2014 that is from December 2014 to June, 2015? ☐ 1= Yes ☐ 2= No

Q 2a. It was observed for the first survey round that you stored your maize in Crib (Open) in the second harvest season of 2014 that is to say from December 2014 to June 2015, rate the Crib (Open) in relation to the loss caused by Rodents, pest, floods, theft, mould, birds, rot, and rats. (Rank using the scale of 0-5 where Very high =5, High=4, medium=3, Low=2 Very low=1, 0=not at all)

List of the storage types used in the second harvest season of 2014 that is from December 2014 to June 2015.		Enter the rank 1-5 (where 1 is the least and 5 highest)							
		Rodents	Pest	Floods	Theft	Mould	Birds	Rot	Rats
a	Crib (Open)								

Q2 b what are the advantages for using the Crib (Open)?
.....
.....

Q2c what are the disadvantages of using the Crib (Open)?
.....
.....

Q2d Would you have liked to use another storage type to store your maize in the second harvest season of 2014 that is to say from December 2014 to June 2015? ☐ 1=Yes ☐ 2=No

Q2e If yes: what prevented you from using the storage type in the second harvest season of 2014 that is to say from December 2014 to June 2015?

Granary……..
Crib (Closed)……..
Sacks…….....
Basket……
Tin……..
Above fire……..…..
House Roof……..…
House corner……

Q2f If no: explain why would you not have wanted to use other storage type (s) in the second harvest season of 2014 that is to say from December 2014 to June 2015

Granary……..
Crib (Closed)…….
Sacks……..……..
Basket……

Tin……..……..……..……
Above fire……..……..
House Roof……..……
House corner…….

Q3. For the Crib (Open) used during the second harvest season of 2014 and for storage period between December 2014 to June 2015, estimate the maize quantity in cups, tins, sacks, basin, basket, you lost in store as a result of Rodents, Pest, Floods, Theft, Mould, Birds, Rot, rats and other? (Match the quantity lost with the storage type and the cause of the loss).

List of the storage types used in the second harvest season of 2014 that is from December 2014 to June 2015.		Rodents	Pest	Floods	Theft	Mould	Birds	Rot	Rats
a	Crib (Open)								

Q 4. For the quantity of maize lost in Q3 above, estimate the amount of money lost in Uganda shillings in relation to; Rodents, Pest, Floods, Theft, Mould, Birds, Rot, rats and other? (Match the amount with the storage type and the cause of the loss).

Storage types used in the second harvest season of 2014 that is from December 2014 to June 2015.		Rodents	Pest	Floods	Theft	Mould	Birds	Rot	Rats	Total
a	Crib (Open)									

Q 5. For the Crib (Open) used in the second harvest season of 2014 that is to say from December 2014 to June 2015, did you use any method to protect the stored maize?

☐ 1=Yes ☐ 2=No

Q 6 a. If YES to Q5, for each of the storage type used in the second harvest season of 2014 that is to say from December 2014 to June 2015, mention the method you used to control the loss against each source of loss and estimate the cost associated with purchasing the method. (Provide response in the table below).

	Storage types used in the second harvest season of 2014 that is to say from December 2014 to June 2015.	The cost associated to the following sources of loss									
		Method used to control the loss. 1=fumigation 2=smoking 3=locks 4=Sun drying 5=other (specify)	Rodents	Pest	Floods	Theft	Mould	Birds	Rot	Rats	Estimate total cost for the Method used in Uganda shillings
a		1. fumigation									

	Crib (Open)	2. smoking									
		3. locks									
		4. Sun drying 5.others specify									

Q 6 b. If your answer is **NO** to question 5, give reason (s) why you did not use a method to protect the maize for that storage type
Crib (Open)……

Q 7. For the Crib (Open) used how much did it cost you to acquire and maintain in the second harvest season of 2014 that is to say from December 2014 to June 2015?

	Type of storage used	Cost of acquisition	Cost of maintenance per month
a	Crib (Open)		

Q 8.For Crib (Open) type you used in the harvest season of 2014 that is to say from December 2014 to June 2015, how would you rate the loss in quality during the storage period; (Use the table below very high=5, high=4, medium=3, low=2 and very low=1)

	Storage types used in the second harvest season of 2014 that is from December 2014 to June 2015.	Tick as it applied to you in the last season				
		Very high	High	Medium	Low	Very Low
a	Crib (Open)					

Q 9 a. Comparing the quality of maize loss from the first harvest season of 2014 and the second harvest season for each storage type the loss was less in the second season (Circle all that applies to you)

Scale (1=strongly disagree, 2=disagree, 3=Neutral, 4=Agree and 5=strongly agree)

	Storage types used in the second harvest season of 2014 that is from December 2014 to June 2015.	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
a	Crib (Open)	1	2	3	4	5

Q 9b. Does the Crib (Open) type store maize until next season?
☐ 1=Strongly Agree
☐ 2=Agree
☐ 3= Neutral
☐ 4=Disagree

☐ 5=Strongly Disagree

If storage used in question 9a above was transitory in the harvest season of 2014 that is to say from December 2014 to June 2015, let us talk about its purpose and the times during which it was stored.

SN	Q 10. Mention transitory Storage type you used?	Q 11. What was the purpose of the transitory storage? (Circle all that apply) (1=In preparation for sale 2=In preparation for consumption 3=In preparation for planting 4=other (specify))				Q 12. For how long did you store the maize? (1=less than one week, 2=one week, 3=two weeks, 4=three weeks, 5=one month)
1	Crib (Open)	1	2	3	4	

Q 13. Storage costs reduced my ability to bargain for higher price for my maize in the second harvest season of 2014 that is to say from December 2014 to June, 2015?

	Storage type	1=Strongly Disagree	2=Disagree	3=Neutral	4=Agree	5=Strongly agree
a	Crib (Open)	1	2	3	4	5

Q 14. The storage type (s) used affected my ability to store during the second harvest season of 2014 that is to say from December 2014 to June, 2015?

	Storage type	1=Strongly Disagree	2=Disagree	3=Neutral	4=Agree	5=Strongly agree
a	Crib (Open)	1	2	3	4	5

Q 15. During the second harvest season of 2014 that is to say from December 2014 to June, 2015, I could not store my maize for long because the storage type used was not safe.

	Storage types	1=Strongly Disagree	2=Disagree	3=Neutral	4=Agree	5=Strongly agree
a	Crib (Open)	1	2	3	4	5

Q 16. The storage type used affected the quantity of maize stored during the second season of 2014 that is to say from December 2014 to June, 2015.

	Storage types	1=Strongly Disagree	2=Disagree	3=Neutral	4=Agree	5=Strongly agree
a	Crib (Open)	1	2	3	4	5

Q 17. The storage type I used encouraged me to sell maize at the earliest opportunity during the harvest season of 2014 that is to say from December 2014 to June, 2015.

	Storage types	1=Strongly Disagree	2=Disagree	3=Neutral	4=Agree	5=Strongly agree

a	Crib (Open)	1	2	3	4	5

Q 18. The storage type I used lowered the maize selling price during the second harvest season of 2014 that is to say from December 2014 to June, 2015.

	Storage types	1=Strongly Disagree	2=Disagree	3=Neutral	4=Agree	5=Strongly agree
a	Crib (Open)	1	2	3	4	5

Q 17. I cannot afford to acquire a modern store for my maize harvest because of high acquisition price.

☐ 1=Strongly Agree
☐ 2=Agree
☐ 3= Neutral
☐ 4=Disagree
☐ 5=Strongly Disagree

Q 28. Longer storage of maize increased the chances of selling my maize at a higher price in the second season of 2014 that is to say from December 2014 to June, 2015.

☐ 1=Strongly Agree
☐ 2=Agree
☐ 3=Neutral
☐ 4=Disagree
☐ 5=Strongly Disagree

Q 29.What was the impediment(s) to your maize storage in the second season of 2014 that is to say from December 2014 to June, 2015? (Circle all that apply you)

☐ 1= Cost of acquiring the store
☐ 2= Cost of maintaining the store
☐ 3= Size of the store (too small for the maize harvested)
☐ 4= Cost of storage e.g. Rats, Mould, Pilferage
☐ 5= Other (specify).....

Q 30. For the storage challenges you faced during the second harvest season of 2014 that is to say from December 2014 to June, 2015 indicate whether you would be willing to accept or willing to pay for innovation in storage. (Use the option provided by circling the option that applies to you in the table below)

Statement	Willingness to accept (1=Yes, 2=No)	Willingness to pay (1=Yes, 2=No)

If you were asked to contribute towards technology to improve storage for the maize for your consumption, would you be willing to accept such improved storage?	1	2	1	2
If you were to purchase improved storage for your consumption, would you be willing to accept it?	1	2	1	2
If someone (say the government) were to pay for improved storage so that you do not have to sell maize immediately after harvest but sell later when prices increase would you be willing to accept such storage.	1	2	1	2
If you were to pay for improved storage so that you do not have to sell immediately after harvest but sell later when prices increase would you be willing to accept such storage.	1	2	1	2

Q 31. What challenges associated with storage not covered above did you experience when you stored your maize harvested during the second season of 2014 that is to say from December 2014 to June, 2015?

.....

.....

Q 32. What suggestions do you have that can help to reduce the costs of storage for smallholder maize farmers in thiscommunity?.....

.....

End of the questionnaire, any question? **End time……..**