



**DETERMINANTS OF INTENTION TO ADOPT MAIZE DRYING
TECHNOLOGIES AMONG SMALL-SCALE FARMERS IN KENYA**

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DEDICATION

I dedicate this work to:

- my family, who have always invested their time and resources in me to enable me to pursue my education;
- my siblings, who have shown undying love and moral support; and
- our Dean, Dr. George Njenga, for believing in me and supporting me and providing me with an opportunity to pursue my Master's studies.

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God Almighty deserves all praise for this work. His providence of love, mercy, grace, forgiveness, strength, health, and the gift of life bestowed in me tolerance and endurance throughout the years of study, from course work to research. I have always been protected and safely shielded under His Mighty Name.

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May God abundantly bless you all.

ABSTRACT

Maize, being the most common staple food across many parts of the world, especially sub-Saharan Africa, is, in most cases, preserved through sun drying techniques among small-scale farmers. This method is prone to significant losses, which could be avoided through the use of mechanised drying technologies. Unfortunately, many farmers in developing countries such as Kenya have yet to adopt this technique on a large scale. It is against this background that this research sought to identify the factors that influence the adoption of mechanised maize drying technologies among small-scale farmers in Kenya. This study was anchored in the Theory of Planned Behaviour (TPB), which offers a structured framework for predicting and explaining human behaviour based on personal attitudes, subjective norms, and perceived behavioural control. Financial constraints and the knowledge base of the farmers were also included in the analysis, as these are important factors in the likelihood of farmers adopting the technology. Data were collected by means of structured interviews with 397 farmers in Nakuru County, Kenya. Correlation analysis was used to determine the strength, magnitude, and significance of the relationships between the variables. Ordered logit, a regression model, was used to determine the relationship between the independent variables, which were: financial resources, personal attitudes, subjective norms, perceived behavioural control and knowledge, and the dependent variable, which was intention to adopt technologies. In addition, other control variables such as gender of the household head, farm size, age of the farmer, educational level of the household head and farm assets owned by the farmer were included as independent variables. The results indicated that 69.02 percent of farmers did not plan to utilise mechanised maize drying technologies, which is cause for concern from a policy perspective. The ordered logit results revealed that all the independent core factors significantly influenced adoption intentions. The farmers' views related to their perceived behavioural control, and financial constraints negatively influenced their intentions to adopt mechanised maize drying technologies. Among the control variables, farm size and educational level positively influenced the adoption intention, while age had a negative influence. Based on these results, it is evident that there is a need to consider personal attitudes, subjective norms and perceived behavioural control of farmers, as well as the implementation of a nationwide campaign to encourage the adoption of mechanised maize drying techniques and a government strategy to bring the cost of credit down, while also ensuring its availability to small-scale farmers. The campaign will bridge the information gap and enhance adoption of mechanised maize drying technologies.

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ABBREVIATIONS AND ACRONYMS

NCPB	National Cereals and Produce Board
CFR	Case Fertility Rate
TRA	Theory of Reasoned Action

KEYWORDS

Adoption; post-harvest losses; technology; intentions; mechanisation

CHAPTER 1: INTRODUCTION

1.1: Agriculture and the Kenyan economy

Agriculture is the primary sector in Kenya's economy. The sector currently contributes 24 percent of GDP directly, which is valued at Kshs 342 billion, and another 27 percent indirectly, which is valued at Kshs 385 billion. Importantly, the sector also contributes approximately 65 percent to total exports and provides more than 18 percent of formal employment to the Kenyan population. Over 60 percent of informal employment is in the rural areas (Government of Kenya, 2009).

The agricultural sector comprises six major sub-sectors, which include industrial crops such as sugar cane, tea, coffee, sisal and cotton. Food crops is another important sub-sector that is mainly dominated by maize which is a staple food for Kenyans, and other crops such as bananas, beans, rice, cassava, sweet potatoes. Horticulture is a major export earner for Kenya, which is largely dominated by cut flowers and cowpeas. Livestock production is the fourth sub-sector, which includes cattle, sheep, goats, chickens, camels and donkeys. Fisheries production in Kenya is largely found along the coast and the western region around Lake Victoria, however fish ponds are gaining in popularity. Finally, the sixth sub-sector is forestry, which comprises traditional natural forests and man-made forests (Government of Kenya, 2009). In terms of the gross domestic production contribution of the six agricultural sub-sectors, horticulture has recorded a remarkable export driven growth in the past five years to become the largest sub-sector, contributing 33 percent of Agricultural Gross Domestic Product (AGDP) and 38 percent of export earnings. Food crops contribute 32 percent of AGDP but only 0.5 percent of exports, while the livestock sub-sector contributes 17 percent of AGDP and 6 percent of exports. The livestock and fisheries sub-sectors have huge potential for growth, which has not yet been exploited.

In Kenya there is a high correlation between national growth and development and the agricultural sector. It is largely acknowledged that the growth in the agricultural sector and that of the Kenyan state was impressively high amongst Sub-Saharan Africa countries immediately after independence (1963), which was maintained for at least two decades. The sector showed steady growth at an average rate of 6 percent per annum for agriculture and 7 percent for the national economy (Government of Kenya, 2009).

In this period, small-scale agriculture grew rapidly as the population rallied around the call to embark on farming by the first President of the Republic, Jomo Kenyatta. This growth was

spurred by expansion because there was ample land and better use of technology. Moreover, provision of extension to farmers and agricultural research were heavily promoted by the state. In addition, many agricultural institutions, including farmers' cooperatives which provided services related to agricultural inputs, marketing, credit and agro-processing, were established and supported by the Government. Budgetary allocation to the agricultural sector during this period averaged 13 percent of the national budget, with a bias towards maize production. It is important to note that maize production in Kenya is an essential activity since the majority of the people are involved in it, and it is also a staple food crop for the general population (Mantel and Van Engelen, 1997).

1.1.1: The maize sector in Kenya

Maize is unarguably the most important crop in Kenya, with over 90 percent of farming households growing it, as it is Kenya's staple food. Given the rapidly growing population in Kenya, which is estimated at one million people per annum, several studies (World Bank, 2003; Shephard, 2008; Kangethe, 2011) have mentioned that it is essential that Kenya and African countries in general boost their maize production. Kenya's countrywide maize production ranges between 24 and 33 million bags per annum, which is lower than the country's consumption (predicted to be over 36 million bags in 2008) because of the excessive populace boom, estimated at 2.9 percent (Kangethe, 2011).

1.1.2: Incentives for maize production in Kenya

Maize production was singled out in the two decades after independence, leading to new public policies to promote its production and marketing. The production and marketing of maize received budgetary support via marketing boards which were government-controlled (Nyangito and Kimenye, 1995), and important policies that were geared towards the provision of subsidies for farmers in terms of input prices, research, credit and services were highly promoted. African resettlement programmes led to an increase in smallholder production between the late 1960s and early 1970s, and expanded maize production until farmers realised greater surplus in production (Government of Kenya, 1978). From the mid-1970s, rapid population growth with scarce arable land which had not been exploited by then in both the medium and high potential regions presented challenges in the growth of maize production and general food security of the state. Some sections of the population suffered food insecurity as the per capita nutritional intake went down (Onono et al., 2013). When coupled with the cyclical droughts of 1979, 1989 and 2009, a potential imbalance between the demand and supply of food became a problem (Government of Kenya, 2010). This led to the development

of a comprehensive national food policy for the first time in 1981 (Government of Kenya, 1981).

The policy introduced guidelines for making decisions on serious issues surrounding food production and distribution, which included marketing, trade, pricing, research and extension, agricultural credit, inputs, land use, food security and nutrition (Government of Kenya, 1981). The policy was aimed at improving food production and distribution across the entire country, from regions of surplus to regions of scarcity. It also aimed at expanding sorghum and millet production in the semi-arid areas, while keeping the strategic reserves of different commodities as a contingency in case of total crop failure (Government of Kenya, 1981). The above objectives were crucial in the policy that targeted keeping the nation food secure, which was even later stated in other documents. From the early 1980s, it was argued that the many interventions of the state negatively affected agricultural terms of trade, thus structural adjustment programmes (SAPs) were gradually adopted in an attempt to turn the declining trend around. However, it was not until 1993 when the agricultural sector was completely liberalised in terms of marketing and production (Onono et al., 2013). Liberalisation broke the structural rigidities, broadened the role of market signals, and aligned relative prices to closely match world market prices, for terms of trade in agriculture to improve and the eventual rise in performance of the sector (Government of Kenya, 1986). With liberalisation, controls such as prices, foreign exchange controls and import licensing were quickly removed. Market forces of demand and supply were left to set the terms of trade without much intervention by the state. The duties of the National Cereals and Produce Board (NCPB) were reduced to only maintaining the strategic grain reserves, and it remained the buyer and seller of last resort (Government of Kenya, 1986). Government services were provided based on demand rather than forcing supply on the various stakeholders such as farmers. While the government still provided extension services to the farmers, it started charging a fee to slowly shift from offering a blanket public extension service for free to demand-driven service provision. The private sector was then allowed to carry out research on commodities which could be sold in the competitive markets, leaving the government to concentrate on matters of national importance facing farmers, such as pests and diseases.

The general trend in productivity was a steady increase from independence up until the mid-1980s, followed by a gradual decline between 1985 and 2004. However, maize yields improved impressively over the period from 1997 to 2007, partly due to the increased use of fertiliser. Fertiliser marketing costs declined substantially from the mid-1990s until 2007, but

the positive trend in fertiliser use was partially reversed in 2008 by civil disruption and a global surge in fertiliser prices (Shawiza, 2016).

Farming contributes approximately 24 percent of Kenya's total income, and half of farming income is derived from the maize sector. It dominates food consumption, accounting for 9–18 percent of total household expenditure across the country. As in other African countries, own production is important in Kenya, with almost 35 percent of total food consumption being self-produced. However, maize contamination, in large part due to poor grain handling, is adversely affecting its availability on supermarket shelves. As expected, there is some variation within the different regions. Maize grain is consumed as milled flour or fresh in cobs. Maize is adaptable to a wide range of climate conditions, and is the most extensively grown crop in many parts of the Rift valley and western region. The main growing areas are the larger Trans Nzoia, Bungoma, Nakuru, and Uasin Gishu counties.

The majority of farmers from these regions sell their produce just after harvesting to the National Cereals and Produce Board (NCPB). Millers who are located in major towns also procure the grains from the farmers (Booker, 2010). According to Ochieng (2010), there still exists a huge deficit in domestic maize supply in Kenya, which is made worse by the ever-increasing population size and post-harvest losses (Komen et al., 2006). These grain losses during storage contribute to food insecurity and the low income of farmers in Nakuru County and Kenya as a whole. Efficient grain drying and storage could contribute greatly to socio-economic development, as stipulated in the Government's Vision 2030 (Government of Kenya, 2007). Losses are directly measured in both qualitative and quantitative terms.

In his document, Kirimi et al. (2011) stated that maize marketing in Kenya is generally done by smallholders who collect/produce and remit to the brokers, who then assemble and transmit to the wholesalers to trade in the market directly to consumers or small retailers. It was further noted that the brokers do not in most cases test for quality standards of the produce before remitting to the market (Kirimi et al., 2011). Thus the nature of the Kenyan market structure is that there are little or no incentives for high quality production and marketing of maize, as quality production rarely translates to higher sales and returns to farmers (Hoffmann and Gatobu, 2013). According to Hoffmann and Gatobu (2013) most maize consumers in Kenya only focus on attributes such as the colour and shape of the maize grains, which are only visually detected, as the modes of quality checks. Hoffmann and Gatobu (2013) used bids in a second-price auction for maize, where they demonstrated that many consumers from western Kenya would

willingly pay 12 percent higher for maize sourced from the nearby market rather than far markets. The farmers were also reluctant to pay more when denied the chance to taste by crushing with their teeth a sample of the grains. It was also noted that farmers were more willing to spend more on locally grown and stored maize.

1.1.3: The production and consumption of maize in Kenya

Over 80 percent of the Kenyan population depend on maize as a daily meal. According to Nyoro et al. (2004), the actual consumption per capita ranges between 98 and 100 kilograms, which means that per year Kenyans consume about 2,700 thousand metric tonnes (MT) of maize. The grain is grown by more than 90 percent of Kenyans, both on a small and large scale. The majority of farmers (70 percent) who engage in maize production are small-scale farmers (Government of Kenya, 2009). It is important to note that of the production done by small-scale farmers; approximately 58 percent is kept for household consumption (Mbithi, 2000). Maize production fluctuated between the periods 1972 to 2008, which caused deficits as the production went below the annual recorded consumption of 2,700 MT per person. Erratic climatic conditions have been viewed as the main cause of the decline in maize production. Yields have remained or dipped lower than the possible six tonnes per hectare, averaging at two tonnes per hectare. “This situation is also attributed to the inadequate absorption of modern production technologies such as high yielding maize varieties and fertilisers, because of high input costs, lack of access to credit, and inadequate extension services to small-scale producers.” attributed to (Onono, Wawire and Ombuki, 2013, p.2). Problems such as insufficient budgetary allocation to agriculture and poor rural roads, coupled with poor marketing by the private sector since the liberalisation of the agricultural market, have constrained agricultural growth and development in Kenya (Government of Kenya, 2009).

1.1.4: Maize drying in Kenya

Drying is an important step in ensuring high-quality grain that is free of fungi and micro-organisms, and that has desirable quality characteristics for marketing and final use. The Food and Agriculture Organization (2006) suggested that a number of factors should be considered during the drying of maize, including temperature and air velocity, rate of drying, drying efficiencies, kernel quality, air power, fuel source, fixed costs, and management. Despite other scientific methods developed to combat the growth of aflatoxin such as *Aspergillus flavus* or *Aspergillus parasiticus* and the removal of aflatoxin after they have been produced by the *Aspergillus* infection, effective drying has been lauded by the Food and Agriculture Organization (FAO) as a simple and affordable mechanism. Drying as a method of food

preservation involves the removal of moisture to avert the development of favourable habitats for the growth of moulds, bacteria, and insects that cause spoilage. Proper storage of dried grains should protect the grains from fungal infection, vermin infestation, mould, and extreme temperatures.

In many parts of Africa, sun drying is the most frequently used and oldest mode of drying grain products (Food and Agriculture Organization, 2006), however it has been found to be ineffective, especially with large amounts of maize. The grains are usually harvested with a lot of moisture, which facilitates respiration, germination and both fungal and insect attacks that lead to spoilage. Moisture is usually naturally high in the crop and starts to drop as the crop grows until it reaches maturity and begin to dry. Existence of a damp or warm spot on the grain can lead to more respiration at storage. During respiration, heat is produced which can spread through the grains in conventional currents and cause more rapid spoilage. Insects and fungi also become more active and cause a lot of damage at the higher temperatures produced by the respiration process. To minimise losses, moisture content below 13 percent is considered safe for the long-term storage of most crops. Even for short-term storage (less than six months), moisture content should be less than 15 percent for most crops. Inadequate drying can result in losses at storage and milling due to the growth of moulds, thus it is critical to ensure drying is done properly to maintain the quality of the crop and reduce transportation and storage losses, which could be experienced in improperly dried grains.

Natural drying or sun drying is the traditional and most economical practice for drying the harvested crop, and is the most popular method in developing countries. Sometimes, whole crop, without having been threshed, are left in the field to dry. For example, after harvesting maize, stacks are made and left in the field to dry. Sun drying is weather-dependent, labour intensive, slow, and causes large losses. Grains lying in the sun are eaten by birds and insects, and are contaminated with stones, dust, and other foreign materials. Unseasonal rains or cloudy weather may restrict the proper drying, resulting in the crop being stored with high moisture content. Some farmers use mats or plastic sheets on which they spread the grains, which reduces contamination and makes collection of grains easier.

Mechanical drying addresses some of the limitations of natural drying, and offers additional advantages such as a reduction in handling losses and better control over the air temperature and space utilisation. However, this method is limited by high initial and maintenance costs,

inadequate size of the dryers, and a lack of smallholder knowledge to operate these dryers. Due to these limitations, dryers are rarely used by smallholders in Kenya (Kumar and Kalita, 2017).

Post-harvest losses in Kenya could be further reduced through the mechanisation of maize drying, which would improve food security in the country. There would also be reduced fatalities caused by aflatoxin attack on maize (Korir et al., 2012). Based on a review of the available literature and a series of case studies, Korir et al. found that on-farm grain losses often exceeded 10–12 percent of grain output, and typically range between 15 and 18 percent. Literature suggests that post-harvest losses can be reduced by the adoption of technology such as mechanised maize drying.

Despite the efforts by the Kenyan government and development partners, levels of technology adoption remain low (Ogada et al., 2010). Technology has mostly been adopted to enhance crop variety. While the average adoption rates of improved maize varieties and inorganic fertiliser of 65 and 76 percent respectively appear impressive, farming machinery is still not popular with Kenyan farmers. The desire of the government of Kenya is to promote the development and adoption of agricultural technologies, since there is a strong link between high productivity and technological advances.

1.2: The concept of technology adoption intentions

A technology is usually comprised of two main components; hardware which can be seen and the invisible software part. Hardware consists of physical tools that embody technology (Chi and Yamada, 2002), while software consists of the information base for the tool. In Mumford's (1946) classification, "technology-as-objects" encompasses the entire range of fabricated items intended for use, including tools, utensils, utilities, apparatus, and machines. Mitcham's (1978) "technology-as-process" encompasses the activities we commonly denote as 'making' and 'using'; the key element here is skill, defined as proficiency in the use of an artefact. Ingold (2002), meanwhile, distinguished technique from technology. Technique refers to skills, regarded as the capability of particular human subjects, and technology means a corpus of generalised, objective knowledge, in so far as it is capable of practical application.

The manner in which farmers perceive a particular technology determines whether they will decide to use it or not. According to Van de Ban and Hawkin (1988), perception enables farmers to filter new technologies and make decisions. Perception also guides the process through which people go, from receiving technology to implementation, and even transfer to others. The transfer of technology involves a process of having information and new skill moved

from one place, usually the source/generator such as laboratories or scientists, to another place, usually users such as farmers (Valera et al., 1987). Adoption and transfer/diffusion of a technology by users is the outcome of introducing a new technique to a society. Technology users (for instance farmers) encounter challenges practising the recommendations of using a new technology most of the time, thus a technology should be made to be user friendly among the target group (Valera et al., 1978). Technology adoption refers to the process by which farmers get introduced to, get interested in and accept, or finally reject, a technology (Cruz, 1978). The process a farmer/technology user follows from being introduced to the technology to the final actual usage after accepting it is discussed in the Innovation Decision Model (Rogers, 1983). The process involves knowing the existence of the technology/innovation, the development of an intention based on the attitudes towards the innovation, a decision to either accept or reject, and finally the idea is implemented. Before adoption, an intention has to be formed in the mind of the adopting agent (farmer).

An intention is defined as a person's commitment, plan, or decision to carry out an action or achieve a goal (Eagly and Chaiken, 1993), while adoption intention refers to an individual's awareness of the technology and an attempt to buy or acquire it. Adoption intention is also viewed as having a relationship with demographic factors like age, gender, profession, and education. Intention starts with a motivational process, a search for alternatives, and alternative evaluation (during which beliefs may lead to the formation of attitudes, which in turn may result in a purchase intention). Then the individual may proceed to reach a decision to purchase the intended item (Eagly and Chaiken, 1993).

Farmers may choose to use a particular technology based on factors such as how the innovation is orally explained, the level of trust in the information provided, any technical facilitation, and the manner in which the farmers believe in the efficacy of the technology. The farming arena is importantly comprised of the technology and the farmers. The potential of both livestock and crops produced is greatly enhanced by the use of agricultural technology development and adoption (Chi and Yamada, 2002). Exogenous factors such as the community beliefs and institutions, together with personal factors such as attitudes of the farmers, are elements in technology adoption. Farmers ultimately decide on their farming system, including whetherto adopt technologies and assign resources to support it or not (Norman, 1980).

In general, factors that influence the adoption intentions of agricultural technology by farmers include technology attributes, adopters' attributes, the manner of technology promotion/introduction, and the broader factors related to the prevailing physical, economic, social and

biological environment of technology use. Farmers have been seen as a major constraint in the development process (Cruz, 1978); there are innovators and laggards, thus the socio-psychological traits of farmers are important. Age, educational attainment, income, family size, land tenure, credit use, value systems, and beliefs have been positively related to the adoption of technology.

Similarly, the perceived attributes of the technology play a crucial role in adoption intentions and continued use. Rogers (1995) defined five perceived attributes of technology that are key drivers of adoption intentions:

Relative advantage: the degree to which the innovation is perceived as superior to the one it replaces.

Compatibility: the level at which the innovation is perceived to show consistency with the existing values, past experiences, etc.

Complexity: the degree of difficulty with which the innovation is perceived to be understood and used.

Trialability: the degree to which the innovation is perceived to be open for trials on a limited basis.

Observability: the level at which the results of the innovation are perceived to be observable by others.

Apart from the technological attributes, other factors such as the dissemination channels and the farmer's surrounding environment cannot be ignored in explaining technology adoption processes. The personal characteristics of the assigned extension workers are important, such as credibility, how well they can relate to the farmers, intelligence, their persuasiveness and resourcefulness, their ability to communicate, their sincerity and how development oriented they are. These features are important in the dissemination process for the extension agents to achieve effective delivery of important information to the target farmers.

The biophysical environment also influences technology uptake. Factors which make up the physical environment include location and distance to the market, the nature of the roads and other important infrastructure like electricity, water availability and rainfall distribution, soil type, and the presence or absence of pests. Farmers who applied irrigation adopted new crop varieties earlier than their counterparts who did not irrigate their farms. A slower rate of

innovation diffusion is experienced when the product does not fetch better prices in the market.

Chi and Yamada (2002) carried out a study in Japan on the factors affecting farmers' adoption of technologies in farming systems. Through focus group discussions, the researchers found that farmers did not have faith in the new technologies. The reasons were that these technologies were not yet demonstrated; the farmers did not have a sufficient level of education but rather trusted their own experience from using cultivation practices embedded over a long period; their rate of seed use and spraying pesticide was high; and farmers of large farms were reluctant to use new technologies as an inappropriate technology posed a risk of greater losses of yields.

In most cases, farmers report higher losses caused by external agents through estimation without standard measures (Lazaro et al., 1993). Similarly, a study conducted by Muzari et al. (2012) in sub-Saharan Africa on the impact of technology adoption on smallholder agricultural productivity found that technology adoption is influenced by factors such as vulnerability to failure, awareness of existence, available institutions governing the use of such technologies, income level of farmers, innovativeness of the farmers, and labour availability. They also established that technologies that are easily adopted are those that have low embedded risks and are less expensive. An additional observation was that some indigenous technologies in Africa are more economical in resource requirement than modern technologies; hence they are preferred by most traditional farmers.

Sulo et al. (2010) carried out a study on the socio-economic factors affecting the adoption of improved agricultural technologies among women in Marakwet County, Kenya. The researchers considered characteristics such as age, education levels, extension services, education, house hold size, the number of the technologies adopted, income, and membership of associations. The results showed that factors such as primary occupation, annual income, household size, and membership of women's groups showed a positive and very significant relationship with the women's adoption of agricultural technologies. The findings showed that women ranked constraints such as a lack of access to land, lack of capital and credit facilities, non-membership of women's groups, non-provision of information by agricultural officers on agricultural production technologies, and ineffective extension services and coverage, among others, as major hindrances to improving their socio-economic wellbeing.

1.2.1: Theoretical background of the technology adoption intention

Several theories have been formulated to explain the process and underlying factors that influence an individual's behavioural change. According to the theory of planned behaviour (TPB) developed by Ajzen (1985), intention to perform a behaviour determines the behaviour, while intention is shaped by the attitude of the individual and subjective norms. An individual's attitude towards accepting an innovation is founded in personal beliefs regarding the outcomes of the adoption. Social norms play a role in terms of an adopter's perception of the social pressure regarding the behaviour.

Previous studies anchored in the TPB identified the key factors that influence the adoption of technologies as personal attitudes, subjective norms, perceived behavioural control, financial endowment, perceived attributes of the method, knowledge base of the farmer regarding the technology, and the farmer's age (Ajzen, 1998; 2000; 2001; Muzari et al., 2012). However, little research has been done to justify whether the findings of these studies are universal or specific to their respective study areas. TPB is largely used in studies conducted in western countries, thus it is not known how well it can fit explaining adoption/behavioural changes in other areas such as Kenya. Although few studies undertaken across different cultures seem to suggest that this theory is equally applicable to different cultures, however (Taylor and Todd, 1995; Armitage and Conner, 2001). For this reason, the present study intends to bridge this gap by studying whether the aforementioned factors apply to the Kenyan context, to deepen the understanding of the determinants of adoption of mechanised maize drying technologies by small-scale farmers in Kenya. The results will inform the decision-making of policy makers in their quest to reduce post-harvest losses. The research will be guided by the Theory of Planned Behaviour (TPB), as it offers a structured framework for predicting and explaining human behaviour. Complexities surrounding the behaviour of human beings can also be dealt with in the TPB, as it provides a good framework for unpacking such complexities as illustrated in Figure 1.

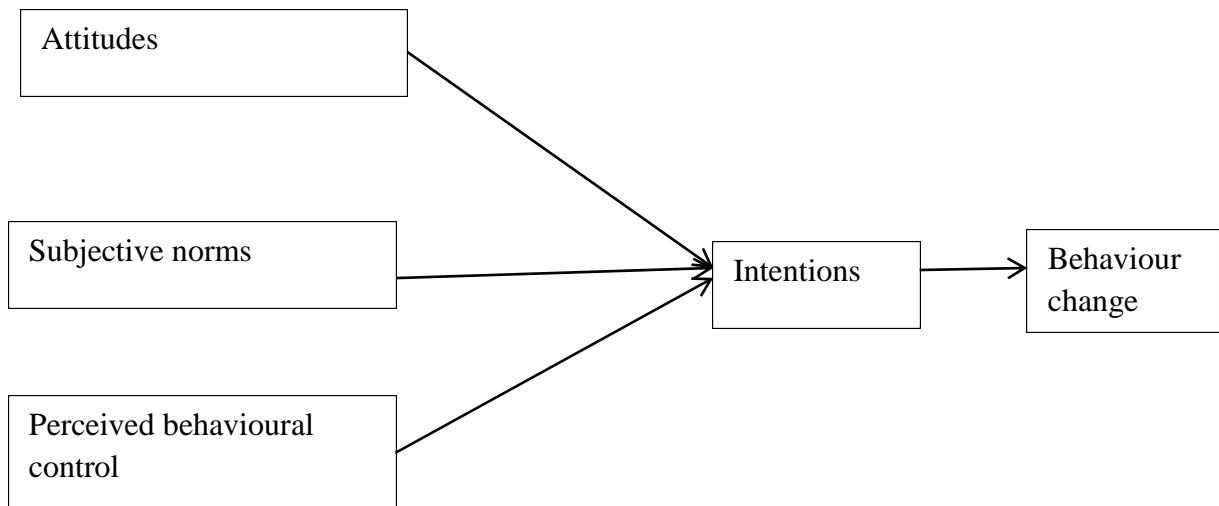


Figure 1: Theory of planned behaviour

Source: Ajzen (2002)

TPB holds that behaviour is determined by intentions, and intentions are determined by three factors: attitudes, subjective norms, and perceived behavioural control. Attitude is “the degree to which a person has a favourable or unfavourable evaluation or appraisal of behaviour” (Ajzen, 1991, p.188.) Subjective norms refer to perceived pressure that socially emanate from members of a family, other significant people or friends who can influence a person to either perform or not perform a behaviour. Perceived behavioural control is related to the perceived ease of use or difficulty of use of a particular technology.

According to TPB, what a person believes about a particular behaviour is what determines whether they would intend to change to it or not (Ajzen, 1988; 1991). The more intentional a person is, the higher the likelihood they would decide to change, provided that the person has control over it. Personal attitudes and the power of referents to influence a person’s decisions, as well as their personal beliefs, influence the intention to perform a particular action such as the adoption of mechanised maize drying technologies. Figure 1 highlights the relationships between perceived behavioural control, personal attitudes, subjective norms and intention to act. According to the TPB, the belief that a particular behavioural change has a better outcome and the eventual evaluation of the resultant outcome shapes personal attitudes. Subjective norm is greatly related to how much referents approve of a particular behaviour, supported by the desire to comply with the demands of such opinion holders. Perceived behavioural control is related to the ease with which a particular behaviour can be executed and its expected benefits in case a person choose to implement.

When the three factors - personal attitudes, subjective norms, and perceived behavioural controls - are joined together, they will jointly influence the intention to perform a particular action (such as the adoption of mechanised maize drying technologies). This theory has, however, not been fully utilised to determine adoption intentions within the Kenyan context, and, in particular, the adoption of mechanised maize dryers.

1.3: Problem statement

From the literature reviewed relating to the adoption of technology, three issues emerged. The first was that the adoption of mechanised maize drying technology is expected to reduce post-harvest losses and thus improve food security in Kenya and other sub-Saharan African countries. However, as indicated by El Oster and Morehart (1999) and Kinyangi (2014), poor households are less likely to adopt technology. It has not been established whether availability of financial resources and the knowledge base of farmers influences the intentions of Kenyans to adopt maize drying technologies.

Secondly, Bandiera and Rasul (2006) posited that behaviour is influenced by beliefs about engaging in the behaviour, therefore the associated positive evaluation of the beliefs positively affects the adoption of a technology. Few studies have, however, been carried out to determine whether attitudes, subjective norms, and behavioural norms of farmers influence their intention to adopt a maize drying technology. These are factors stated within the Theory of Planned Behaviour (Ajzen, 1991).

Thirdly, previous research (Lambrecht et al., 2014) on the adoption of post-harvesting technologies indicated that access to information on the availability, cost, and technical know-how regarding a technology influences the intention to adopt that technology. Maize drying technology is a post-harvest technology, but it has not been determined whether access to information may affect the intention of small-scale farmers to adopt this technology. Empirical studies undertaken on the determinants of the adoption of agricultural technology have mainly focused on risk and uncertainty, as well as the availability of supportive infrastructure, as predictors of adoption decisions (Ogada et al., 2014). More recently, however, the focus has extended to social networks and the economic endowment of farmers. For this reason, the present study will investigate the factors stated in the TPB, namely personal attitudes, subjective norms, and perceived behavioural control as related to the adoption intention of farmers, while also considering the additional factors related to the socio-economic condition of farmers.

Other factors not included in the TPB framework, but which have been discussed in prior studies as greatly influencing the adoption of technology in Kenya (Mignouna et al., 2011; Kariyasa and Dewi, 2011), include age, farm size, gender, education level, and farm assets. Research undertaken by Mignouna et al. (2011) on the influence of the TPB elements on adoption intention factors found that the TPB elements mediated the adoption intention factors related to the socio-economic condition of farmers, although with different strengths. No research has been undertaken to establish if factors cited in the TPB influence the intention to adopt maize drying technologies. This study will therefore seek to establish whether, in addition to the TPB adoption intention factors, financial capacity and knowledge affect the intention to adopt maize drying technologies in Kenya.

The TPB was applied to determine the factors that influence the adoption intention of farmers, including socio-economic factors, to reach a conclusion regarding necessary interventions towards ensuring a shift to mechanisation by farmers. This will also help to bridge the knowledge gap regarding whether context differences should be considered while providing the interventions, as studies have been conducted elsewhere on the subject matter of this study.

1.4: Research objective

The factors that influence the adoption intentions of mechanised maize drying technologies among small-scale farmers in Kenya form the basis of this study. Making use of the TPB, the role of personal attitudes, subjective norms, and perceived behavioural control were investigated. Given prior studies on small-scale technology adoption, the researcher also investigated the role of access to finance and farmers' knowledge.

1.5: Hypotheses

The above research objective will be achieved through testing the following research hypotheses.

H1: Personal attitude significantly influences the intention to adopt mechanised maize drying technologies among small-scale farmers in Kenya.

H2: Perceived behavioural control significantly influences the intention to adopt mechanised maize drying technologies among small-scale farmers in Kenya.

H3: Subjective norms significantly influence the intention to adopt mechanised maize drying technologies among small-scale farmers in Kenya.

H4: Availability of financial resources significantly influences the intention to adopt mechanised maize drying technologies among small-scale farmers in Kenya.

H5: Knowledge significantly influences the intention to adopt mechanised maize drying technologies among small-scale farmers in Kenya.

1.6: Significance of the research

Considering that over 90 percent of farming households are growing maize as a staple (Government of Kenya, 2009), this research on agricultural technology adoption is critical. Maize is a staple food in Kenya and in most parts of Sub-Saharan Africa, therefore any research carried out on maize with the objective to boost this sector is of huge importance to all stakeholders.

The efficiency of crop production, which depends on a large number of factors, can be used to measure the performance of the agricultural sector. Declining agricultural productivity and cereal wastage post-harvest in Kenya is worrisome and a real challenge for both the county and national governments, which have a population of more than 40 million Kenyans that need to be food secure. Global warming, which could lead to further losses in agriculture, simply makes this problem worse. A better understanding of the factors that include both social constraints and facilitative measures towards technology adoption is key to inform policies aimed at promoting the successful transformation of agricultural production from merely subsistence to agribusiness.

Although there is a lot of research on the efforts made to improve agricultural productivity, there is limited literature on the key social and economic drivers of adoption intentions of maize drying technologies by small-scale farmers in Nakuru County. There is thus an urgent need to carry out research on factors influencing maize drying technology to reduce grain loss during storage, as this could provide appropriate solutions to combat the huge maize deficit of around 200,000 metric tonnes per year in Kenya (Government of Kenya, 2009).

This study is significant for the different players in the maize production sector in the following ways:

- For the farmers, proper grain drying and storage would reduce the amount of grain loss, boosting their earnings. This would create an incentive for many farmers to boost their production by committing much of their land to maize production. Those farmers who are financially constrained will be facilitated through loans to acquire modern storage

facilities. These interventions are suggested by the results of the study, which indicate that financial constraints are an impediment to the adoption of these technologies.

- The financial institutions would acquire more customers for their loans, as farmers would be borrowing agricultural loans from them in order to buy new grain drying facilities.
- The suppliers of farm inputs will also benefit from this research, because if farmers increase their production more inputs will be purchased from the vendors, thus translating into more sales and likely more profits. More demand for inputs will be created when the farmers get to understand the bottlenecks of technology acquisition and when the government intervenes to ease the trade of these technologies.
- The government will achieve the objective of creating a food secure nation, as stipulated in the Sustainable Development Goals (SDGs). It is the role of the government to maximise the social welfare of its citizens, hence it should take part in ensuring that price subsidies are effected.

The findings of this research will also be helpful to academics, researchers, and the Ministry of Agriculture of Kenya in assessing the underlying reasons for the low adoption of agricultural technologies, increased post-harvest losses, and poor agricultural production, which contribute to poverty. It will further contribute to Kenya's Vision 2030 in agriculture, where mechanisation is targeted to be achieved.

1.7: Scope of the study

The data collection was carried out in Nakuru County, Kenya, among small-scale maize farmers. Nakuru County was selected among the 47 counties of Kenya because of its unique and rich diverse population. The county represents all people and cultures of the country, therefore the data collected were assumed to represent the views of all Kenyans. The research investigated the relationship between behavioural and personal factors with adoption intentions, specifically households' adoption of maize drying technologies, using the TPB.

1.8: Operational definition of terms

Agricultural technology adoption: refers to a process that begins with awareness of the existence of a technology and progresses through a series of steps that end in the appropriate and effective use of the technology by farmers, for the sake of convenience and improved productivity.

Adoption intention: refers to individuals' decisions or plans to use maize drying technologies on their farms. It begins with awareness, followed by an attempt to buy or hire the technology.

Post-harvest losses: are grain losses that farmers suffer at the point of harvesting and beyond, before they finally dispose of the grains. Losses mainly occur between harvesting and the point of consumption, and result from poor drying techniques.

Personal attitudes: are views related to the attractiveness of a particular technology. A negative attitude would mean the person does not like the technology, which will eventually impact his or her decision on whether or not to adopt it.

Subjective norm: is a combination of the normative beliefs of a person together with the motivation to act in accordance to the directives/expectations of people who matter to them. This is mostly influenced by pressure from significant others in the community.

Perceived behavioural control: refers to views related to the perceived usefulness or ease of use of mechanised maize drying technologies.

Technology acceptance: refers to the process a person goes through, from awareness to making a decision, to use a particular technology.

Productivity: refers to various aspects of efficiency in agricultural production, where the goal of reduced production costs is emphasised so that farmers have higher output and income while improving food security.

Mechanised technology: is the process of using agricultural machinery to mechanise the work, greatly increasing farm productivity.

Aflatoxin: is toxic metabolite that is naturally occurring and produced by the fungus *Aspergillus flavus*, a mould found on food products such as maize.

CHAPTER 2: LITERATURE REVIEW

2.1 : Introduction

This section reviews the literature on agricultural mechanisation in Kenya and the available maize drying technologies. The legal framework and policies developed to govern as well as speed up the rate of growth of mechanised agriculture are also part of the focus of this chapter. Further, the factors associated with maize drying technology adoption intentions are reviewed, the theoretical background of technology adoption in agriculture is established, the theories of social learning, technology acceptance, reasoned action and planned behaviour are extensively reviewed, and their relationship with maize drying technology adoption intentions is established. The TPB is adopted for this study based on its appropriateness in explaining the theoretical drive of adoption intentions of farmers. A gap in the literature is identified to justify the execution of this study, before the conceptual framework that guided the empirical approach of this study is discussed.

2.1.1 : Agricultural mechanisation in Kenya and the legal framework

Agricultural mechanisation is a major agricultural production input that encompasses the application of mechanical technology to agriculture as a means to enhance the productivity of land and human labour (Ministry of Agriculture, Livestock and Fisheries, 2015). Agricultural mechanisation adds value through decreased costs of production and a reduction of drudgery in farming activities. It also improves the delivery timeliness and efficiency of farm operations and improves the quality of products. The different sources of agricultural power are human power, animal power, mechanical power, electrical power, and renewable energy. Currently, the use of motorised power stands at 30 percent, and hand and animal draught (ADP) are at 50 and 20 percent in Kenya respectively (Ministry of Agriculture, Livestock and Fisheries, 2015). The use of farm machinery and equipment depends on the production system, farm size, and the availability of power. Agricultural mechanisation services are offered by individual farmers, private service providers, and the public sector, including agricultural mechanisation stations (AMSes) and agricultural technology development centres (ATDCs). To successfully plan and implement agricultural mechanisation a holistic approach is required, which should include private sector involvement and consider economic profitability and the creation of an enabling environment, with clear roles for both public and private sector stakeholders.

The Ministry of Agriculture in Kenya has embarked on a number of legislative and regulatory reforms to create an enabling environment for all the players in this sub-sector. The enactment

of the Agriculture, Fisheries and Food Authority (AFFA) Act, the Crops Act, and the Kenya Agricultural and Livestock Research (KALR) Act in 2013 consolidated numerous pieces of legislation to address the overlap of functions and obsolete legislation, and to benefit from economies of scale. The Acts provided for the establishment of the AFFA and Kenya Agricultural and Livestock Research Organisation (KALRO). Other relevant existing legislation include the Land Act, Standards Act Cap 496, the Appropriations Act, the Dairy Act, the Fisheries Act, the Water Act (2002), the National Cereals and Produce Board Act, the Micro and Small Enterprises Act, the Environmental Management and Coordination Act of 1999, the Devolution Act, and the Intergovernmental Relations Act of 2012 (Ministry of Agriculture, Livestock and Fisheries, 2015). Despite this, the Acts do not sufficiently address legislation affecting agricultural mechanisation.

Although the National Agricultural Mechanisation Strategy (NAMS) was adopted by the government in 1995, because the Strategy is not anchored in a written policy, its implementation has proved to be a challenge. For agricultural mechanisation to make a contribution to agricultural development and effectively contribute to increased food security, there is a need to promote the development and adoption of modern, appropriate, cost-effective, and environmentally safe mechanisation technologies for crop, livestock, and fisheries production. Kenya has enormous potential for agricultural production that remains largely untapped, thus the Strategy aims to give clear direction for sustainable growth and the development of agricultural mechanisation.

2.2: Maize drying technology adoption

2.2.1 : Introduction

Weldegiorges (2014) defined technology adoption as a process that begins with awareness of the technology, and progresses through a series of steps that end in appropriate and effective usage of the technology. According to Weldegiorges, technology adoption consists of five steps. First, technology adoption requires awareness. At this point, the potential users receive adequate information about the benefits of a technology. The second step is assessment. At this point, the expected users evaluate the usefulness and usability of the technology, and the ease or difficulty of adopting it. This is followed by acceptance or refusal by the potential users, i.e. they decide whether to acquire and use the technology. The fourth step is learning. If they decide to use the technology, the users need to develop the skills and knowledge required to use the technology effectively. The final step is application or usage. Here, the users

show appropriate and effective use of the technology. Further, there is a distinction between adoption of a technology at the individual farm level and aggregate adoption in a targeted region. Adoption at the farm level describes the realisation of farmers' decisions to apply a new technology in the production process, while aggregate adoption is the process of spreading or diffusing a new technology within a region (Feder and Slade, 1984).

Farming is an undertaking that occupies the daily routine of most agricultural producers and involves numerous important decisions, such as what crops to plant, what inputs to use, when to plough, when to plant the seeds, how to irrigate, how and when to harvest, how much to keep for home consumption, how much to sell, and how much to store for later sale.

2.2.2 : Availability of agricultural technology

Most African traders and manufacturers do not have the ability to manufacture expensive mechanisation implements like combine harvesters, tractors, maize dryers and power tillers (Diao et al., 2014), thus many nations import these tools from other continents like Asia specifically India and China) and America. The trends of mechanisation have significantly trailed the global trends in manufacturing and marketing of these tools. Unfortunately, because of the importation of these implements, their prices have remained high in the African markets, as opposed to the prices in China and India where farmers are regularly subsidised (India Ministry of Agriculture, 2008 and Zhang et al., 2015).

As the capacity to manufacture mechanisation tools remains limited, many users will continue to import from other continents, and the dependence on such imports will continue for a long time. Private sellers have learnt to effectively transport the tools to areas of demand to trade. In some countries, governments have been involved in importation and sale to farmers at a lower price, especially when there is a strong political need to help the farmers and perhaps improve the agricultural production and food security of such countries. However, government participation in this kind of trade is highly discouraged as it slowly squeezes out private participation, and may eventually lead to a decline in the performance of the agricultural sector as well as imposing a heavy budgetary burden, especially when it is funded through long term borrowing. In the long term, private traders lose their grip on trade and the government takes full control, which can be misused by politicians who seek to benefit from the economic rents that this trade attracts. This may result in a supply chain being built around larger machinery, stifling demand for smaller, potentially more suitable, machines. Private traders can only sell spare parts and perform repairs on faulty machines, which in essence causes the existence of

numerous brands of spare parts occasioned by many sellers who seek to differentiate themselves in the market and gain some significant sort of market power (Diao et al., 2014). It should also be noted that the involvement of the government in the trade sometimes causes a significant adoption of equipment, despite the many other drawbacks. However, the perceived costliness of these machines has a negative bearing on farmers' intentions to adopt; many small and medium-scale farmers believe that these technologies are beyond their financial reach (Diao et al., 2014).

Empirical evidence indicates that the share of agricultural imports by private agents in African countries ranges between 0-10 percent in Nigeria and Tanzania, and up to close to 100 percent in Kenya, Ghana and Ethiopia (World Bank, 2014). For instance, a study by the World Bank in Zambia indicated that only 15 percent of the tractors were imported by private agents, with loans acquired through projects. In some cases, like Kenya, Ghana and Ethiopia, governments get involved in the trade through private firms for efficient imports and distribution in the economy (World Bank, 2012a; 2012b; 2013a). This could give a perception of private involvement, but the fact is that the governments are actually deeply in control of the trade (World Bank, 2012d).

Farmers prefer to import second hand machines, since in most cases there is little or no significant drop in performance. It has been found that where spare parts for these machines are readily available, the machines can last longer than expected, and may cost even less than those subsidised (Houssou et al., 2014; Diao et al., 2014).

“Many machines currently in operation appear to have surpassed their expected useful lifespan of five to 12 years. For example, 85 percent of tractors operating in Tanzania are 11 years or older” (Diao et al., 2014, p.23). In a survey regarding tractors in Nigeria, it was found that tractors that were acquired new and those acquired used lasted similar lengths of time (Takeshima et al., 2015).

2.2.3 : Cereal-drying and technology use

The history of grain handling, and specifically drying, is long, and grain quality maintenance has always been the main factor to consider in post-harvest grain management. The quality of grains is caused by factors such as, crop variety, the pre-harvest environment, and post-harvest management. Most grains are harvested with moisture contents above 18–20 percent (wet basis), but have to be stored at 13 percent moisture content to avoid quality deterioration. Traditionally, single grains would be harvested each year in the dry season and sun-dried before

storage. Over the last 20 years, however, non-photo period sensitive modern grain varieties have been introduced, facilitating the widespread adoption of multiple cropping. A large volume of grains is now harvested during periods of high rainfall, thus the practice of sun drying is not feasible for many producers. Modern varieties also have lower seed dormancy than traditional varieties, and will deteriorate at a rapid rate if stored with high moisture content.

Failure to reduce moisture content to acceptable levels results in a number of quality problems (Juliano, 1996). First, delayed drying of maize and rice could cause problems related to respiration and fungi attack, which are agents of quality deterioration. The affected maize loses primary quality features such as colour and taste. Second, delayed drying invites aflatoxin (*Aspergillus flavus*), which is a type of fungus that completely destroys the grains and renders them inedible for human beings. Serious disorders which could damage the liver and cause cancer can be caused by aflatoxin present in maize. Ingestions of this carcinogen also cause slowed growth in children.

2.2.4 : Aflatoxin as a major cause of maize losses

Aflatoxin attack is regarded as a major health hazard in maize grain consumption. This mycotoxin is caused many species of fungi, which attack maize both before and after harvesting depending on the field management practices and prevailing weather conditions as the crop nears maturity. Aflatoxin contamination is not only a Kenyan problem, but is also present in many sub-tropical and tropical areas. Aflatoxin is the main cause of maize contamination in Kenya (Strosnider et al., 2006). Factors such as slow drying and poor storage mechanisms create a favourable environment for attack by aflatoxin (Wilson and Payne, 1994; Hell et al., 2008). It is reported that the formal and informal grain sectors have high aflatoxin prevalence of between 16 to 65 percent in the sampled grains, a level that is far above acceptable (Lewis et al., 2005; Gathura, 2011; Daniel et al., 2011). Since maize constitutes the daily meal for many Kenyans, accounting for 36 percent of total calorie intake, aflatoxin may present a serious threat to the Kenyan population (Kirimi et al., 2011). According to Shephard (2008), a person can be seriously affected even when exposed to low levels of aflatoxin.

Despite the fact that aflatoxin itself is physically invisible and tasteless, its presence causes fungal growth issues related to the damage of the outer protective layers of the grains, causing discolouration and eventually a reduction in the quality and taste. Consumers who observe the above characteristics may reduce their aflatoxin exposure by rejecting maize grains which possess them, or by redirecting them to other uses which do not present harmful health hazards.

Grain fermentation can reduce aflatoxin levels up to 80 percent, which makes beer less risky if aflatoxin attacked maize is used in production (Strosnider et al., 2006).

The fight against aflatoxin in Kenya has faced serious challenges. While consumer and producer awareness has been heightened through national adverts encouraging best practices at production level, sometimes consumers do not observe information about food safety of the grains at the point of sale before purchasing. This presents a serious threat to maize marketing and the health of the persons consuming the grains. Since many consumers do not conduct quality checks of grains, there are limited incentives to produce and market aflatoxin free grains, especially if attributes that matter to consumers cannot be accurately observed after purchase (Kirimi et al., 2011). The nature of the Kenyan market has perhaps cultivated a culture of poor grain handling, putting consumers at risk of exposure to aflatoxin. In July 2004, aflatoxin poisoning killed people and livestock across Kenya in an outbreak of 317 cases, with 125 deaths of people reported (Korir et al., 2012).

To abate this menace, the Food and Agriculture Organization (2006) suggested that a number of factors must be considered in drying, such as temperature and air velocity, the rate of drying, drying efficiencies, kernel quality, air power, fuel source, fixed costs, and management. Despite other scientific methods developed to combat the growth of aflatoxins, such as inhibition of the growth of *Aspergillus flavus* or *Aspergillus parasiticus* and the removal of aflatoxin after they have been produced by the *Aspergillus*, effective drying has been lauded by the FAO as a simple and affordable mechanism. Drying is an important step in ensuring good-quality grain that is free of fungi and micro-organisms, and that has desirable quality characteristics for marketing and final use.

Maize drying is commonly done in the open sun after harvesting in most African countries. Drying as a method of food preservation involves the removal of moisture to avert the development of favourable habitats for moulds, bacteria, and insects that cause spoilage. The food crop must be dried to between 12 and 14 percent of moisture content for most grains with an initial moisture content of 30 to 80 percent (Food and Agriculture Organization, 2006). Mechanisation of maize drying could reduce the amounts of post-harvest losses in Kenya, as well as significantly increase food security in the country. Further, it could reduce the case fatality rate (CFR) of aflatoxin poisoning due to poor grain drying.

2.2.5 : Grain-drying methods

When crops are left standing unharvested, they lose their quantitative and qualitative values due to attacks by moulds, rodents, birds and insects. It is thus recommended to finish the harvesting process at once if possible (Food and Agriculture Organization, 2011). Additionally, the removal of any contaminants and dust, as well as any other foreign bodies like straw, seeds, weeds and dead insects, is necessary, as they cause spoilage of the grain by filling the air spaces around the grains. Spoilage occurs when the moisture content is high, as it facilitates fungal and insect attacks, as well as germination and other respiration problems. Although the moisture content in the growing plant is usually necessarily high, it starts to decline as the crop matures, and further drops at drying for better and longer storage (Food and Agriculture Organization, 2011). During respiration, heat is generated. It is therefore necessary to reduce the moisture which consequently reduces the rate of respiration. This would help to lessen the possibility of germination and lengthen the storage life. Fungi and insects also thrive in the warm temperatures caused by the respiration process; at low temperatures they become metabolically inactive, hence the rate of spoilage is low. The grain should essentially be kept clean and dry to avoid heating that would hasten spoilage. The respiring grain produces additional water that dampens the grain further and cause more quality loss (Food and Agriculture Organization, 2011).

The moisture content of a crop is normally given on a 'wet basis' (wb), and is calculated as follows (% mcwb) (Sethuraman and Naidu, 2008. p. 179):

$$\frac{\text{Weight of moisture}}{\text{Weight of wet sample}} \times 100$$

Occasionally 'dry basis' (db) moisture content is given, and it is important to know which has been used. For example, if 100 kg of moist grain is dried and loses 20 kg of water, the moisture content is:

$$\frac{20 \times 100}{100} = 20\% \text{ on wet basis (wb) or}$$

$$\frac{20 \times 100}{80} = 25\% \text{ on dry basis (db)}$$

As stated in a report by the Food and Agriculture Organization (2011), at harvesting, maize grains carry a moisture content of between 18 and 25 wet basis percent. This percent may vary

depending on various factors such as the prevailing weather conditions, the stage of harvesting, the season, and the type or mode of drying. Determination of the level of moisture in the grain can be done using many methods, some of which include oven drying and the distillation process. In these methods, maize grain samples are taken to the laboratory for testing to determine the moisture content. Before sampling is done, maize should be thoroughly mixed to avoid picking samples from regions that contain different levels of moisture, as there is a possibility that there could be a variation in moisture level depending on how the grains are stored after harvesting. The factors which may cause differences in moisture content include:

Drying systems: These vary from simple sun drying techniques using thin layers, to a simple maize crib to expensive mechanised systems such as continuous flow dryers. A farmer's choice of a particular system is guided by several factors which include:

Rate of harvest: The drying system must have adequate capacity to cope with the pace of grain delivery for drying. It is critical that the drying process be fast enough to avoid holding up the harvesting process.

Total volume to be dried: It is important to dry the grains at the beginning of the harvesting season when it is dry.

Storage system: "Sometimes the storage system and the drying system may be the same structure, for example, a ventilated maize crib used for drying the crop is likely to be used afterward to store the shelled crop in bags. Some bin-drying systems have a similar dual purpose" (Sethuraman and Naidu, 2008. p. 184).

Cost: Both capital and running costs should be considered while choosing a particular drying system.

Flexibility: Systems which allow different crops to be dried is preferred. Drying can be divided into natural and artificial drying techniques. In natural drying, the grain either dries at room temperature or is exposed to direct sunlight without artificial facilitation for faster drying. In artificial drying, artificial facilitation is done to enable a faster rate of drying using mechanical means such as the provision of flow of fast moving air, which could be at a higher temperature to provide a quick drying process.

2.2.5.1: Natural drying

Farmers have traditionally relied naturally on moving air to lower the moisture content to amounts safer for long term storage. Ventilations are properly made so that even grains with

moisture content of about 30 percent can be safely dried and stored inside the store. There are three main techniques used in natural maize drying: one in which layers that are shallow are used to dry the grains while exposing the crop carrying the grains to wind and sun and also preventing moisture on the ground from reaching the crop; and drying on, a structure that is properly ventilated to allow in air through the crop.

Field drying: This method is popular where crop maturity coincides with the beginning of the dry period. Here, the crop is left standing on the ground for one or two months to reach moisture content fit for storage. The challenge with this method is that the crop is prone to attack by rodents, birds and wild animals. Furthermore, rainfall and wind damage can reduce the quality of the crop as there is limited control of these natural occurrences. New improved crop varieties meant for high yields are especially prone to environmental damage, for example, traditional maize varieties usually have a better maize cob cover than the hybrid maize, which exposes the latter to attack by natural agents. One disadvantage of field drying is that it may delay clearing for the next season's activities. For instance, where the next rainy season follows immediately, this could be an impediment for field preparation. In addition, this method is not possible in irrigated fields where early and timely harvesting is required, since high cropping intensity is established.

Shallow-layer natural drying: The harvested crop is spread on purpose-built platforms, the ground, trays or roofs. This process facilitates a faster drying process but it depends on the amount of humidity in the ambient air as the crop is exposed to the sun. For even drying the crop should be adequately stirred, however it has to be covered every evening to avoid being rained on in cases of a rainy period. The labour requirements may be reduced considerably by placing the harvest on a plastic or tarpaulin sheet for easy handling, or on a platform/tray covered by transparent plastic.

Ventilated structures for natural drying: Here, the crop containing the grains is suspended on a pole to allow for free exposure to flowing air and sunshine for slow drying for smaller quantities of harvest. In the case of larger quantities, the crop can be stacked and covered with straws on a platform or racks to protect against rainfall which could slow down the drying process or even facilitate spoilage. Apart from maize, other crops like rice and groundnuts can

be dried using this method. Ventilation should be as good as possible, as this method depends heavily on free flowing air in the drying process. For greater protection of the grains, a well-ventilated and raised structure can be used to allow for an undisturbed drying process well secured from any rain. In Africa, maize is predominantly left on the ground in stacks until the moisture content in the grains falls below 18 percent. Further drying is made possible on the cob once the grains are transferred to the granary after harvesting.

The importance of pre-drying is to reduce the chances of spoilage at a later stage, since the materials/baskets may either be open to allow proper ventilation, or closed tightly to guard against entry of other foreign materials and insects which could cause damage and spoilage. An effective two-step technique used to be used, where traditional maize varieties had a sheath that covered the grains on the cob, which was tough to the extent that they could not easily break when exposed to some form of stress. However, with the current population pressure there is limited land left for this kind of drying; farmers are forced to use the same land season after season, limiting any time for field drying of crops. The number of pests has increased as a result, thus most improved high-yielding crop varieties require immediate harvesting and transfer to the place of drying or safe storage, otherwise the rate of spoilage will be very high. Many farmers still prefer the traditional circular granaries, which could still do well if modified. For proper aeration, the granary should have the basket properly woven with loose fittings with at least 40 percent air spaces and the wall slightly raised. The diameter of the basket can be made wider to about 150cm based on the level of humidity. Since constructing a circular basket with a bigger width may be problematic, rectangular ones could be made to store more than nine bags of produce. A rectangular structure made with slatted walls and a flat floor is called a ventilated maize crib.

The floor should be raised to about 90 cm in areas with rodents, and fitted with legs and rat guards. As long as the recommended width of the crib and the area for storage is used, maize grains could be dried without mould development, but if it takes longer than 10-15 days to reach moisture content of below 18 percent, mould may develop regardless of whether the maize is in the field or in a store. The rate at which the grains dry depends on the relative humidity and the speed of movement of air around the crib of the granary. Drying will stop when the moisture content reaches a point of equilibrium. When the prevailing relative humidity is about 70 percent, maize grains can dry to a moisture content of 13.5 percent.

2.2.5.2: Artificial drying

Sometimes the humidity may be so high to allow natural grain drying in the sun. Heated air is then artificially forced through the grain to facilitate the drying process. Locally, several methods have been developed and availed to farmers for drying purposes. In this case, grains can only be dried as long the heat energy available can sustain the drying process. Panicles of paddy and maize stored on horizontal grids are kept dry by heat from a fire occasionally lit below the grid, and the heap of panicles is rotated regularly to reduce the chances of growth moulds in the grains. Granaries can be raised and fires lit below the heap of pinnacles to finish the drying, but the grains attain a particular odour and flavour when subjected to treatment that contains smoke and hot air. To overcome this problem, dryers fitted with chambers of “hot air or heat exchange units and smoke stacks or chimneys are used. The fire is lit at the mouth of the oil barrel tube, and hot air and smoke is exhausted via the chimney. The heated barrels in turn heat the surrounding air, which rises through the crop” (Mrema et al., 2011, p. 368). There must be some form of aeration when heat is applied to dry the grain, which can be achieved by providing physical stirring since convection currents naturally would not move enough air through the grains.

Low-temperature drying: This also known as near-ambient drying, whereby the grain is stored at room temperature. Four major factors drive the use of this method: the variability of weather, the harvest moisture content, the air flow in the storage bin, and the amount of heated air. These low-temperature dryers are built to dry the grain slowly while maintaining its quality. This system operates well when the daily temperature is between 30 °C and 50 °C, yet this method can take more than five months to achieve the desired moisture content of the preserved grain. A number of factors influence the rate at which the grain will dry: airflow rate, initial amount of moisture and amount of heat applied. Air flow is the most important feature of this method, as without an appropriate airflow, the spoilage rate will increase (Family Services, 1977).

For a relative humidity of more than 70 percent, dryers with heated air are preferable. When electric thermal dryers are used, a barrier/ resistant heater which is run using electricity is placed in front of the fan to heat a stream of air that will pass through the grains. In electric heat dryers a humidistat can be used to regulate the heater, but when a solar dryer is used, the air needs to be passed inside a collector for heating to between 12 and 13°F, whereby the fan and the motor facilitate passage of air into the grain holding bin. This method is advantageous

as it provides high quality drying with less equipment, but it is disadvantageous as it requires a long drying time, a good supply of electricity, and good managerial skills.

Multiple-layer drying: This method requires higher temperature heating compared to the previous process, but takes less time. A heated airstream enters the grain with the help of a fan and motor. Once the grain dries, the heat is turned off and a stream of ambient air regulates the temperature to room temperature for the grains to cool down. This method is advantageous in that the drying bin can be used for both drying and storing corn, and it also requires little labour since there is limited handling of the grain. However, in this method there is a high likelihood of over-drying, especially at the bottom (Bern et al., 2013). Stirring of the grain to facilitate uniform drying and to reduce the chances of overheating can also be used in this system of drying; however additional stirring increases the operational expenses in this system.

Batch drying method: This method includes both the bin and column batch drying methods.

Bin-batch drying: Here, a certain amount of grain, usually two to four inches, is placed in the dryer's bins first. The grain is dried and later cooled, then drying is stopped and the batch is removed (Bern et al., 2013). A dryer with a fully perforated floor is used with or without stirring. After completion of the drying process the grain is then stored on the bin's floor, which reduces the time required to unload the grains. However, there is no wet grain holding in bin-batch roof dryers.

Column batch drying: Two perforated steel sheets form the dryer, which is usually approximately 12 inches thick. In this method dryers can also be used as coolers, which makes it more advantageous. The method is, however, disadvantageous, as a lot of time is lost during cooling. When the column batch recirculating dryer is used the moisture content variation problem is avoided, yet the additional handling process may result in grain spoilage (Family Services, 1977).

Continuous flow drying method: Six different systems are used in this method.

Cross flow drying: This is the most common method used, whereby the airstream is perpendicular to the grain flow, however the grain near the drying air is over dried, while on the other side the grain is under dried. Moisture gradient (the difference in moisture content between inside and on the surface of the grains) exists when drying is complete. A higher moisture content variation in this method is usually caused by a low airflow rate, thus airflow rate is a critical feature which should be closely monitored.

Concurrent flow drying: Hot air and wet grains move in the same direction for maximum heating, but the wettest grains area are subjected to the hottest air. There is uniformity in drying such that the kernels are moved out of the heating zone with uniform temperature and moisture. The efficiency in energy usage is about 40 percent more than the cross flow dryer. The depth of the beds must be 12 inches, otherwise more power will be required to run the fan.

Counter flow drying: Here, hot air and grain move in opposite directions, hence the driest grain meets the hottest air. Temperature is also uniform since the grain leave the drying zone with the same moisture and temperature just like in the concurrent flow dryer. The temperature should be maintained below 180 °F, otherwise the driest kernels are more likely to crack due to exposure to the hottest air.

While drying maize grains, it is important to note that cracks in the corn should be reduced, especially at threshing, as they could cause problems at the drying and storage stages. Stress cracking could result in rapid heating and cooling of the grain, and stress-cracked kernels often absorb water too quickly and are more prone to breakage and mould damage. To reduce the amount of grain that is lost due to stress-cracking, medium temperatures and slow cooling, or natural air and low-temperature drying methods, should be employed.

2.2.5.3: Problems associate with grain drying

One of the main problems in grain drying is over drying, which may cause a lot of stress to the kernels and result in cracking, which reduces the viability of the grains. Additionally, over dried grains lose the required moisture content that keeps the grain safe during storage and also attractiveness in the market due to being lighter. At the point of sale, one bag of maize grains at 15 percent moisture content weighs more than one at 12 percent moisture content.

In an air short-circuiting dryer, the flowing air follows a smooth path without resistance, which in the case of grain is usually the shortest route possible through a batch. The presence of contaminants like fine seeds and chaff cause drying difficulties because they block the air spaces within the grains, and cause resistance to air flow during drying. For this reason the grains must be cleaned before undertaking the drying process.

Most farmers apply sieving and winnowing, which help to separate chaff and other foreign materials from the grains. For effective sieving, a two stage process is recommended whereby first a sieve with bigger holes is used to allow more course particles of chaff to pass through, and in the second stage a finer sieve which allows finer particles like fine seeds to pass through

is used. Preliminary cleaning is recommended before storage for major contaminants to be removed, and another proper cleaning can be done before the grain is sold. This applies in particular to seed grain.

2.2.6 Maize drying methods used in Kenya

Drying in Kenya is mostly done using sun drying in the open air and solar dryers, with the majority of farmers depending entirely on natural sun drying. Open air drying is the oldest, most widely used, and most inexpensive method. In this method, the stem bearing the crop is cut down and left to dry. The crop is then staked for more than a month to dry. Despite the rudimentary nature of this process, it still remains common because the power requirements (solar radiation and air's enthalpy) are readily available in the ambient environment, and little or no capital cost is required as the running costs are low (often family labour only). After shelling, the grains are spread in the open air to dry in the sun. This practice is associated with various limitations, i.e. it is dependent on weather conditions, it is labour intensive, conditions are unhygienic, it is time-consuming, it produces non-uniform drying which may encourage aflatoxin growth and pest interference, and it requires a large area for spreading the produce out to dry (Food and Agriculture Organization, 2011). Unfortunately, farmers do not have accurate methods of measuring moisture content, but rather count the number of days the grain is subjected to sun drying. This method is rather subjective and often not reliable, which can lead to widely varying and sometimes erroneous conclusions.

Mechanised dryers, despite being faster, more efficient and providing a better-quality product, are expensive and require substantial amounts of fuel or electricity to operate, leading to high costs of drying. To improve their drying mechanisms, some farmers in Nakuru, Kenya, have adopted the use of solar dryers. Two types of solar dryers are commonly used: passive and active dryers. Natural circulation solar energy dryers (passive) depend entirely on solar energy. In such systems, solar-heated air is circulated through the crop by buoyancy forces or as a result of wind pressure, acting either singly or in combination (Ekechukwu and Norton, 1999). Active solar dryers are more complex but are more farmer-friendly, as they are installed with a proprietary moisture meter to test grain moisture content. These dryers were developed to improve the quality and quantity of grains.

Mechanical maize dryers are better in the sense that moisture and temperature control are more efficient and effective, and they can be operated at night and generally with less labour, while producing a higher milling yield of grains. These are the reasons why this researcher was

interested in analysing the intention of farmers to adopt mechanical dryers. The aim is to advise on measures to improve their usage by farmers in the study area. Figure 2 is an illustration of maize solar dryers.



Figure 2: Solar dryer

Source: Feed the Future Program

2.2.7 The importance of improved grain drying

In Asia, many large grain handlers only use mechanised maize drying techniques to dry the grains for milling. The systems used include in-store aeration, fluidised-bed dryers and column dryers. Artificially heated air is used to dry grains with a lot of moisture content in fluidised-bed dryers and column dryers.

The importance of drying grains with high moisture levels is to achieve a higher milling yield efficiently. According to Soponronnarit et al.'s (1998) experimental trials, mechanical drying can help achieve a higher milling yield of more than 4.8 percent within a shorter period of time compared with sun drying. With very high competition in the milling industry in Kenya, achieving such a milling yield would likely improve the financial performance of the Kenyan economy if the technology were to be adopted by Kenyan farmers. The results of the use of mechanical dryers has been impressive, with farmers reporting a substantial reduction in grain wastage, improved quality of grains, and reduced aflatoxin invasion. However, for commercial farmers, it will be important to consider the profits generated while using these technologies,

otherwise it would defeat the point of mechanisation if losses are incurred given the price fluctuations of maize in Kenya. Proper training in terms of using the equipment is also required to enable efficient drying, since in some cases the likelihood of grain cracking which may render the grain unmillable is very high.

Adoption intentions among farmers of the above mentioned technologies could be explained through an array of theories. This study adopted a theoretical review that covers a number of theories that explain the process through which farmers go before they decide on a particular technology.

2.3 Theoretical review

This section highlights various theories related to the study, including explanations of the process that farmers/individuals go through when deciding to adopt new technologies. A theoretical framework is a collection of interrelated ideas based on theories; it is a reasoned set of propositions that are derived from and supported by data or evidence (Kombo and Tromp, 2006). The present study was guided by the following theoretical framework and model. Four theories related to intention to adopt new technologies are reviewed.

2.3.1 Theory of social learning

The effect of social learning in technology adoption has been greatly emphasised in the literature (Besley and Case, 1993; Rosenzweig, 2001; Rasul, 2006; Uaiene et al., 2009). Farmers in a village observe the behaviour of relatives and neighbouring farmers, including their experimentation with new technology. Once the results of the new method give an indication of a positive benefit, a farmer becomes motivated to use the new technology in the subsequent year (Uaiene et al., 2009). According to Bandiera and Rasul (2006), social networks also play a role, with the probability of adoption being higher amongst farmers who engage in agricultural discussions with others.

Earlier research by Besley and Case (1993) used a model of learning where the profitability of adoption is uncertain and exogenous. Studying a village in India, they found that once farmers discovered the true profitability of adopting a new technology, they were more likely to adopt it, however imperfect information regarding the technology may hinder its adoption. Rosenzweig (1978) found that farmers may not adopt a new technology because of imperfect knowledge about its management and eventual benefits. Adoption may eventually occur due to a farmer's own experience and the experiences of a lead farmer. Three paradigms have been widely used to explain the differences in technology adoption as linked to social learning: the

Innovation-Diffusion Model, the Adoption Perception Model, and the Economic Constraints Model.

The **Innovation-Diffusion Model** is based on the assumption that the technology is technically and culturally appropriate, but adoption is hindered by asymmetric information and high search costs. According to this paradigm, diffusion is the process by which an innovation is adopted and gains acceptance by members of a community. Professionals in a number of disciplines, from agriculture to marketing, have used this theory to increase the adoption of innovative products and practices (Uaiene et al., 2009).

The **Adopters' Perception Model** holds that the perceived attributes of the technology influence the adoption behaviour of farmers. Farmers' perceptions could be related to attributes such as ease of use of the technology, suitability, convenience, and trialability. This means that, even with comprehensive information, farmers may subjectively evaluate the technology differently than scientists do (Ashby et al., 1995). For this reason, understanding farmers' perceptions of a given technology is crucial in the diffusion of new technologies.

Finally, the **Economic Constraint Model** contends that factors related to input fixity in the short run, such as access to credit, land, labour limits and production flexibility, influence technology adoption decisions (Shampine, 1998). According to Gameda et al. (2001), using the three paradigms in modelling technology adoption improves the explanatory power of the models.

2.3.2 Technology acceptance model

Much research has focused on identifying and explaining the theoretical frameworks surrounding adoption intentions using the Technology Acceptance Model (Plouffe et al., 2001). The Technology Acceptance Model proposes that attitudes towards using a system are controlled by two external variables, namely perceived usefulness and perceived ease of use. Attitude towards using a system directly affects the behavioural intention to use the system, which then determines the actual system use. According to Davis et al. (1989), perceived usefulness is defined as the prospective user's subjective probability that using a specific technology will increase his or her farm productivity, while perceived ease of use is defined as the degree to which the prospective user expects the target technology to be free of effort. Davis et al. (1989) noted that various researchers have utilised the Technology Acceptance Model to study the acceptance of technologies, however its shortfalls, listed by Lee et al. (2003), include its self-reported usage, that it is based on a single subject, that it has measurement problems,

that it does not explain causation, and that in general, it focuses on attitude as the key factor that influences adoption. The TPB, developed by Ajzen (1985) and Ajzen and Fishbein (1975), extended the Technology Acceptance Model to include perceived behavioural control as a factor determining behavioural intention, together with the subjective norm.

2.3.3 Theory of Reasoned Action (TRA)

The TRA was formulated by Ajzen and Fishbein (1975) in attitude research using Expectancy Value Models, when the authors tried to estimate the discrepancies between attitude and behaviour. The fundamentals of the TRA came from the field of social psychology. The main tenet of the TRA is that an individual's behavioural intention in a specific context depends on intention to change, attitude towards the change, and subjective norms (Ajzen and Fishbein, 1980).

Ajzen and Fishbein (1980) stated that a person's behaviour is determined by their intention to perform that behaviour, and that this intention, in turn, is a function of the person's attitude toward the behaviour and their subjective norms. Thus, one of the potential indicators of a possible behavioural outcome is intention. Intention, which is an indicator behaviour, refers to the cognitive representation of a person's willingness to do a particular function or behaviour. Behavioural intention is the relative strength of a person's likelihood to perform an anticipated behaviour. This is influenced by attitudinal factors that capture how individuals are engaging to perform the intended behaviour, based on their behavioural beliefs and their ability to evaluate the outcomes of their decisions or behaviours (Ajzen, 1991). Behaviour can either be verbal or non-verbal (such as body language), signals, signs, or vocal expressions.

Subjective norms are a combination of the normative beliefs of the relevant individuals, along with the motivation to comply with such beliefs or expectations (Ajzen and Fishbein, 1975). Thus a person's attitude, combined with subjective norms, forms the person's behavioural intention. The TRA can therefore be extended to conceptualise the human behavioural pattern in decision-making regarding the utilisation of a new innovation or technology. It explains that individual behaviour, such as utilisation of an innovation, is driven by behavioural intention, where behavioural intention is a function of an individual's attitude toward the behaviour, informed by the subjective norms surrounding the performance of the behaviour.

In a study that employed the TRA to understand technology adoption, Liker and Sindi (1997) developed and tested a model based on the TRA, in order to understand the challenges posed by communication systems on the performance of management teams. The model was tested using a cross-sectional design, using a self-administered questionnaire completed by a sample of 94 information system users and non-users from two of the largest accounting firms in the USA. The study measured attitudes toward the system and intention to use the system in the future (or continued use by existing users). “The results showed that intention to use the system was influenced by social norms encouraging system use, and by perceptions of the impacts of system use on valued skills, controlling for the effect of attitudes. Attitudes toward use of the system were affected by the perceived usefulness of the system and its impacts on valued skills. Attitudes were also strongly related to ease of system use, an unanticipated finding. The most surprising result was that general attitudes were not found to predict intention to use the system,” (Liker and Sindi, 1997, p.147).

Similarly, Otieno et al. (2016) noted that attitude and subjective norms have been found to be important determinants of peoples’ intentions to perform an action, such as adopting and using a new technology. They further stated that attitude has a significant influence on the intention to adopt and continue using a technology.

The TRA has not been extensively utilised in studies evaluating technology adoption and diffusion in the field of agriculture. A key drawback of the theory is that it fails to acknowledge the fact that individual behaviour may be directed by general constraints (Ajzen, 1985)). Ajzen (1985) provided an additional variable, that of perceived behavioural control, to address the limitations of the TRA when he published the Theory of Planned Behaviour. This theory seeks to address the seeming over-reliance on intentions to predict behaviour. This is why the present researcher applied the TPB, as it provides a better explanation of adoption intention of agricultural technologies. Figure 3 represents the variables used in the TRA.

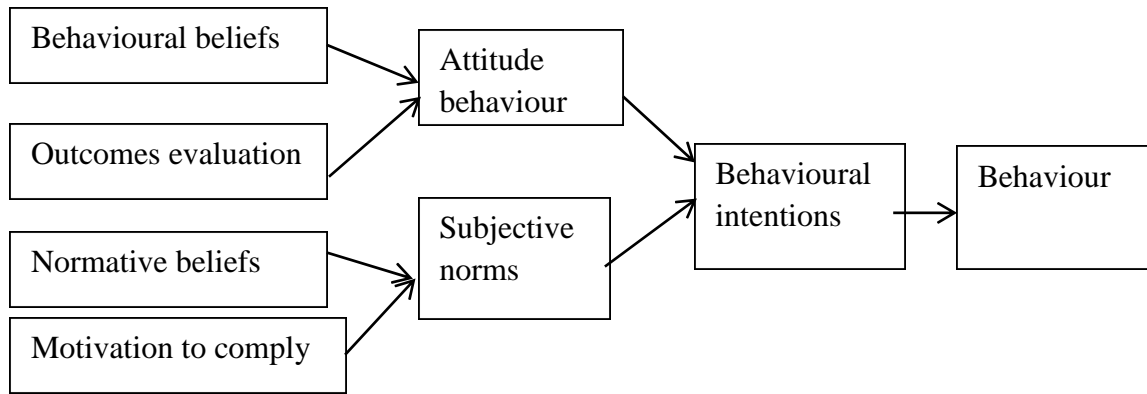


Figure 3: Theory of reasoned action
Source: Fishbein et al. (1991)

2.3.4: The Theory of Planned Behaviour (TPB)

Ajzen (1985) provided a useful framework for understanding a recipient’s behaviour in the TPB, which explains how different stimuli activate a particular behaviour, such as the intention to use a particular technology. The TPB provides a useful framework for understanding farmers’ decision-making according to their attitudes, subjective norms and perceived behavioural control, and the relationship with their intention to use mechanised maize dryers.

Similar to the TRA, the TPB developed by Ajzen (1985) explains that behaviour (such as technology adoption) is a function of intention. The individual’s behaviour is determined by his or her intention regarding that behaviour. Intention is built upon three components, namely attitude, subjective norms, and perceived behavioural control. The likelihood that a person will engage in a certain behaviour is also an indicator of intention, which is determined by the relevant salient beliefs about the behaviour. Attitudes toward adoption of technology, for instance, would refer to the individual’s evaluation of that technology, which can be positive or negative. To measure an individual’s attitude towards a particular technology, researchers have tried to simplify the understanding of the attitudes of the agents involved. Wauters et al. (2010) assessed farmers’ attitudes towards the adoption of soil conservation strategies using two unipolar seven-point scales, with endpoints ranging from ‘Extremely unpleasant’ to ‘Extremely pleasant’, and from ‘Extremely bad’ to ‘Extremely good’. They stated that an assessment in this way was consistent with many measurements of the attitude construct used previously, which merely used an instrumental item measured on a scale ranging from ‘Bad’ to ‘Good’, and a more experiential scale (the Unpleasant–Pleasant Scale). This showed a positive relationship between attitude and intentions.

Subjective norms are defined as the individual's perception of the social pressures to use or not use a particular technique; it is a belief of an individual about how much others would like him or her to use that particular method. Subjective norms are driven by normative beliefs and the motivation to comply with social pressure. According to the Expectancy-Value Framework, subjective norms can also be quantified (Pawlak et al., 2008). Similarly, Wauters et al. (2010) measured subjective norms by asking the respondents to answer two sets of questions. On the first scale, farmers were asked to indicate whether most people who are important to them would totally disapprove or totally approve of their usage of the technology. In the second question, farmers were asked to rate the truth of the statement that most people who are important to them think they should apply the technology. The respondents had to answer on a unipolar seven-point scale with the endpoints: 'Totally not' and 'Totally approve'. The results suggested that subjective norms are antecedents of a person's intention to perform a particular behaviour.

Perceived behavioural control refers to the way a person regards a particular behaviour as being difficult or easy to undertake, which is related to control belief and the influence of significant others in decision making. Situational and internal factors also restrict or facilitate the use of a technology. The Expectancy-Value Framework could be used to measure perceived behavioural control quantitatively (Pawlak et al., 2008) using two items. The first item requires farmers to rate the truth of the statement: "Whether I apply this technology or not depends entirely on me, and not on factors facilitating or inhibiting usage of the technology". The endpoints of this scale are "Totally not" and "Totally yes". The second question requires farmers to indicate the difficulty of applying the practice on a scale with endpoints ranging from "Extremely difficult" to "Extremely easy" (Wauters et al., 2010). Because Actual Behavioural Control (ABC) is often difficult to assess, many studies have used perceived behavioural control as a proxy for ABC (Wauters et al., 2010). In cases where respondents are assumed to be capable of adequately estimating their actual control, this is a good measure.

As stated earlier Wauters, et al. (2010, p.99), to measure intention to adopt agricultural technology using TPB, most of the attitude research followed the Expectancy-Value method. This method is based on the assumption that the attitude towards a technology is dependent on the belief about it, and its evaluation can be good or bad. The expectancy-value method has three basic components: belief (*b*) towards technology, value (*v*) of the technology for the individual, and expectation or attitude (*a*), which is the result of the first two.

$$a = \sum_{i=1}^n b_i v_i$$

According to the TPB:

$$B \approx I \infty AT + SN + PBC$$

where:

B = Technology, I = Intention, AT = Attitude, SN = Subjective norm, PBC = Perceived behavioural control, bb = Behavioural belief, oe = Outcome evaluation, nb = Normative belief, mc = Motivation to comply, cb = Control beliefs, and p = Power.

Computable Model of the TPB:

$$B \approx I = \gamma_1 \sum_{\substack{i=1 \\ j=1}}^s bb_i oe_i + \gamma_2 \sum_{\substack{k \\ = \\ 1}}^t nb_j mc_j + \gamma_3 \sum_{k=1}^u cb_k p_k$$

Illustration of the theory of TPB:

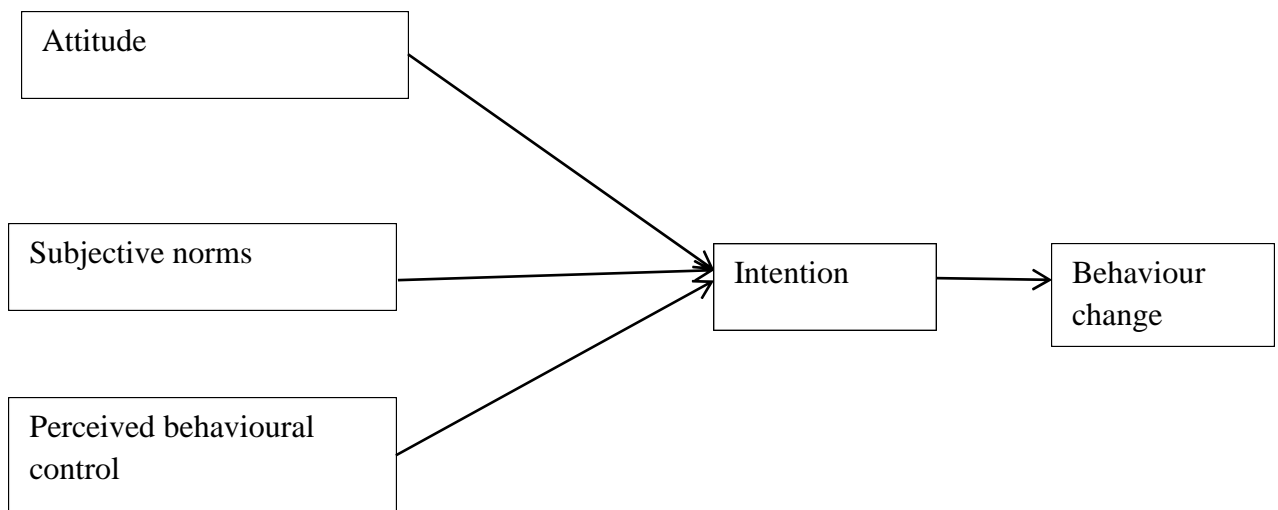


Figure 4: Theory of TPB

Source: Ajzen (2002)

2.3.4.1 Empirical review of TPB

Sextus Empiricus, a Greek scientist, came up with the idea of generating scientific arguments based on observational data. This precipitated a general diversion from doctrines of the day, which had involved dependence on theoretical support instead of relying on the observation of phenomena as perceived through experience (Mugenda, 2008). The term ‘empiricism’, therefore, is a concept that emphasises the role of experience and observation in acquiring knowledge (Keeton, 1962). This concept focuses on those aspects of scientific knowledge that are closely related to experience, usually formed through experimental arrangements. Mugenda (2008) further argued that it is a fundamental requirement of scientific method that all hypotheses and theories be tested against observations of the natural world, rather than relying solely on *a priori* reasoning, intuition, or revelation.

Empirical evidence of the TPB largely supports the fact that other studies have essentially differentiated two dimensions of technology adoption intention: goal intentions, which commit people to achieving a certain goal, and implementation intentions, which enable users of the adopted technology to derive usage experience (Sniehotta and Schwarzer, 2005). According to Sniehotta and Schwarzer, people plan to adopt a particular technology once a situation is encountered and they develop an intention to adopt. In some instances, people do not necessarily proceed to form an intention, which develops a gap between intention and the actual

behaviour (Sniehotta and Schwarzer, 2005). Thus, goal-directed behaviours can increase the probability of a person engaging in a particular behaviour (Korzilius et al., 2007).

Several studies have investigated implementation intentions in the context of the TPB (Sheeran and Orbell, 1999; Verplanken and Faes, 1999; Orbell et al., 1997). An experimental study, for example, showed that among people with similar scores on the TPB variables, individuals who formed implementation intentions were almost twice as likely to proceed to actual adoption of a technology. In trying to explain the gap between behavioural choice and action, Kuhl and Beckmann (1985) introduced the theory of action control. This theory assumes that, besides motivational factors such as goal intentions, there is a second category of non-motivational factors that may cause a failure to enact an intended action.

Additionally, He et al. (2008, p.290) noted that “the perceived ease of use of a technology, its usefulness, vendor competence, introduction and recommendation by a third party (subjective norm), and vendors’ attitudes toward customers (attitude), influence the intention to purchase and use a technology”. Their results supported the validity of the Technology Acceptance Model (TAM), which asserts that buyer-to-buyer purchase intention is determined by perceptions of the ease of use, perceived usefulness, introduction by a third party, and vendors’ attitude.

He et al. (2008) recommended further investigation into the influence of external variables such as age, gender, income, cultural background, occupation, family status, and education on adoption intentions (p. 290). However, a study conducted by Belleau et al. (2007) on technology purchasing by young buyers found that external variables have little influence on buyers’ behaviour decisions.

2.3.4.1: The theoretical sufficiency of the TPB

A lot of research has been done to compare other models with TPB in trying to establish its theoretical sufficiency. For instance, Taylor and Todd (1995) compared three theories - the Theory of Reasoned Action, the Theory of Technology Acceptance and the Theory of Planned Behaviour-with the aim of finding their relevance in explaining technology adoption. The researchers found a strong relationship between intention to adopt and the actual adoption of experienced technology users, compared to those with limited experience. Rather than introducing experience as a variable into the model, Taylor and Todd (1995) tested the model twice (once with data from experienced IT users and once with data from inexperienced IT users) (p. 566). The researchers found that their decomposed model provided a fuller

understanding of behavioural intention by focusing on the factors that are likely to influence information systems use through the application of design and implementation strategies.

Other researchers preferred meta-analysis studies to determine the theoretical efficiency and sufficiency of the TPB. In some studies, researchers focused solely on the TPB (Armitage and Conner, 2001; Notani, 1998), while others also assessed the TRA (Hausenblas et al., 1997; Sutton, 1998; Hagger et al., 2002). The vast majority of these meta-analysis studies showed robust support for the TPB. Armitage and Conner (2001) analysed 185 independent studies based on the TPB. In their meta-analysis, the scholars found that the TPB worked very well, with a multiple correlation of 0.63 for predicting adoption intention. The model accounted for 27 percent of the variance in behaviour (adoption) and 39 percent of the variance in intention. Perceived behavioural control accounted for significant amounts of variance in intention and adoption, independent of TRA variables (Armitage and Conner, 2001). The researchers sought to establish if indeed each of the previous studies used self-reports. They realised that the TPB had 11 percent positive results in terms of variance in adoption for cases where adoption measures went down.

Overall, Armitage and Conner (2001) noted that subjective norm was a poor predictor of behavioural intention. They also noted that the role of the format of a questionnaire and the level of social desirability had minimal effects on models which applied TPB, which was similar to the findings written in their next paper (Armitage and Conner, 1999). The efficiency and sufficiency of the theory of TPB was also supported in the meta-analysis study conducted by Godin and Kok (1996). The scholars looked at 56 studies that used the theory to study health-related behaviours, and verified the theory's efficiency. Godin and Kok's meta-analysis also found that the TPB explained intention. They noted that two variables, perceived behavioural control and personal attitudes, played an important role in explaining intention. While intention was found to be the most important predictor of behaviour, perceived behavioural control significantly added to the prediction.

According to Notani (1998) studies involving the TPB found similar support for the model, with perceived behavioural control serving as an antecedent to both adoption intention and actual adoption (p. 1325). The findings indicated that perceived behavioural control is a stronger predictor of adoption when it is operationalised as a global measure, and is conceptualised to reflect control over factors primarily internal to the individual. Other theorists such as Sutton (1998) compared the TPB and the TRA in a meta-analysis. Sutton

(1998) found greater support for the TPB by evaluating the performance of these models in predicting and explaining intention and adoption. The models explained between 40 and 50 percent of the variance in intention, and between 19 and 38 percent of the variance in adoption. Another meta-analysis to determine the usefulness of the TPB against the TRA was also conducted by Hausenblas et al. (1997). While limiting their analysis to intention and adoption, they found a large effect size for the following relationships: “intention and adoption, attitude and intention, attitude and adoption, perceived behavioural control and intention, and perceived behavioural control and adoption. The effect size was moderate between subjective norm and intention” (Notani, 1998, p. 1327).

The results of the study by Hausenblas et al. (1997) suggested that the TPB is superior to the TRA in studies involving adoption intentions. Other scholars have found similar results in meta-analytic comparisons of the theories in different research contexts involving adoption intentions. Hagger et al. (2002) examined 72 physical activity studies that used these theories, using meta-analytic techniques to correct the correlations between the TPB and the TRA. They also used path analysis to examine the relationships among variables, and found that the major relationships in both theories were supported, but that the TPB accounted for more variance in physical activity intentions and adoption. Overall, these meta-analyses overwhelmingly demonstrated the theoretical sufficiency of the TPB, with the majority of these studies demonstrating a strong explanatory power of the TPB in adoption intentions.

It is important to note that several researchers mentioned concerns about the measurement of TPB variables (Armitage and Conner, 1999; Godin and Kok, 1996). These concerns underscore the need for the proper conceptualisation and operationalisation of variables, as suggested by Ajzen (2002). Unfortunately, not all researchers have followed the model as originally conceptualised by Ajzen, resulting in misleading results and difficulty comparing the different studies that used the theory. However, when the TPB model is operationalised as recommended by Ajzen (2006), measurement issues are minimised and the model’s predictive power increases. In summary, the meta-analyses and comparative studies previously discussed justify the selection of the TPB for the present study, which aimed to provide an understanding of what influences farmers’ decisions with regard to adoption intention of mechanised maize drying technologies.

2.3.4.2: Critique of the literature

In spite of the extensive and successful application of the TPB in adoption behaviour studies, the theory has recently been criticised for insufficient consideration of moral attitudes' influence on adoption (Arvola et al., 2008). According to the TPB, all moral influences on decisions to acquire a particular technology that is perceived to be new were assumed to be mediated via the measures of attitudes, subjective norms, and perceived behavioural control (Ajzen and Fishbein, 1980).

Ajzen (1991) acknowledged the critique that, at least in certain contexts, one needs to consider not only perceived social pressure, but also personal feelings of moral obligation or responsibility to make decisions about technology usage (whether it is morally right to use such a technology). The author further stated that this moral duty would definitely impact on intentions, in parallel with attitudes, subjective norms and perceived behavioural control.

According to Olsen (2010), the TPB is, in principle, open to the inclusion of additional predictors, if it can be shown that they capture a significant proportion of the variance in intention or adoption after the theory's current variables have been taken into account. Based on a study of college students' usage of unethical techniques, Ajzen (1991) proposed that moral obligation and information regarding the technology are such additional factors that would be expected to influence intentions and add to the predictive power of the TPB (Beck and Ajzen, 1991).

A meta-analytic review of the TPB provides strong support for the predictive validity of the theory. The theory provides a parsimonious explanation of the informational and motivational influences on behaviour, i.e. it is easy to comprehend and it can be applied in technology adoption studies. There are, however, a number of limitations to the scope of its use and the extent to which it can be deemed to be a complete model of farmers' decisions. Further, while the TPB does consider normative influences, it does not take into account environmental or economic factors that may influence a person's intention to use a particular technology. It also assumes that adoption is the result of a linear decision-making process, and does not consider that this can change over time.

The TRA and the TPB have been widely applied in Western cultures, however it is not clear that the assumptions underpinning them are suited to other cultures, such as that of Kenya (Bagozzi et al., 1992). Very few cross-cultural studies have been undertaken using the TPB and the TRA, yet the limited findings suggest that the theories are not equally effective in

different cultures (Bagozzi et al., 1992). Culture shapes attitudes, subjective norms, and perceived behavioural control, thus cultural variations could cause significant differences in the evaluation of the relevance and usefulness of a particular technology. This would have an impact on the acceptance and intentions to adopt. Suttan (1998) argued that intention is likely to be a dynamic concept, constantly under re-evaluation as situations change, or as one moves from one geographical region to another.

The aforementioned studies provided context and a deeper understanding of the aspects that informed the choice of the TPB for the present study. The additional elements explained below were included in the TPB, based on the adoption studies undertaken in Kenya and elsewhere, which revealed their importance and the need to undertake the study in Kenya.

Based on the limitations of the TPB, the researcher introduced two variables based on the literature: knowledge/information and financial resources, which play a critical role in farmers' intention to adopt agricultural technologies (Otieno et al., 2016). According to Parvan (2010), access to information related to a particular technology through extension agents and farmers' own experience influences the intention to eventually adopt the technology. The sharing of farmers' experiences informs them about the availability of technologies and the ease or difficulty of using these technologies, which increases their likelihood of adoption. As suggested by Ajzen (1991), having information only adds to the predictive power of the TPB, as it influences agricultural technology adoption intentions.

Financial resources remain a barrier to technology use in the Kenyan agricultural environment. Agricultural technologies like mechanised maize drying require a considerable financial outlay, and if farmers do not have financial resources and have difficulty accessing credit, their ability to acquire new technologies is limited. Such farmers may therefore not be motivated to even seek such technologies.

2.4: Gap in the research

From the preceding discussion, it is clear that a number of studies have been carried out on the factors that affect the adoption of mechanised maize drying technologies among small-scale farmers across the globe. Previous studies anchored in the TRA and the TPB identified key factors that influence the adoption of these technologies, namely attitude, subjective norms, and perceived behavioural control. However, the researchers ignored the influence of the

nature of information regarding the technologies, as well as other factors such as educational level/knowledge and access to financing, which could play a critical role in shaping individuals' intention to adopt new technologies.

2.5: Hypotheses

The core constructs in the hypothesised research model of the TPB are personal attitude towards adoption, subjective norms, and perceived behaviour control as key elements of adoption intention. However, there are other additional variables, such as financial resources and farmers' knowledge regarding the technology that could also influence their intention to adopt. All these factors are discussed below.

2.5.1: Personal attitudes

According to Ajzen (2002), personal attitude refers to the attractiveness of the proposed technology. That is, the degree to which the individual holds a positive or negative personal valuation regarding adopting mechanised maize-dryers.

The null hypothesis used to test this relationship was:

H₀₁: Personal attitude towards mechanised maize dryers will not have a positive influence on adoption intention of small-scale farmers in Kenya.

2.5.2: Subjective norms

The subjective norms variable measures the perceived social pressure from family, friends or significant others to adopt a particular technology (Ajzen, 1991). It refers to the perception that referents would approve of the decision to adopt (Ajzen, 2002), and is shown as a direct determinant of technology adoption intention in the TPB (Ajzen, 1991). This means that, with significant social influence and pressure, an individual would adopt a technology even if they were not in favour of it (Venkatesh and Davis, 2000).

Studies have shown mixed results regarding subjective norms as a predictor of adoption intention, while others have shown a significant relationship between subjective norms and intention (Davis et al., 1989; Mathieson, 1991; Chau and Hu, 2001; Lewis et al., 2003; Taylor and Todd, 1995; Venkatesh and Davis, 2000; Ramayah et al., 2003; 2004; Yulihastri, 2004; Chan and Lu, 2004).

The hypothesis used to test this relationship is:

Ho2: Subjective norms do not significantly influence the intention to adopt mechanised maize drying technologies among small-scale farmers in Kenya.

2.5.3 Perceived behavioural control (PBC)

Perceived behavioural control refers to the presence or absence of requisite resources and opportunities and the ease or difficulty of use of the technology (maize dryers in the present study) (Ajzen, 1991). Perceived behavioural control helps individuals to deal with situations that they may lack complete volitional control over (Ajzen, 2002). The performance of a particular behaviour (for instance adoption of agricultural technology) is correlated to the confidence of the individual in his or her ability to perform the behaviour (Ajzen, 1991).

Perceived behavioural control is based partly on past experience and partly on second-hand information through exchanges with family and friends (Ajzen, 1991). Research has shown that perceived behavioural control accounts for a considerable variance in intention and adoption, and that there is a positive relationship between perceived behavioural control (PBC) and intention (Mathieson, 1991; Taylor and Todd, 1995; Jen-Ruei et al., 2006). The higher the available resources are, the higher the individual's confidence in his or her ability will be, and the more likely the individual will be to adopt the technology. The hypothesis used to test this relationship was:

Ho3: Perceived behavioural control does not significantly influence the intention to adopt mechanised maize drying technologies among small-scale farmers in Kenya.

2.5.4: Availability of financial resources

As noted earlier, previous researchers did not consider the effect of economic factors such as farmers' financial resources, which may influence their intention to use a particular technology. The present study included financial resources in the TPB when measuring technology adoption intention. Technology adoption is an investment for farmers (Kinyangi, 2014), therefore the decision to adopt new technology represents a shift in a farmer's investment strategy, coupled with risks. Furthermore, the costs associated with technology adoption require that farmers invest a great deal of their resources to acquire it.

The elimination of subsidies for seed and fertilisers in the 1990s, due to the World Bank-sponsored structural adjustment programmes in sub-Saharan Africa, worsened farmers' financial constraints (Chidzonga, 1993; Bisanda and Mwangi, 1996; Nkonya et al., 1996; Akulumika et al., 1996). Moreover, the cost of hybrid grain production is more than double

the cost of the production of maize using traditional practices (Seboka et al., 1996). According to Getahun (2000), access to credit will relax farmers' financial constraints, enabling them to buy greater inputs.

According to El Oster and Morehart (1999), technologies that are capital-intensive are only affordable for wealthy farmers; farmers with financial constraints prefer cheap technologies that require low capital investment. Meinzen-Dick et al. (2004) suggested that a lot of care should be taken by key stakeholders while promoting technology adoption, to avoid technologies with a high investment requirement that smallholders cannot afford because they are poor and lack the necessary resources. Yet institutions that provide resources such as credit and insurance may provide a mechanism for the adoption and long-term use of technologies. These institutions should also provide facilities and mechanisms that enhance farmers' access to productive inputs and product markets. Crop insurance could, to some extent, lessen farmers' exposure to risks (Meinzen-Dick et al., 2004).

Norms, behaviours, and practices embedded in society could influence farmers' access to these financial resources, and thus could also encourage or discourage the adoption of a particular technology. For example, the practice that financial management is a preserve of the male members of society could limit female farmers' access to financial resources, thus having a negative impact on their adoption of agricultural technologies. This is cause for concern because women constitute the majority of rural farmers in Africa. An understanding of local cultural practices and preferences is thus important if women are to benefit from agricultural research (Meinzen-Dick et al., 2004).

Because it is difficult to collect reliable information on farmers' incomes, few studies have attempted to relate their income/financial resources to their adoption behaviour (Shahin, 2004). In the present study, it was expected that access to financial resources would increase the probability of farmers adopting technologies. Consequently, influence of financial resources was assessed using the following hypothesis:

Ho4: Financial resources do not significantly influence the intention to adopt mechanised maize drying technologies among small-scale farmers in Kenya.

2.5.5: Knowledge and adoption intention

Information is a crucial prerequisite in new technology adoption (Lambrecht et al., 2014), while the acquisition of this information is another factor that determines the intention to adopt.

Farmers need to learn of the existence and the effective use of technology. The decision to continue using an adopted technology comes before a period of learning to use it (Marra et al., 2002).

The availability and diffusion of important information about a technology, which informs the level of information campaigns and extension activities, are crucial in increasing awareness, but the demand for such information also plays a role (Lambrecht et al., 2014). Some farmers are more eager to learn than others, e.g. they may actively search for information about technologies and farming in general. More experienced and educated farmers may easily find information compared to illiterate ones, as will farmers with strong social networks and more social capital. Determining awareness and the need for information is an important first step in the analysis of technology adoption; disregarding this step may result in non-exposure bias in estimates of intention and subsequent adoption rates, programme impact, and determinants of adoption (Diagne and Demont, 2007).

Rates of adoption may be overestimated in cases where farmers actively engage in information searches by themselves, or when extension agents intensively target these groups of farmers. This is because in both cases, the research participant may want to show performance in the case of extension and reception in the case of farmers, which may not necessarily reflect on the ground. For instance, previous studies on the adoption of new rice varieties in Cote d'Ivoire and Ghana (Diagne and Demont, 2007) showed that adoption rates would increase greatly if awareness was increased, and that estimated effects of adoption determinants differ greatly, whether non-exposure bias is corrected or not. Interestingly, Kabunga et al. (2012) carried out a study in Uganda on the adoption of mineral fertiliser, but they did not find a link between determinants of awareness and actual adoption, or between potential adoption and actual adoption. They thought that the level of awareness would play a role, especially in a case where mineral fertilisers had recently been introduced.

The decision to try out a new technology does not imply a decision to continue to apply the technology. A number of studies suggest that adoption and continued use are driven by different factors altogether (Kijima et al., 2011; Barrett et al., 2004). For adoption and continued use, farmers need to have a deeper understanding of the modalities of application and the technical specifications beyond just being aware about the existence of the technology. Farmers need to understand the effect of the technology on yields, labour requirements, other costs and market prices. Caswell et al. (2001) indicated in their study that access to information reduces the

uncertainty about a technology's performance, and may change an individual's assessment from purely subjective to objective over time. However, farmers may perceive and evaluate technology differently to the way in which scientists do (Uaiene et al., 2009). Access to information may also result in farmers declining to adopt technology. The hypothesis used to test this relationship was:

Ho5: Knowledge does not significantly influence the intention to adopt mechanised maize drying technologies among small-scale farmers in Kenya.

2.6: Other factors

Besides the key factors stated above, other factors implicitly influence adoption intentions. These factors were, however, not pertinent enough to be included in the conceptual model.

2.6.1: Gender of the household head

Understanding norms surrounding gender and intention to adopt technologies is important. Several studies found that there are differences between men and women in their adoption intentions. Generally, the literature reports that men favour the use of certain technologies to a greater extent than women do. Women also experience greater anxiety with regard to technology, leading to negative perceptions (Keller et al., 2007).

There is also a strong association between the gender of the household head and the acceptance of technological recommendations. Results of a study by Bisanda and Mwangi (1996) in sub-Saharan Africa showed that male-headed households have more access to ownership of land, education, and information on new technologies. Women are mostly denied credit on the basis of lack of collateral, hence they cannot finance the purchase of post-harvest handling technologies such as mechanised maize drying, leading to low adoption rates (Mkandawire, 1993). Credit institutions should therefore be advised to refocus their lending rules to include women financing to enable them to afford these important facilities in farming (Mkandawire, 1993). In this study, in order to determine the contribution of gendered norms to technology adoption, farmers were asked to state whether they thought mechanised maize dryers could be used by both genders.

2.6.2: Age and education of the household head

The age and education level of the household head are factors that are correlated with the knowledge base of the farmers. The age of the household head relates to farming experience, which influences the way in which farmers approach new technologies by influencing the determinants of adoption intention, while educated household heads are more informed, and

are therefore more knowledgeable regarding the risks of new technologies. The age of the household head is a variable which has proven to be a significant driver of farmers' technology adoption intentions. Asiedu-Darko (2014) noted that age is an important factor that influences the probability of the adoption of new technologies, because it is a primary latent characteristic in adoption decisions.

Similarly, the educational level of a household head could potentially influence the intention to adopt maize drying technologies. According to Udoh (2009), an effective eight-year primary school education means an individual is able to read and write, at least in the local language, which will significantly influence his or her understanding of the machines, and, ultimately, adoption. Waller et al. (1998) and Caswell et al. (2001) argued that education creates a favourable mental attitude towards the acceptance of new practices, especially of information-intensive and management-intensive practices. According to Ehler and Bottrell (2000), education reduces the amount of complexity perceived in a technology, thereby increasing a technology's adoption.

According to Ehler and Bottrell (2000), one of the hindrances to the widespread adoption of mobile grain dryers as an alternative method to solar dryers is that they require greater technical understanding.

2.6.3: Farm size

Another key factor that influences technology adoption intention is farm size, which refers to the total land available to a farmer for agricultural production. This factor is a proxy for economies of scale and has an influence on the perceived behavioural control of farmers. Feder and Slade (1984) reported that the influence of farm size on technology adoption varies according to the type of technology and the setting of the local community (Parvan, 2010).

A study by Fuglie and Kascak (2001) on soil fertiliser testing, integrated pest management (IPM) and the diffusion of conservation tillage practices adopted by American farmers, focused on basic factors such as farm size. The findings indicated that farmers with larger farms were more likely to adopt technologies than their counterparts who had small pieces of land. Using a cross-sectional approach that involved using current data while also seeking to understand historical changes over time, the researchers were able to account for underlying dynamic influences in adoption, finding that differing rates of technology diffusion among regions

persist over time. Elsewhere, Besley and Case (1993) indicated the disadvantage of using recall data, which may force researchers to assume that exogenous factors do not change over time/are kept constant in the course of diffusion. But this may not be the case since other factors may actually change.

In a study conducted in Honduras by Neill and Lee (2001), farm size had a positive influence on the adoption of new technologies. It was revealed that farmers with larger farm had the ability to adopt fixed and more expensive technologies, as well as smaller and less expensive ones. They further observed that farmers with smaller farms adopted less capital intensive technologies in the beginning, before shifting to more expensive ones. This positive relationship between farm size and likelihood to adopt represents a significant problem for Managing Environmental Resources to Enable Transitions (MERET) to More Sustainable Livelihoods. The MERET programme targets poor households which have a higher risk of food insecurity and an inability to adopt important technologies that could move them out of poverty.

According to Awotide (2016), rice farmers with larger farms devote little of their land to the cultivation of improved varieties. On the one hand, this could be linked to the fact that some households do not want to experiment with new technologies on large farmlands because of uncertainty, but it could be due to the fact that farmers with large farms may want to maximise profit and are therefore more likely to practice multiple cropping. In this study, large farm size, as measured in acreage, was expected to positively influence adoption intention of maize drying technology. The farmers were thus asked to state the extent to which they agreed with the statement: “The size of my farm is large enough to allow use of mechanised maize dryers.”

2.7: The conceptual framework

A conceptual framework explains relationships between interlinked concepts and the connections between the variables under study (Ravitch and Riggan, 2012). Other key elements were added based on previous studies to the elements of the TPB, to form a hybrid conceptual model to investigate adoption intention of maize farmers in Kenya. The choice of a particular technique is influenced by variables related to personal attitudes, subjective norms, perceived behavioural control, financial endowment, and farmers’ knowledge. This conceptual framework therefore features five independent variables and one dependent variable, as shown diagrammatically in Figure 5.

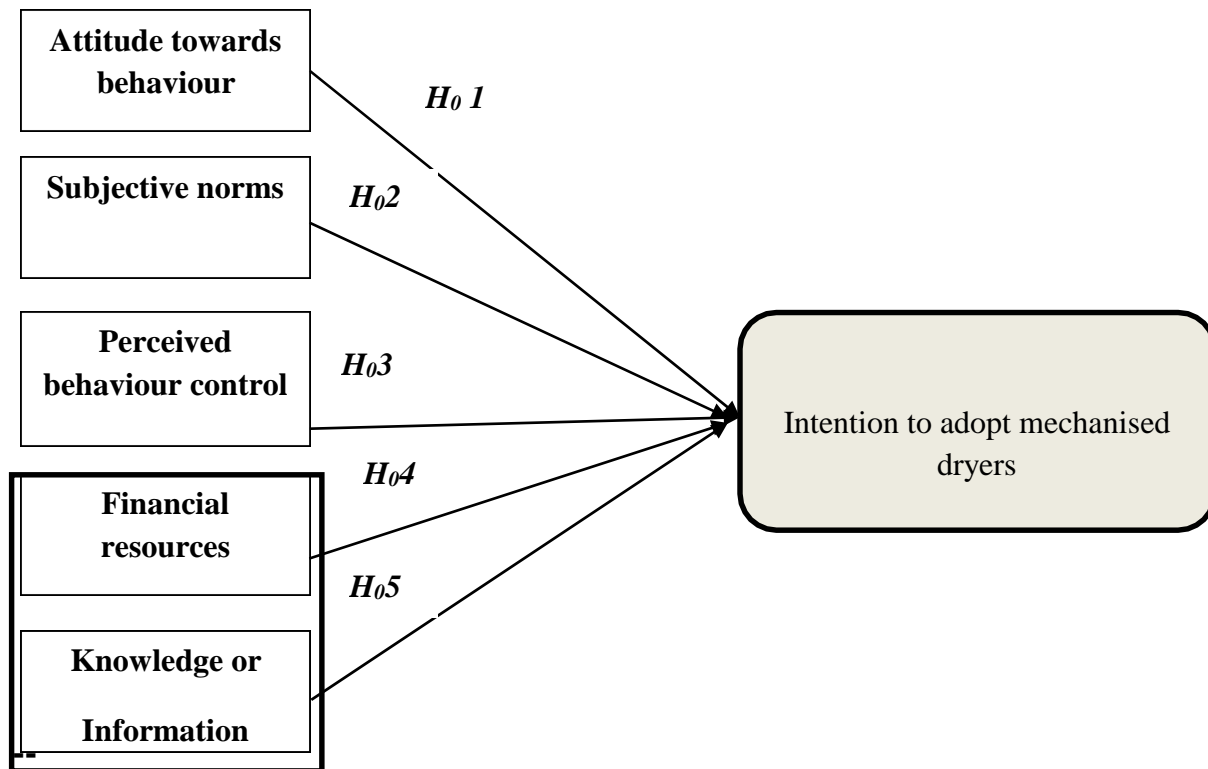


Figure 5: Conceptual framework showing interrelationships between key variables of the study

Source: Researcher’s own

2.8: Chapter summary

This chapter provided a theoretical analysis of intention to adopt mechanised maize drying technologies, including a critical review of the theories, which led to the identification of a gap in the literature. Theoretical literature based on prominent theories and models of farmers’ intentions, as well as empirical literature, presented strong evidence for the formulation of the hypothesised research models. The TPB formed the basis of this study. In this chapter, the meanings of concepts such as adoption intentions, personal attitudes, subjective norms, and perceived behavioural control, all of which underpin the TPB, were discussed in-depth. An empirical review of the theory was used to formulate a hybrid conceptual framework that includes the key constructs of the TPB and other socio-economic variables that influence farmers’ intentions to adopt agricultural technologies. Further, the hypotheses that were tested were presented, together with the conceptual framework with all five key variables.

CHAPTER 3: METHODOLOGY

3.1: Introduction

This chapter explains the methodology employed in collecting and analysing the data. The study area, research design, development of the research questionnaire, pilot study, technique used in identifying the target population, sample determination, data collection techniques, and analysis are discussed. The study relied on quantitative data that were collected in structured interviews using an interview schedule. This chapter explains the nature of the data, their sources and the various statistical techniques that were employed. Ethical concerns are also discussed.

3.2: Study area

Nakuru County, formerly known as Nakuru District, is among the 47 counties in Kenya formed after the promulgation of the new Constitution. The county lies within the Great Rift Valley, and receives adequate rainfall of approximately 1,270 mm per year to support different farming activities. The county covers an area of 1,392.55 km², and is located amid longitude 5° 28` and 35° 36` East and latitude 0° 13 and 1° 10`. The climatic conditions of the regions are considered suitable for both crop cultivation and animal keeping. The main crops grown in the region include maize and wheat. According to the Kenya National Population and Housing Census (2014), Nakuru's population was 1,867,461 as at 2009, but was expected to increase greatly in the future, indicating the need to produce adequate food (Center for Enhancing Democracy and Good Governance, 2014).

Nakuru County was chosen for this study as it is one of the main maize production regions in Kenya. Maize farmers in the region have suffered post-harvest losses related to chilly weather, and because the common practice of sun drying requires a lot of time and space. It is estimated that 40 percent of the grain grown in the county is lost due to poor post-harvest handling, mainly related to drying (EGSP, 2013). Aflatoxin, which thrives in wet conditions, has been a great concern to farmers; yet mechanical maize drying has not been popular in the region. Despite its numerous advantages, such as reduction in grain wastage, improved hygiene, and a reduction of aflatoxin, mechanical maize drying is rare. It was thus considered important to determine the drivers of intention to adopt mechanised maize drying technologies in the region.

3.3: Research design

A cross-sectional research design was applied in this research, whereby data were collected at one time from the small-scale farmers in Nakuru County. A research design is considered the blueprint for the collection, measurement, and analysis of data. According to Omair (2015), it is a plan used by researchers to connect conceptual research problems with empirical research. The research design indicates the type of data that will be required for a given study, the appropriate methods to collect the data, the required analyses, and how the information obtained can be used to answer the research questions (McNamara et al., 2016). The types of data and methods used in a study need to be effective for the purpose of reaching a firm conclusion.

Different aspects are taken into consideration when selecting the type of research design to use (Omair, 2015; Feuerriegel, 2016). The purpose of an inquiry may range from a desire to explore to a desire to describe, explain, predict, or evaluate. An exploratory design is normally used when the study area has limited research intervention to provide an explanation for the state of affairs. This design provides a ground-breaking intervention for future research about the subject matter (Saunders et al., 2012). The focus is on gaining insights and familiarity for later investigation, or when problems are in a preliminary stage of investigation. The goal is usually to provide familiarity with the settings, basic details and going concerns for follow-up research, and the end result is to suggest a direction for future research in the area of study.

The rationale behind the use of exploratory research for this study was because of its ability to describe data and the attributes of a study environment. This design is recognised for the provision of accurate and valid study variables, as dictated by research questions. Compared to explanatory research, it is considered to be more structured.

The data collected using this kind of research design include observations and experiences in the field (Cronholm and Göbel, 2016). To meet the objectives of this study, five hypotheses were formulated, which sought to provide an understanding of the relationship of the different variables with the intention to adopt mechanised maize drying technology by farmers. Correlation analysis was employed to establish cause-and-effect relationships.

3.3.1: Target population

Zhao et al. (2013) defined a target population as a group of people whom a researcher is interested in studying. The target population of any study should fit a particular specification,

based on the research topic. The present study sought to evaluate the factors influencing adoption intentions of mechanised maize drying technologies among small-scale farmers in Nakuru County, Kenya, therefore the target population was small-scale farmers in the region. According to the Government of Kenya (2009), the population of Nakuru County is approximately 1,867,461, of which 45.8 percent live in urban areas.

Research undertaken by Muhunyu (2008) indicated that Nakuru County has 296,451 farmers, who farm an average of between one and two hectares of maize and other crops such as potatoes, beans, and finger millet. Nakuru County was considered fit for the present study because it is one the highest producers of maize in the country.

3.3.2: Sampling

A sample must represent the population under study in order for the collected data and subsequent conclusions to be generalised to the entire population. A sampling frame is all the potential participants from which a sample is drawn (Kothari, 2004). In the present study, the sampling frame consisted of the 1,867,461 people living in Nakuru Country. Nakuru has many small-scale farmers who are engaged in maize farming, which provided an ideal opportunity to evaluate their intentions regarding the adoption of mechanised maize drying technologies.

3.3.3: Sample size and sampling procedure

This section presents the method used to determine the study sample size from which the data were collected, as well as the sampling techniques used.

3.3.4: Sample size

As stated, it is imperative that a sample be representative of the population (Keita and Gennari, 2014). Singh and Smarandache (2011) defined a sample as a portion of a population, which is selected for observation and analysis for the purposes of providing insight into the entire population. The present study employed a random sampling technique, as it was considered that it would yield a more representative sample than other measures (Kothari, 2004). The use of random sampling gave every individual in Nakuru County an equal chance of being selected to participate in the study. The researcher conducted the study on 400 small-scale maize farmers, and a formula adopted by Cochran (1963) was used to calculate the sample size:

$$n = N \left[\frac{1}{1 + N * e^2} \right]$$

where: n = sample size; N = population size; e = level of significance (5 percent).

To generate a representative sample size at the 95 percent confidence interval, the desired sample size was demonstrated using the following equation:

$$n = \frac{296451}{\left[1 + 296451 * 0.0025\right]}$$

$$= 399.5 \sim 400$$

$$n = 400$$

Therefore, the minimum amount of respondents for the present study was 400 individuals of the target population of 1,603,325 residents. The respondents were selected from the 11 sub Counties of Nakuru from a list of farmers provided by the county ministry of agriculture. The entire county formed the sampling frame since maize production is largely practiced across the County.

3.3.5: Data-collection instruments

To achieve reliability, researchers are required to use tools that yield accurate data that can be used to draw conclusions. The present study used primary data, which were obtained using survey questionnaires and one-on-one interviews. According to Von Leupoldt et al. (2017), questionnaires administered in a one-on-one interview offer numerous advantages over administered questionnaires.

The present study's target population was farmers whose literacy levels were quite low, and most did not understand English. The questionnaire administered during the interviews provided an opportunity for the researcher to engage with the interviewees and interpret the questions in their preferred language, which in most cases was Kiswahili, the national language. Some of the attributes that make researchers consider using a questionnaire in data collection include the fact that it preserves user anonymity, it is scalable, it can be used to capture data for a large number of recipients, and it can cover all aspects of a subject. The benefits of using interviews include the fact that the researcher can obtain detailed information about personal feelings, perceptions, and opinions. Interviews allow the researcher to ask more detailed questions, and they usually achieve a high response rate. Furthermore, respondents' own words are recorded, avoiding misrepresentation (Hamza, 2014).

Due to the large sample that had to be interviewed, the researcher contracted two experienced

research assistants with a good command of the language to assist with the data collection. The researcher trained them for a week on her research expectations in order to reduce random and systematic errors due to interviewer mistakes and non-standardised survey implementation across interviews. The researcher also undertook 50 interviews while the assistants observed, to ensure that they understood the required interview procedures.

One of the risks that the use of a single questionnaire instrument poses is Common Methods Bias (CMB). According to Podsakoff (2012), CMB occurs when variations in responses are caused by the instrument, rather than the actual predispositions of the respondents that the instrument attempts to uncover. The questionnaire used by the researcher did pose this risk, as the researcher used one questionnaire to capture data on both the dependent and the independent variables. The researcher mitigated this risk by having the data assistants help to administer the questionnaires, and basic observations made in the field were used to prompt farmers where necessary. The assistants also discussed subjects unrelated to the questionnaire content to give the interviewees a break during the interview, as a way of mitigating CMB (Podsakoff, 2012).

The survey questionnaire was developed in line with the conceptual framework and the research hypotheses. The questionnaire consisted of two sections; the first collected the demographic information of the respondents, and the second measured the dependent variable (intention of farmers to adopt mechanised dryers). The five-point Likert scale used to measure these items ranged from: 1 = Not at all, to 5 = To a very large extent.

For the purpose of clarification, the survey questionnaire gave a brief description of mechanised maize dryers, together with a pictorial representation. Secondary data were obtained from published materials such as books, journals, and government reports, among other relevant sources.

3.3.6: Measurement of the variables

The independent variables measured in the questionnaire (see Appendix I) were: personal attitude, subjective norms, perceived behavioural control, financial resources and education level.

Personal attitude was measured by means of five items: ‘Using the system increases maize productivity’, ‘I need to try using a mechanised dryer first’, ‘Mechanised drying is not convenient’, ‘Mechanised drying does not suit my farming activities,’ and ‘I like mechanised

maize dryers'. Farmers were then asked to state the extent to which they agreed with the statement on the Likert scale.

Subjective norms was measured by asking the respondents the question: 'Do you think your relatives would allow you to use mechanised maize drying technologies?' Farmers were asked to answer using the Likert scale.

Perceived behavioural control was measured by asking the respondents to respond to two statements: 'Mechanised maize drying technology is too difficult to use' and 'Usage of this technology will depend entirely on me', on the Likert scale.

Financial resources was measured through four items: 'I have enough money to purchase a mechanised dryer', 'It is difficult to get loans from the bank', 'The mechanised maize dryers incur high running costs,' and 'Mechanised maize dryers are expensive to buy'. The farmers were asked to indicate the extent to which they agreed with the statements on the Likert scale.

Farmer's knowledge was measured by four items: 'I am aware that mechanised drying technologies exist', 'I can read to educate myself on post-harvest management practices, due to my level of education', 'I understand the costs and benefits of mechanised dryers', and 'I understand how mechanised dryers work'. The farmers were asked to indicate the extent of their agreement with the statements on the Likert scale.

The age brackets of the farmers were measured by asking them to indicate where they belonged among the following age categories: Below 25; Between 26 and 35; Between 36 and 45; and Above 45 years.

To collect information about the gender of the farmers, a binary variable gender, whereby farmers were asked to indicate their gender, was used, with one representing male and zero representing female.

Regarding the education levels of the farmers, a categorical variable was used whereby farmers indicated the category of their level of education. The categories provided included a technical level, which is usually a low level of education whereby farmers attend community polytechnics for apprenticeships. This is meant to equip them with skills such as carpentry, farming induction, masonry, plumbing and rural electrification. Another category was a diploma level, whereby farmers attain some form of specialisation after secondary school. The

third category was a bachelor's degree. These three levels were identified during the pre-test and adopted for this study, since the majority of the farmers fell within these categories.

Farm tools were also an important variable to be considered as an indicator of the level of mechanisation by farmers. Similarly, a categorical variable was used with four levels, beginning with ownership of a phone for communication, a tractor, a chisel and a harrow.

Farm size was measured using two categories, in which most of the farmers fell. These were below five acres and between five and 20 acres.

House type was measured by asking about the types of houses the farmers lived in, in terms of either permanent or temporary structures. Temporary structures included those made of mud walls, wood, and grass, while permanent structures included those made of concrete or stones, bricks and ballast.

Farming experience was determined by asking how many years the farmers had engaged in maize farming. The categories included less than five, five to ten, 11 to 15, and more than 15 years. Table 1 indicates the variables used in the analysis.

Table 1: Description of Variables

Variable	Description
Dependent variable Adopt	Extent to which farmer intends to use maize dryers (1=Not at all, 2=To a small extent, 3=To a moderate extent, 4=To a large extent, 5=To a very large extent)
Independent variable	
Knowledge	Access to information
Finance	Financial resources constraints
Norms	Norms associated with use of the technology
Perceived behavioural control (PBC)	Perceived behavioural control
Attitude	Personal attitude of the farmer
Age	Age bracket in years
Gender	Binary variable with 1=male 0=female
Education level	Categories 1=technical, 2 diploma, 3=bachelor's degree
Assets	Ownership of tools 1=phone, 2=chisel, 3=harrow, 4=tractor

Farm size	Category of farm size, 1=below 5 acres and 2=between 5 and 20 acres.
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3.3.7: Pilot study

To test the validity and reliability of the data collection instrument, a pilot study using the test-retest method was done. The pilot study was used to identify deficiencies in the design, which were corrected before project resources were expended. Research reliability and validity are important to determine whether the relationships shown in the conceptual framework are valid. According to Hertzog (2008), one percent of the sample size is adequate for a pilot study. For the present study, 20 farmers from one of the divisions of the county, which was equivalent to 5 percent of the sample size, were selected for the pilot study. One week later, the same participants were requested to respond to the same questionnaires, to investigate any variation in the responses between the first and second tests.

3.3.8: Validity

Validity, as defined by Panc (2015), indicates the accuracy of research data and the extent to which the data collection methods employed are useful. One of the steps undertaken by this researcher to ensure the face validity of the instrument was to develop the questions after a thorough analysis of literature regarding adoption intentions among smallholder farmers in Kenya and other countries, thereby ensuring that the questions measured the intended aspects. The researcher also ensured clarity and ease of understanding of the questions. To ensure content validity, the researcher engaged three experts on the subject to seek their views on the questions and their appropriateness for measuring the various variables.

3.3.9: Reliability

Reliability indicates the stability of the data, suggesting that the data collection technique employed in a study will offer the same results in repeated trials (Tresoldi et al., 2015).

The researcher used the test-retest method to test the reliability of the instrument. The researcher conducted 50 interviews with smallholder farmers, and repeated the interviews again with the same interviewees one week later. Statistical tests conducted before and after the interviews, using Pearson's correlation co-efficient, revealed a coefficient of 0.75, indicating a strong relationship between the first and second rounds of responses. Items in the Likert scales were also explained thoroughly, giving different levels to indicate the magnitude of rejection or acceptance.

The researcher also made sure that, where the respondents seemed not to understand a question due to their literacy levels, it was repeated and an explanation was provided, ensuring that all respondents understood the questions. The researcher undertook 50 interviews together with the assistants prior to data collection, to ensure that they understood the questions and would be able to ask the questions correctly. Once they had begun collecting the data, the researcher joined them for a few more interviews, as an observer, to ensure that they were being consistent.

The researcher conducted a pilot study of 50 interviews before beginning the data collection process. Feedback received, which was incorporated into the edited questionnaire, included the need to simplify the language further to ensure ease of understanding. The questionnaire was also too long, so the researcher reduced the number of questions and the order of the questions so that the interviews started with easier questions to create a rapport, followed by more detailed questions. Wordings were amended and further explanations and examples were provided for questions where the explanations were insufficient.

3.3.10: Data collection procedure

The purpose of data collection is to gather information that can be used for accepting or rejecting a study's hypothesis (Axinn and Pearce, 2006). The method used for data collection must take the nature of the required data into account. Both primary and secondary data were used for this study. Primary data were collected via questionnaires administered during an interview, as well as through observation. Most of the farmers spoke Kiswahili, which is the national language, therefore the researcher and the research assistants translated the questions into Kiswahili.

3.4: Challenges encountered in data collection

The researcher experienced a few challenges in the data collection with translation to the local dialects for farmers who did not understand basic Kiswahili and English. Nakuru is a multicultural region with over 42 tribes residing in the county, but the majority of farmers were conversant with the two main languages. For this reason, the language barrier, although experienced, was not a major problem. One other notable challenge was with the estimation of the size of farms, especially amongst female respondents who did not have accurate information about their land size.

3.5: Data analysis

The data were analysed using quantitative methods such as inferential statistics. An analysis of survey data was processed through manual editing and coding on SPSS software, and was

eventually analysed using both SPSS and STATA. For the descriptive results SPSS was used but a rigorous estimation of the factors that influence adoption intentions was done using STATA in the ordered logit regression analysis.

The actual analysis was done in three main phases. The first involved descriptive statistics of frequency, using STATA as the analysis tool to establish the characteristics of the respondents. The results are presented in tables, charts, and graphs. The second phase involved correlation analysis to determine the linear dependence between the variables. The results are presented in a correlation matrix. The third phase was use of the ordered logit model to establish the relationship between the independent variables on the dependent variable.

For the variables of TPB which had sets of Likert questions, Principal Component Analysis was used to condense the set of questions into a set of indices that were exported to the ordered logit regression analysis. Multivariate statistical techniques have been widely used in farm technology adoption studies (Guto et al., 2010), particularly when an in-depth database is available. As a multivariate analysis tool, PCA is a convenient way to reduce high dimensional data into a smaller number of components. PCA has been referred to as a data reduction/compression technique (dimensionality reduction), and is an effective factor reduction technique for reducing an original large set of variables into a cluster of heterogeneous sets of variables. PCA was performed on a set of Likert questions used to measure farmers' views on the items used in the Theory of Planned Behaviour. The standardised sets of questions were condensed into an index that was used in the regression analysis (Abdi, 2007). The index corresponded to the component scores that were exported to other statistical units by simple linear regression. The index corresponds to the component scores that were exported by simple linear regression, whereby Y is the component score and X is the variable being reduced in the principal component analysis. Table 2 shows the hypotheses together with the relevant statistical tools used for analysis.

Table 2: Summary of data analysis

Hypothesis	Variable	Statistical tool
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H ₁ : Personal attitude significantly influences the intention to adopt mechanised maize drying technologies among small-scale farmers in Kenya.	Personal attitude - Suitability - Convenience - Trialability - Increased productivity - Likability	Correlation analysis Regression analysis
H ₂ : Subjective norms significantly influence the intention to adopt mechanised maize drying technologies among small-scale farmers in Kenya.	Subjective norm - Acceptance of technology by relatives - Usability across gender	Correlation analysis Regression analysis
H ₃ : Perceived behavioural control significantly influences the intention to adopt mechanised maize drying technologies among small-scale farmers in Kenya.	Ease of operating the drying machinery	Regression analysis Correlation analysis
H ₄ : Availability of financial resources significantly influences the intention to adopt mechanised maize drying technologies among small-scale farmers in Kenya.	Financial resources - Cost of product - Running costs - Access to credit	Correlation analysis Regression analysis
H ₅ : Knowledge of the farmer significantly influences the intention to adopt mechanised maize drying technologies among small-scale farmers in Kenya.	Knowledge - Awareness - Access to information - Ability to read and learn	Regression analysis Correlation analysis

The third phase was conducted using the ordered logit model, where each of the hypothesised exogenous variables was predicted to influence farmers' intention to adopt new technologies. The ordered logit model is used when the response variable is categorical and has some meaningful ordering. In this study, the farmers were asked if they intended to use mechanised maize dryers. The dependent variable was ordered on a scale ranging from 1 (Not at all) to 5 (To a very large extent). In order to model the intention to use technology as a function of a set explanatory variable, the researcher used the generalisation of the binary-choice framework, known as the ordered logit estimation technique (Fullerton, 2009). Consider an index model for a single latent variable Y^* where:

$$y_i^* = x_i' \beta + v_i \epsilon_i$$

$$y_i = j \text{ if } \alpha_{j-1} < y_i^* \leq \alpha_j \dots\dots\dots ii$$

The probability that the observation i will select alternative j is:

$$p_{ij} = p(y_i = j) = p(\alpha_{j-1} < y_i^* \leq \alpha_j) = F(\alpha_j - X_i' \beta) - F(\alpha_{j-1} - X_i' \beta) \dots\dots\dots iii$$

The ordered logit model generalises the notion of multiple thresholds. We cannot observe y^* directly, only the range within which it falls. The observed choice might reveal only an individual's relative preference. For the ordered logit, F is the logistic cumulative density function, expressed as:

$$F(z) = \frac{e^z}{1 + e^z}$$

The parameters to be estimated are a set of coefficients β corresponding to the explanatory factors in x , as well as a set of threshold values $I-1$ corresponding to the I alternatives. Larger values are taken to correspond to higher outcomes. If there are I possible outcomes, a set of threshold coefficients or cut points $(\alpha_1, \alpha_2, \dots, \alpha_{I-1})$ are defined, where

$\alpha_0 = -\infty$ and $\alpha_I = \infty$. The ordered logit model with j alternatives will have one set of

coefficients with $(j-1)$ intercepts. An ordered choice model is characterised by the multiple intercepts. In the interpretation of the coefficients, the sign of the parameters shows whether the latent y^* variable increases with the regressor, and vice versa. The ordered logit model

with j alternatives will have j sets of marginal effects. The marginal effect of an increase in a regressor on the probability of selecting alternative j is:

$$\frac{\partial p_{ij}}{\partial x_r} = F'(\alpha_{j-1} - x_i' \beta) - F'(\alpha_j - x_i' \beta) \beta_r$$

where the sum of the marginal effects of each variable on the different alternatives is zero. The interpretation of the marginal effects is such that each unit increase in the dependent variable increases/decreases the probability of selecting alternative j by the marginal effect, expressed as a percent relative to the base category. The reduced form equation that was estimated in this study is as follows:

$$Adopt = \alpha_0 + \beta_1 Attitude + \beta_2 SubjectiveNorms + \beta_3 PBC + \beta_4 Finance + \beta_5 Knowledge$$

The dependent variable was Adopt, which refers to the respondents' intention to adopt mechanised maize drying technologies, while the independent variables were knowledge, availability of finances, subjective norms, perceptions, and personal attitudes. These variables

were hypothesised to influence the intention to adopt mechanised technologies.

3.6: Correlation analysis

A correlation analysis is an opportunity to foretell results and explain the relationship among variables (Creswell, 2008). During correlation, no attempt is made to control or manipulate the variables like in experimental analyses; the correlation statistic is used to describe and measure the degree of a relationship between two or more variables or sets of scores (Creswell, 2008). Typically, the individual or small group of individuals being examined possess some skill or have an unusual problem.

Pearson's correlation is a test of the strength of association between two variables in a model. Strong positive correlations have values of 0.5 to 1.0, while strong negative correlations have values of -1.0 to -0.5. Below strong correlations follow medium correlation, weak correlation, and no correlation. The correlation analysis is also used to detect the level of multicollinearity. If two independent variables have a strong correlation, say above 0.8, then it becomes difficult to assess which variable is actually responsible for explaining some of the changes in your dependent variables (intention to adopt). This is because the level of multicollinearity is high.

3.7: Ethical considerations

Ethics encompass the norms or standards in distinguishing between what is right and wrong. Ethics play a significant role in any research (Patel et al., 2016), and include the behaviour of the researcher. The integrity, reliability, and validity of research rely heavily on ethical principles. Stakeholders in a research project need to be assured that the research project follows ethical guidelines, such as observing human rights, complying with the law, addressing matters associated with conflict of interests, and safety precautions, among other considerations. The manner in which researchers handle the various ethical concerns has a significant influence on the integrity of the research project. Furthermore, the handling of the ethical concerns has an impact on the community's perception of the research, which will affect their participation.

A major ethical consideration is to protect the participants from harm (Lacey et al., 2016); a researcher needs to respect their decisions and dignity, minimise risk, and maximise the benefit of the participants. The researcher should also select respondents from a target population that will give relevant information about the objectives of the study.

An Institutional Review Board (IRB) ensures that human rights are not violated during a research project. One of the strategies the researcher considered to prevent unethical behaviour

included reviewing the research methodology to ensure that ethical practices were observed (Engels et al., 2011). While checking against human rights violation, IRB also protects institutions and researchers against potential legal implications of actions that may be considered unethical by other stakeholders, by preventing such actions.

Other important ethical aspects the researcher has taken into account for this study include making respondents aware that participation in the research was voluntary, and that they could cease participation at any point without negative consequences. The respondents were also fully informed about the aims and procedures of the survey, as well the study's purpose, intent, motivation, potential use of the data, and the methods of data collection. The introduction further clarified the issue of confidentiality, which is a primary concern in any study. The respondents chosen for the study were also eligible; for this study, the respondents had to have lived in Nakuru County for the previous planting season, be a small-scale farmer, and be over 18 years of age.

3.8: Chapter summary

This chapter explained the methodology employed in the study, the research design, the data collection, and the analyses. The chapter further indicated why the researcher chose Nakuru County as the target population, indicating that it is among the regions in the country recognised for high maize production. The chapter emphasised the need for researchers to ensure validity and reliability, and the ethical considerations were discussed.

In the next chapter, both the descriptive and econometric results are presented. These are the result of rigorous data collection, cleaning and analysis to generate meaning from the raw data.

CHAPTER 4: FINDINGS

4.1: Introduction

This chapter presents the study findings regarding factors that influence the adoption intention of mechanised maize drying technologies among small-scale farmers in Nakuru County. This section is divided into three sub-sections. The first sub-section presents the results of the descriptive statistics in terms of age, gender, household size, educational level, house type, farm size, type of assets and maize farming experience. These results are presented in the form of frequency distributions in table format. Here, frequencies and percentages are used for all categorical variables. The second sub-section presents the results of the correlation analysis, which also indicate whether there is serious multicollinearity or not. The third sub-section presents the results of the regression analysis in response to the study hypotheses. The results are based on the ordered logit model.

4.2: Results

4.2.1: Response rate

A total of 400 respondents were targeted in this study, of which 396 completed the questionnaires, representing a 99 percent response rate. The high response rate is likely attributable to the level of training offered to the enumerators and the supervision structure. Furthermore, using interviews to gather information, rather than leaving the questionnaires with the respondents to complete, contributed to the high response rate. The rapport between the participants and the researcher and assistants helped the farmers to be at ease during the data-collection process. The use of Kiswahili as the language of communication aided this rapport and enhanced the accuracy of the data collected.

4.2.2: Demographic characteristics of small-scale farmers

Table 3 presents the results of the demographic characteristics of the farmers. The respondents were evenly distributed by gender, with 46 percent men and 54 percent women. Most of the respondents were household heads (84 percent). Of the respondents, 38 percent were aged 36–45 years, 31 percent were aged 26–35 years, and 21 percent were older than 45 years. Only 10 percent of the respondents were younger than 25 years.

Table 3: Descriptive statistics for gender, age, and household head

Variable	Response	Number	Percentage
Gender	Female	214	53.90
	Male	182	46.09
Age (years)	Below 25	39	9.82
	26–35	124	31.23
	36–45	149	37.53
	Above 45	85	21.41
Household Head	Yes	333	84.09
	No	63	15.91

A total of 80.85 percent of the farmers held a technical qualification having attended a polytechnic, 16 percent held a diploma, and 3 percent held a bachelor’s degree, as presented in Table 4. This implies that the majority of the farmers in the study area were not well educated.

Table 4: Descriptive statistics for education level and house type

Variable	Response	Number	percentage
Education level	Technical	321	80.85
	Diploma	65	16.37
	Bachelor’s degree	11	2.77
House type	Temporary	38	35.18
	Permanent	70	64.81

The findings indicate that most of the farmers lived in permanent houses (65 percent), while 35 percent lived in temporary housing. Despite the fact that most of the respondents owned permanent houses, which is an indication of better living standards, less than 5 percent had appropriate farming tools such as chisels, harrows and tractors, which are vital to farming. This is an indication that small-scale farmers in the study area lack the equipment and technologies needed to ensure maximum utilisation of their farms. This also shows that most small-scale farmers rely on manual labour as opposed to using equipment that would make working on their farms easier.

Regarding the size of their farms, most respondents (95 percent) farmed less than five hectares (see Table 5), however they seemed to treasure communication, as 95 percent owned mobile phones. Other than their personal communications, these phones could be used to access information on farm inputs and markets.

Table 5: Descriptive statistics for farm size, assets, and maize farming experience

Variable	Response	Number	Percentage
Farm size (acres)	5–20	20	5.05
	Below 5	376	94.95
Assets	Phone	364	92.85
	Tractor	3	0.76
	Chisel	12	3.06
	Harrow	3	0.76
Maize farming experience (years)	Less than 5 years	15	3.77
	5–10	47	11.83
	10–15	60	15.11
	More than 15	275	69.26

Most of the farmers had considerable experience in maize farming; the majority (69 percent) had more than 15 years of experience, 15 percent had 10–15 years’ experience, and less than 4 percent had been farming for less than five years.

4.2.3: Intention to adopt mechanised maize drying technologies

First, the researcher asked the farmers whether they had used a mechanised maize dryer before. As shown in Table 6 below, most (95 percent) indicated that they had not.

Table 6: Respondent has used a mechanised maize dryer before

Response	percentage
Yes	5.18 percent
No	94.82 percent

The respondents were also asked whether they had plans to use a mechanised maize dryer in the future, but most (69.02 percent) did not. Only 13 percent agreed to a very large extent that they had plans to use one in the future. Other than exposure, there could be other factors that made the farmers reluctant to adopt the technology. This could indicate that they were either sceptical about the efficacy of the machines or just had a lack of financial ambitions, as these machines seemed very expensive to most of the farmers.

Table 7: Intention of respondents to adopt maize drying technologies

Extent of adoption intention	Had planned to use	
Responses	Freq.	percentage
Not at all	274	69.02
To a small extent	19	4.79
To a moderate extent	25	6.3
To a large extent	28	7.05
To a very large extent	51	12.85
Total	397	100

4.3 Descriptive results of independent variables

4.3.1: Personal attitudes among small-scale maize farmers and their intention to adopt mechanised maize drying technologies

The sampled farmers were asked about their perceptions regarding the adoption of mechanised maize drying technologies, using the statement “I like mechanised dryers”. As indicated in Table 8, only 5.04 percent of farmers did not agree at all with the statement, 37.78 percent agreed to a moderate extent, and 21.91 percent agreed to a large extent. Regarding whether they thought these technologies were not convenient for them, 5 percent did not agree at all and 3.53 percent agreed to a moderate extent. Interestingly, the majority of farmers agreed to a very large extent (56.42 percent) that the technologies are not convenient for them. Similarly, 58.9 percent of farmers also thought that these technologies do not suit their farming

operations. This was an interesting finding, as it suggests that, despite the farmers liking these technologies, they did not think they were convenient or suited their farming operations. Only 3.02 percent did not agree at all that the technologies do not suit their farming operations, however 58.94 percent agreed to a very large extent that these technologies do not suit their farming operations. Perhaps this is due to their low scale of production and the considerable costs involved in acquiring these technologies.

Table 8: Intention of respondents to adopt maize drying technologies based on personal attitudes

Extent of adoption intention	I like mechanised dryers		Convenient to my farming technique		Maize drying technology suits my farming		Using the system increases productivity	
	Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent
Responses								
Not at all	20	5.04	21	5.29	12	3.02	99	24.94
To a small extent	30	7.56	35	8.82	103	25.94	40	10.07
To a moderate extent	150	37.78	14	3.53	12	3.02	80	20.15
To a large extent	110	27.71	103	25.95	36	9.07	86	21.66
To a very large extent	87	21.91	224	56.42	234	58.94	92	23.17
Total	397	100	397	100	397	100	397	100

The opinions of the sampled farmers varied the most regarding whether they thought using mechanised drying has an effect on productivity. A total of 23.17 percent were strongly convinced that using the system would increase productivity, while 20.15 percent were moderately convinced that it would. This implies that some farmers were not sure whether such technology would yield a significant increase in productivity, because they had not tried it.

4.3.2: Subjective norms of small-scale maize farmers and intention to adopt mechanised maize drying technologies

The farmers were asked whether they thought their relatives would allow them to use these technologies, and whether they thought the technologies were usable by both genders.

The results in Table 9 indicate that the majority of farmers (50.38 percent) thought their relatives would let them to use these technologies, i.e. these technologies were acceptable in their society. Only 3.78 percent did not agree at all with the statement. However, these farmers seemed to believe that a particular gender would not easily be able to use these technologies; 37.78 percent did not agree at all that the technologies were usable by both genders.

Table 9: Intention of the respondents to adopt maize drying technologies based on subjective norms

Extent of adoption intention	My relatives could allow me to use it		Usable by both genders	
	Freq.	Percentage	Freq.	Percentage
Not at all	15	3.78	150	37.78
To a little extent	20	5.04	110	27.71
To a moderate extent	72	18.14	60	15.11
To a large extent	90	22.67	32	8.06
To a very large extent	200	50.38	45	11.34
Total	397	100	397	100

4.3.3 : Perceived Behavioural Control of small-scale maize farmers and intention to adopt mechanised maize drying technologies

In terms of whether the farmers thought their farms were large enough to allow mechanisation, the majority did not agree at all. A total of 54.16 percent were strongly convinced that their farms were not of a size that would allow mechanisation, and only 5.29 percent agreed to a

large extent that they had farms large enough to allow mechanisation. This seemed to echo the earlier finding that farmers did not agree that mechanised maize drying technologies would be convenient to them. It is also worth noting that 40 percent of the farmers did not agree at all that it would be easy to use mechanised maize drying systems, while another 16.88 percent agreed to a moderate extent that they could easily use them. Less than 3 percent of the respondents agreed to a large extent that using the systems would be easy (Table 10).

Table 10: Intentions of respondents to adopt maize drying technologies based on Perceived Behavioural Control

Extent of adoption intention	The size of my farm is large enough to allow the use of mechanised maize dryers		Mechanised maize drying technology is not difficult to use	
	Responses	Freq.	Percentage	Freq.
Not at all	215	54.16	159	40.00
To a small extent	80	20.15	110	27.71
To a moderate extent	60	15.11	67	16.88
To a large extent	11	2.77	51	12.85
To a very large extent	21	5.29	10	2.52
Total	397	100	397	100

4.3.4: Financial resources of small-scale maize farmers and intention to adopt to mechanised maize drying technologies

The respondents were asked questions related to their financial resources, to which they had to reply according to a five-point Likert scale. As shown in Table 11, most of the respondents (97.98 percent) agreed to a very large extent that mechanised maize dryers were expensive to buy, while 0.25 percent agreed to a large extent that they were expensive. None of the respondents moderately agreed that the cost of the mechanised dryers was fair. In addition to the cost of purchasing mechanised dryers, most respondents (90.68 percent) agreed to a very large extent that these technologies involve high running costs. Only 3.78 percent did not agree at all that maintenance costs were high.

Acquisition and maintenance costs did not seem to be the only financial concerns of farmers in Nakuru County, as they also reported barriers to accessing credit facilities. Over 90 percent of

the respondents agreed to a very large extent that obtaining credit was very difficult. Interestingly, as with the perceived cost of dryers, only 3 percent of the farmers thought it was not at all difficult to access credit facilities through banks. The majority of farmers (88.16 percent) indicated that they did not think they had enough money to purchase a mechanised maize dryer, agreeing to a very large extent.

Table 11: Financial resources of small-scale maize farmers and their intention to adopt mechanised maize drying technologies

Extent of adoption intention	The mechanised maize dryers are expensive to buy		Mechanised maize dryers incur high running costs		It is difficult to get loans from the bank		I don't have enough money to purchase a mechanised dryer	
	Freq.	Percentage	Freq.	Percentage	Freq.	Percentage	Freq.	Percentage
Not at all	1	0.25	15	3.78	12	3.02	12	3.02
To a small extent	6	1.51	6	1.51	1	0.25	10	2.52
To a moderate extent	0	0.00	5	1.25	12	3.02	11	2.77
To a large extent	1	0.25	11	2.77	15	3.78	14	3.52
To a very large extent	389	97.98	360	90.68	359	90.57	350	88.16
Total	397	100	397	100	397	100	397	100

4.3.5 : Knowledge of small-scale maize farmers and their intention to adopt mechanised maize drying technologies

The findings for 'knowledge' are shown in Table 12. From these findings, it was evident that most farmers (90 percent) had little or no knowledge of how the mechanised dryers work, with only 1 percent of the farmers being absolutely sure they understood how the technology works. The farmers were also asked if they understood the costs versus the benefits of the maize dryers. As shown in Table 12, most farmers (83 percent) indicated that they had no understanding whatsoever, and 6 percent agreeing to a very large extent that they had a high level of understanding of the costs versus the benefits. Surprisingly, most of the farmers (95 percent) mentioned that they could not read to enlighten themselves on post-harvest management practices, due to their low level of education; this despite the fact that over 80 percent had indicated that they held at least a technical level as their highest level of education. Regarding whether they were aware of maize drying technologies, 62 percent suggested that they had no such knowledge, 25 percent were aware only to a small extent and 3 percent were only moderately aware. Only 5 percent of the farmers were fully aware of the technology (percent agreed to a large extent and 5 percent to a very large extent).

Table 12: Farmers' responses to knowledge questions

Extent of adoption intention	I understand how mechanised dryers work		I understand the costs and benefits of mechanised dryers		I can read to educate myself on post-harvest management practices		I am aware that mechanised drying technologies exist	
	Freq.	Percentage	Freq.	Percentage	Freq.	Percentage	Freq.	Percentage
Not at all	360	90.68	333	83.78	380	95.71	247	62.22
To a small extent	4	1.00	26	6.68	4	1.00	100	25.19
To a moderate extent	7	1.76	13	3.35	5	1.26	12	3.02
To a large extent	22	5.54	0	0.00	0	0.00	16	4.03
To a very large extent	4	1.00	25	6.19	8	2.02	22	5.54
Total	397	100	397	100	397	100	397	100

4.4: Correlation analysis for the relationships between the independent variables

The relationships between the independent variables were analysed using correlation analysis and an ordered logit model. Table 13 presents the results of the correlation analysis between the variables. According to the results, there was a strong relationship between knowledge and financial resources and between knowledge and personal attitude of the farmer. Another strong relationship was between subjective norms and perceived behavioural control. Age and knowledge and age and attitudes were also correlated. Finally, there was also a strong correlation between educational level and finance. However, the results of the correlation analysis presented in Table 12 indicate that there was no serious multicollinearity among the independent variables checked. This allowed the use of the variables in the subsequent regression analysis to establish whether these variables influence adoption intention of the small-scale farmers.

Table 13: Correlation analysis of the variables used in econometric analysis

Variables	Knowledge	Finance	Attitude	Norms	Perceived behavioural control	Age	Gender	Education level	Farm assets	Farm size
Knowledge	1.000									
Finance	0.52*	1.000								
Attitude	0.40**	-0.198	1.000							
Norms	0.123	0.1410	0.163	1.000						
Perceived behavioural control	0.453	0.312	0.143	0.38***	1.000					
Age	0.32*	0.25	0.42*	0.38	0.24	1				
Gender	0.12	0.11	0.23	0.27	0.19	0.11	1			
Education level	0.62	0.57*	0.14	0.27	0.15	0.48	0.09	1		
Farm assets	0.37	0.52	0.21	0.18	0.21	0.41	0.22	0.51	1	
Farm size	0.29	0.24	0.12	0.14	0.21	0.31	0.19	0.34	0.26	1

*** Significant at 1 percent level; ** Significant at 5 percent level; * Significant at 10 percent level

4.5 : Regression analysis

The ordered logit model was used to evaluate the relationship between the dependent variable and the independent variables, as per Table 14. First, Principal Component Analysis (PCA) was used to generate indices for the variables personal attitude, subjective norms, perceived behavioural control, financial resources, and knowledge. The likelihood ratio chi-square of 356.75 and a p-value of 0.0001 showed that the ordered logistic model used was statistically significant, that is, it fit significantly better than a model with no predictors. Other statistical calculations included coefficients, standard errors, and the associated p-values. As seen in Table 13, all hypothesised factors had a significant influence on adoption apart from gender of the farmers. All the coefficients, except that of perceived behavioural control and age, were positive, implying that they positively influenced the adoption intention of the farmers.

Table 14: Factors that influence the intention to adopt mechanised maize drying technologies

Adoption variables	Coefficient	Standard error	p-value
Attitude (score)	0.693*	0.024	0.0552
Subjective norms (score)	0.335**	0.470	0.048
Perceived behavioural control (score)	-0.429*	0.022	0.0821
Finance constraint (score)	-0.585***	0.172	0.001
Knowledge/information (score)	0.431*	0.127	0.061
Age	-0.18**	0.14	0.041
Gender	0.23	0.22	0.154
Education level	0.42**	0.09	0.032
Farm assets	0.21	0.34	0.651
Farm size	0.13*	0.21	0.071
Constant	3.2225***	0.131	0.0007

N = 380; Likelihood ratio = 356.75; *p* = 0.0001, Pseudo R squared = 0.5134

*** Significant at 1 percent level; ** Significant at 5 percent level; * Significant at 10 percent level

The results presented in Table 13 show that personal attitude, subjective norms and knowledge positively influenced the intention to adopt mechanised technology at 10 percent, 5 percent, and 10 percent significance level respectively. However, perceived behavioural control and financial resources had a negative and significant influence on intention to adopt, at 10 percent and 1 percent significance levels respectively. This implies that the farmers' views, related to their personal attitudes, increased the likelihood of their using mechanised maize drying technologies. Similarly, views related to the opinions of significant others regarding maize drying technologies were significant in influencing their adoption intentions. Knowledge of these technologies is also an important aspect, as it increases the probability of using the

technology, as indicated by the positive coefficient for knowledge. However, negative views about their financial resources (financial constraints), together with the perceived difficulty of using the technologies, reduced the likelihood of farmers' intention to adopt.

In terms of the control variables, educational level and farm size had a positive and significant influence on the adoption intention of farmers at 10 percent and 5 percent significance level respectively. Age of the farmers had a negative and significant influence on the adoption intention of the farmers; however gender of the household head did not have a significant influence on the adoption intention of the farmers.

Table 15: Ordered Logit results for hypotheses

Hypothesis	Result
H ₁ : Personal attitudes significantly influence the intention to adopt mechanised maize drying technologies among small-scale farmers in Kenya.	Supported
H ₂ : Subjective norms significantly influence the intention to adopt mechanised maize drying technologies among small-scale farmers in Kenya.	Supported
H ₃ : Perceived behavioural control significantly influences the intention to adopt mechanised maize drying technologies among small-scale farmers in Kenya.	Supported, but negative relationship
H ₄ : Availability of financial resources significantly influences the intention to adopt mechanised maize drying technologies among small-scale farmers in Kenya.	Supported
H ₅ : Knowledge of the farmer significantly influences the intention to adopt mechanised maize drying technologies among small-scale farmers in Kenya.	Supported

In the next chapter, the results presented above are discussed in detail, while also relating them to previous studies done in this area of research. This is meant to provide a comparison of the results where possible, appreciating the divergence of opinions and explanations of the results.

CHAPTER 5: DISCUSSION

5.1: Introduction

Due to the recent pressure to manage the issue of food insecurity, different stakeholders have turned to mechanisation as one of the approaches to intensify production. Mechanised maize drying increases the yield per hectare and limits losses compared to the traditional approach of sun drying. The objective of this study was to establish the factors influencing the adoption intentions of mechanised maize drying technologies among small-scale farmers in Nakuru County, Kenya. This chapter highlights the findings in relation to the research hypotheses and the findings of other relevant studies. The chapter further gives an insight into how the findings can be used in policies and in practice.

5.2: Discussion of the descriptive results

In this section, the results of the farmers' socio-economic characteristics are discussed. These include age, years of education, gender, house type, farm size, agricultural assets owned and farming experience.

The gender of the respondents was fairly equally distributed, which suggests that the level of involvement in farming across the genders is fairly equal. Agricultural production is an important industry, especially in communities that are entirely dependent on farming for their survival. Growth in rural agriculture has, however, been hampered by gender bias and unequal access to resources and opportunities for many years (IFAD, 2011). The role of men and women in farming, access to and control over resources, as well as division of labour, are important socio-economic aspects to consider in the dissemination of any rural farm technologies. According to the Food and Agriculture Organization (2005), rural women in particular are responsible for half of the world's food production, and produce between 60 percent and 80 percent of the food in developing countries. An equal involvement of women in agriculture presents the county government of Nakuru with the opportunity to promote technology among women who have been viewed as better placed to embrace them.

In terms of the age of the respondents, the majority were aged between 26 and 45 years, which is the most active age bracket. Farming in less developed nations is principally labour intensive, which can only be done by energetic farmers (IFAD, 2011).

Another key observation was that less than five percent of the farmers owned the necessary tools for maize production. Only a few of the farmers had used mechanised maize dryers and the majority did not plan to use them in the future. The respondents perhaps did not understand the potential benefits of using the technology, or they lacked the opportunity to explore the technique. According to Obeng-Ofori et al. (2014), technology plays an important role in enhancing agricultural production, but the adoption rate in many developing nations is still low. Technical innovations such as mechanised maize dryers will help farmers achieve food security due to reduced post-harvest losses at drying point. Scholars such as Obeng-Ofori et al. have indicated that incorrect assessments of technology use have contributed to reduced adoption rates among farmers, which could be why the majority of the farmers did not plan to use mechanised maize dryers in the future. The authors further indicated that farmers trust proven technologies that have been previously adopted.

The respondents' farms were small, with the majority owning less than five acres. Land size is a proxy for economy of scale, an important consideration in acquiring technology. Having larger farms may make it possible for large scale production and experimentation of new technologies. Furthermore, spreading of production risks is possible as farmers may diversify production such that risks of total failure can be avoided or reduced. In a significant number of cases, the adopters of technologies have been found to come from large farms (Walton et al., 2010; Robertson et al., 2012), thus agricultural technologies such as maize dryers should be developed to be user-friendly and convenient for small-scale farmers.

The majority of the farmers, although only having a technical training, had a considerably greater maize farming experience in general. Farming experience offers farmers a chance to observe and even experiment with different farming techniques over the course of time, while improving on their efficiency. It also complements their low education level since the ability to manage farm production improves over time. This is also important as unproductive means will be avoided and improvements made with time. More experienced farmers should therefore be able to assess the need and also the type of techniques that could improve productivity. With regard to maize drying technologies, it would be expected that farmers with greater farming experience would be able to adopt more of the technologies, holding other factors constant.

5.3 Discussion of Ordered Logit Results

An ordered logit model was used to test the hypotheses and provide insight into how the independent variables related to the dependent variable. From the results, it is evident that all the hypothesised variables had a significant influence on the adoption intentions of the farmers.

Personal attitude towards the technology had a positive and significant relationship with the intentions of farmers to adopt mechanised maize drying technologies, at a 10 percent significance level. Their views related to whether they liked the technology, whether it was convenient, whether it would suit their production activities, and whether it would increase productivity, and were assessed using the TPB. As expected, these views had an impact on the farmers' adoption intentions. As stated by Ajzen (2002), personal attitudes, a big element of the theory of planned behavior, shape personal views with regards to the attractiveness of the technologies. Genius et al. (2006) found that personal attitudes were important determinants of the adoption of agri-environmental measures by farmers in Italy. Similarly, McCann et al. (1997), looking at similarities and differences between organic and conventional farmers in Michigan, found that organic farmers expressed a higher level of concern for the environment than farmers who used conventional methods. This implies that that their attitudes towards environmental conservation shaped their decision to adopt organic farming. These studies were concerned with how farmers' attitudes relate to behaviour change. Hence, as captured in the TPB, personal attitudes cannot be ignored in trying to understand the adoption behavior of farmers. As indicated in this study, the attitudes of the farmers play a critical role in adoption of maize drying technologies which calls for policy intervention which has an attitude aspect to boost the adoption.

With regard to subjective norms, the results indicated that these have a positive and significant effect on the intention to adopt mechanised maize drying technologies, at a 5 percent significance level. Subjective norms are the perceived social pressure from family, friends, or significant others, with reference, in this study, to adopting a technology. The perception of others of a technology is an important factor in an individual's choices. A study by Ajzen (1991) showed that subjective norms are a direct determinant of technology adoption intention. In a similar observation, Ajzen (2001) noted that people tend to adjust their beliefs according to those of the group of which they are a member. This could imply that social capital influences farmers' decisions even more in rural areas, due to the close relationships they have among themselves. Individuals are also influenced by the views of the majority; when a large proportion of an individual's referent social group holds a particular view, it is likely that the

individual will agree (Ajzen, 2001). Davis et al. (1989) observed that, in making a decision, individuals are influenced by their colleagues, and that subjective norms are an important area for further research. This suggests that, under significant social influence and pressure, an individual would adopt a technology even if they were not in favour of it (Venkatesh and Davis, 2000). Other scholars seem to deviate from this notion, as they found mixed results regarding subjective norm as a predictor of adoption intention. For example, Davis et al. (1989), Mathieson (1991), Chau and Hu (2001) and Lewis et al. (2003) explained that there is a very weak link between subjective norms and agricultural technology adoption. Similarly, Armitage and Conner (2001) noted that subjective norm was a poor predictor of behavioural intention. However, based on the findings of this study, it would be prudent to keep in mind the importance of subjective norms in technology dissemination to the farmers by various stakeholders.

With regard to views related to perceived behavioural control, it was evident that the views had a negative and significant influence on intention to adopt the technologies at a 10 percent significance level. This implies that the farmers who felt that they did not have large enough farms and that the technologies were not so easy to use, were less likely to adopt mechanised maize drying technologies. According to Ajzen (2002), perceived behavioural control helps individuals to deal with situations where they may lack complete volitional control over the behaviour. The author further argued that the performance of a particular behaviour is correlated to the confidence of the individual in his or her ability to perform the behaviour. Perceived behavioural control is based partly on previous experience, and partly on the thorough exchange of information between family and friends. Factors that may control the level of perceived difficulty in using a particular agricultural technology may influence how a person perceives the technology and the decision of whether or not to adopt it (Ajzen, 1991). Contrary to these findings, many authors support the importance of availability of requisite resources like land, which builds confidence in one's ability and willingness to adopt agricultural technology (Taylor and Todd, 1995; Jen-Ruei et al., 2006). In this regard, Ndubisi (2004) suggested that the perceived difficulty in use and the perceived usefulness of the technology have an impact on the decision to use it. In another meta-analytic approach, using the Expectancy-Value Framework, Pawlak et al. (2008) reached a conclusion that the views related to the perceived ease or usefulness of a particular behavior for instance adoption of a technology cannot be ignored since it played a critical role in personal decisions with regard to behavior of the individual.

In the present study, perceived costliness and difficulty in accessing financial resources were found to have a negative and significant influence on the intention to adopt maize drying technologies, at a 1 percent significance level. Therefore, farmers' perceptions about the financial burden that would accompany the acquisition of these technologies are very important when it comes to their intention to adopt agricultural technologies. This finding supports those of Obeng-Ofori et al. (2014) and Agwu (2014). Investments in innovations like mechanised maize drying technology require high entry costs and carry greater risks than investments in mature technologies (Diederer et al., 2003). In addition, it is difficult to raise external capital for a high-risk investment. A farmer who has greater capital, therefore, has greater financial capacity to adopt the technology. If the results turn out to be unfavourable, the losses are potentially affordable. The availability of financial resources have been found to positively influence the intention to adopt technology; the decision to adopt is often an investment decision (Isgin et al., 2008). However, this factor has proved insignificant in some cases (Larson et al., 2008; Roberts et al., 2002).

In the present study, the farmers' knowledge had a positive and significant influence on the intention to adopt mechanised maize drying technologies, at a 10 percent significance level. This implies that availability of knowledge and information about mechanised maize drying technology amongst the farmers in Nakuru County, Kenya, is an important prerequisite. Information is the key to the diffusion of innovations (Rogers, 1995). Information on agricultural practices is typically sourced from extension services or consultants. The present study found that one of the reasons why farmers may adopt more of a technique is if information concerning the practices is availed to them. This finding rubber stamps the findings of Obeng-Ofori et al. (2014) in Ghana, where mechanised maize drying was adopted mainly by medium- and large-scale farmers who were more informed about the benefits of using the technique.

Research by Robertson et al. (2012) and Larson et al. (2008) showed that adoption is more likely if farmers are knowledgeable, and if information on agricultural technologies provided by extension services is seen as useful. Information about a new technology demystifies it and makes it more acceptable, while knowledge reduces the uncertainty about a technology's performance and may therefore change an individual's assessment from subjective to objective over time (Caswell et al., 2001). Exposure to knowledge/information about new technologies significantly affects farmers' choices about them. Feder and Slade (1984) indicated how increased knowledge induces adoption, provided a technology is profitable. Knowledge sources for farmers in Nakuru have mainly been agricultural extension services, however due

to the low rate of dissemination, there has not been much impact on enhancing increased adoption of the practice of mechanised maize drying among farmers in Nakuru County. It is, therefore, evident that there is a need to enhance information dissemination among farmers in the county as it is an important driver of technology adoption. This dissemination should focus on influencing adoption behaviours of farmers to appreciate mechanised maize drying as a strategy that could increase yield.

Age was negatively related to the intention to adopt mechanised maize dryers, as younger farmers were more likely to adopt mechanised maize drying technologies. It could be that young farmers are more aware of the benefits of productive technologies, while older farmers may be more conservative, less flexible and more skeptical about the benefits of new technologies. On the other hand, the older farmers have more experience in farming and are more likely to embrace innovation compared to young farmers, however they tend to be more risk averse and therefore try to avoid new techniques. Challa and Tilahun (2014) noted that the age of farmers influences the probability of adoption of new technologies because it is related to farming experience, yet in many other studies, “age of the household head may not be significant or in other cases negatively influence adoption of technology (Bernier et al., 2015, p.12)”. This implies that age as a variable should be taken into consideration by policy makers in order to make informed decisions that will influence farmers to change their perceptions towards the adoption of maize drying technologies.

Level of education of household heads had a significant influence on the adoption intention of farmers, possibly because better educated farmers are more receptive to technologies and are more willing to try out new things; through experimentation they get to use a number of new techniques in their quest to improve their welfare through production. Gido et al. (2015) argued that higher levels of education tend to build the innovativeness of farmers as well as improve their information processing, which is important in the adoption of improved agricultural practices. A previous study by Udoh (2009) indicated that having at least eight years of primary school education means farmers are able to read and write at least in the local language, which significantly influences their understanding of simple instructions for using machines, and hence their adoption. Waller et al. (1998) and Caswell et al. (2001) argued that education is thought to create a favourable mental attitude for the acceptance of new practices, especially of information-intensive and management-intensive practices. According to Ehler and Bottrell (2000), education is thought to reduce the amount of complexity perceived in a technology, thereby increasing its adoption. They added that one of the hindrances to the widespread

adoption of mobile grain dryers as an alternative to solar dryers is that they require a greater technical understanding of the system, which is acquired through education.

Farm size also had a significant influence on the adoption intention of farmers. Land is a primary fixed asset without which farmers are limited on production unless they rent in land (acquire on leasehold). Furthermore, those who own land on short term leases do not enjoy the liberty of making long term investments, especially on costly farm adjustments, thus they end up making short term and less costly investments. According to Khonje et al. (2015), farmers with larger pieces of land have a high probability of adopting agricultural technologies.

Adoption intentions of farmers are also significantly influenced by their ownership of agricultural assets. Assets are important in facilitating usage of other productive assets, and they signify the ability and willingness to employ mechanisation in farming. Productive assets could facilitate the purchase of external inputs, helping farmers to take more risks. Teklewold et al. (2013) argued that productive farm assets provide a means of spreading risks for farmers. While spreading the risks, farmers will be motivated to try out new techniques without much risk of total failure in case of a disaster in the production process.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1: Introduction

This chapter provides a conclusion to the research based on the insights gained from the findings. While much research has been conducted on the subject at hand, little has been done to eliminate the existing barriers to adoption of agricultural technologies among small-scale farmers in Kenya. The government has a role to play in influencing the adoption behaviours of farmers by developing policies that focus on farmers' perceptions and their ages, as these were the two variables that were found to have a significant impact on adoption behaviour of farmers.

6.2: Conclusion

The main objective of this study was to establish which factors influence the adoption intention of mechanised maize drying technologies among small-scale farmers in Kenya. The gender distribution of the respondents was almost equal, suggesting a gender balance for farmers in the study area. The age bracket with the greatest number of respondents was between 36 and 45 years old, while the majority of farmers had permanent houses but their farms were smaller than five acres. This implies that they may be constrained in using mechanised technology which requires bigger portions of land - usually above five acres. Most of the farmers did not have heavy machinery like tractors, which they perceived as being too expensive for small-scale farmers.

Although a wide range of factors influence the adoption of mechanised maize drying technologies, this study focused on five variables, namely financial resources, personal attitude, perceived behavioural control, subjective norms, and knowledge, using an ordered logit model. The following conclusions were drawn from the findings.

Views relating to personal attitudes influence the farmers' adoption intention, thus (H₁) is accepted. Similarly, views related to subjective norms of farmers influenced their intention to adopt mechanised maize drying technologies, and H₂ is therefore accepted. H₃ is accepted, as perceived behavioural control influences the farmers' intentions to adopt the technologies; the PBC views had a negative impact on the farmers' adoption intentions.

H₄ stated that availability of financial resources among small-scale farmers in Kenya will significantly influence their intention to adopt mechanised maize drying technologies. According to the ordered logit model conducted, the variable for financial constraint was

negative and significantly influenced the farmers' intention to adopt mechanised maize dryers, thus the hypothesis is accepted. The views related to financial constraints such as difficulties in accessing credit negatively influenced farmers' intentions to adopt mechanised maize drying technologies, while the knowledge of the farmers significantly influenced their intention to adopt mechanised maize drying technologies, thus H₅ is accepted.

In conclusion, it is evident that access to financial resources, farmers' subjective norms, knowledge, personal attitudes and perceived behavioural control are some of the important factors that policymakers should consider while aiming to influence small-scale farmers' intentions to adopt technologies in Nakuru County, Kenya. Notably, the key elements of the theory of planned behavior were all significant determinants of adoption of maize drying technologies. Indeed as stated by various scholars including (Wauters et al., 2010; Mugenda, 2008; Pawlak et al., 2008; Sniehotta and Schwarzer, 2005; Sheeran and Orbell, 1999; Verplanken and Faes, 1999; Orbell et al., 1997; Ajzen, 1985), who advanced the theory, in their studies, these three elements are paramount in explaining the adoption intents of people.

The concept of mechanised maize drying is yet to be fully sold to the young farmers of Nakuru County and Kenya as a whole. The level of government intervention to support training, demonstrations, and other services such as extension contacts to enhance adoption of mechanised maize drying technique is still wanting.

Government should improve the dissemination of knowledge to farmers to keep them abreast of advancements, especially regarding technologies that would greatly improve their productivity and reduce post-harvest losses. Such initiatives will not only enhance maize production in the region, but will change farmers' perceptions regarding the adoption of new farming techniques, which will have a positive impact on the country's food security. Initiatives should focus on enhancing access to extension services and training and promote the development of farmers' co-operatives, as they are a useful tool through which the extension officers can disseminate information.

The government monitoring agency needs to aggressively monitor the extension agents to ensure that all farmers, including small-scale farmers, get adequate and accurate information about the maize drying technologies available to meet their grain drying needs. Government should also partially subsidise the acquisition of the technology to promote the increased use thereof, as mechanisation is too expensive for most small-scale farmers.

Educational institutions should adopt a long-term strategy to encourage increased adoption of

agricultural technologies among farmers in the country. This study revealed that a lack of information is one of the constraints that limit the adoption of mechanised maize drying technology in Nakuru County; most of the farmers were not aware of the innovation or its impact on maize production.

Financial resources were found to influence the adoption intention of farmers, which was in line with previous findings. For this reason, it is important to take into consideration the financial capabilities of farmers when seeking to promote the adoption of these important technologies in Nakuru County.

6.3: Recommendations

These recommendations are made based on the theoretical framework, conceptual framework, literature review, findings and conclusion of the study.

1. The government, through the Ministry of Agriculture, Livestock and Fisheries (MALF) and other relevant stakeholders, should make efforts to conduct a nationwide awareness and sensitisation campaign on post-harvest losses and mitigation technologies such as mechanised maize drying technologies, to solve the issue of food insecurity in the country by increasing maize yield. The campaign will bridge the information gap which was found to be among the fundamental constraints that limit farmers' behaviour concerning the adoption of technology. Through extension services, the government should encourage farmers to embrace agricultural techniques to increase their production.
2. There is a need to promote the development of farmers' co-operatives in the region, as no information concerning such organisations was mentioned in the study.
3. The government could use co-operatives to manage the machines and provide services to the co-operative members. Government could also subsidise the acquisition of dryers.
4. To address the lack of information among small-scale farmers in the region, it is important that the government encourages farmers to use extension services.
5. There is a need to increase farmers' capital and credit facilities to make these technologies accessible, e.g. the government and other stakeholders could provide tax-free tools and equipment to the farmers.
6. Maintaining the machines can be quite expensive. Government could work in partnership with the manufacturers to ensure that they train a few members of the co-

operatives on maintenance of the machines and provide technical back-up in the initial years.

7. The government could enlist the help of private-sector companies to provide maize drying services to small-scale farmers who cannot afford to purchase the machines. For their co-operation, government could provide tax breaks and make imported machines exempt from import duty.
8. Farmers need to be educated on the need to diversify farming activities, thereby creating multiple income streams. This will enhance their financial stability and resilience, and could provide them with an opportunity to form savings groups that would enable them to build financial resources with purchasing power as a group.

6.4: Limitations of the study

Despite the fact that there is still much to be done, this research generates significant findings with regard to the adoption of agricultural technology, especially to do with maize drying. It is worth noting that the study has a number of limitations, which could limit the generalisation of the findings to other contexts and situations in the technology adoption area of research. The main limitation is regarding the key factors that influence adoption intention. The factors studied here extensively relate to those mentioned by previous scholars in the Theory of Planned Behaviour, which include subjective norms, perceived behavioural control and personal attitudes. Although the researcher included access to finance and knowledge, which are factors that play a critical role in influencing the TPB factors by enhancing the ability of the farmers to have both capacity and adequate information, there are other unique drivers that could further explain the technology adoption behaviour and provide further support for the reasons and findings described in this study. Further, national issues related to taxation and pricing of these technologies could play a role, and with the advent of devolution in Kenya, new research to investigate the impact of devolution on agricultural incomes and motivational change towards technology use could form a basis of research which is not adequately included in this study.

6.5: Suggestions for future research

The present study makes valuable contributions to the body of knowledge, and future studies could build on this by considering the following recommendations:

1. This study investigated the adoption behaviour of farmers regarding mechanised maize drying technology using five factors: access to financial resources, perceived behavioural control, knowledge, farmers' subjective norms, and personal attitude. However, previous studies have affirmed that there are more factors that play a role, including age, gender, farm size, sensitisation, mentoring, and demonstrations by extension officers. Conducting a study with a focus on such constraints will assist in devising effective solutions.
2. It is important to explore the role of extension agents as a key source of knowledge amongst small-scale farmers in the reduction of post-harvest losses.
3. There is need to compare the adoption of agricultural technologies between farmers growing maize in the region and farmers growing other crops, such as wheat. Such analysis will identify some of the specific constraints that limit the adoption of technology among maize farmers in the region.
4. Although the findings of this research could be applied in other counties with similar ecological and social conditions, research can also be done to verify if these factors determine technology adoption intention in other counties in Kenya.
5. Experimental comparative research could quantify the losses of farmers who use the drying technologies and those who use traditional sun drying methods. This information could be used in sensitising farmers on the need to adopt modern technologies that reduce post-harvest losses.

Future studies should include more variables that could influence farmers' perceptions, to adequately understand their behaviour regarding the adoption of mechanised maize drying. This will contribute to the development of effective policies, which will in turn contribute to the increased adoption of agricultural technologies among farmers in Nakuru County and the country as a whole.

6.6: Lessons learned during the research

Training of the research assistants and enumerators was a huge and time consuming task. It was clear that researchers should plan for and dedicate substantial amounts of time for recruiting, hiring, and training research assistants and enumerators, especially if individuals do not have experience with research. The researcher met with the interviewers (enumerators) for

a whole week before the beginning of the study to review the protocol, practice the interview guide, and do some role-playing. As the interviewers became more familiar with the process, the training decreased. Also, as a matter of experience, the researcher recommends that researchers consider issues of language and literacy early while preparing for the field study. Many farmers could speak Kiswahili and some English, but they could barely read and/or write the language. These issues may affect the desired accuracy of information collected.

Translation of the research tool should involve many people, especially locals, in order to provide a variety of words and contextual translations, especially when conducting the field surveys in villages. Standard procedures for translating text may not be desirable due to differences in opinion about correct and/or preferred terms. Researchers should also consider involving local committees or leaders to ensure that the translations yield culturally acceptable wordings and meanings.

Rigorous training is paramount to ensure that etiquette in the local dialects is maintained throughout the field work to avoid arousing negative emotions, which may jeopardise the entire process. Local cultures and any bad experiences should be considered in light of the fact that the target population has faced serious problems in the past, thus questions that could potentially remind them about past misfortunes should be carefully handled. For instance, Nakuru was a hot spot in the post-election violence of 2007/08. The farmers were severely affected and their productive assets were vandalised, leading to a massive decline in production.

The mode of advertisement for interviewers should be robust to provide a good mix of individuals who can properly handle the survey. In this study, the researcher used some staff from the Ministry of Agriculture who were used to working in the region with farmers. These were not sufficient, however, and the researcher had to recruit additional staff to manage the whole survey. Unfortunately the additional interviewers had limited experience with research, and thus faced challenges with handling farmers who in most cases were used to senior staff from the Ministry.

In conclusion, engaging cultural insiders as enumerators, building community partnerships and support, including members of the community on the research team, and developing culturally appropriate and sensitive language and materials, is very important for acceptability and the smooth running of a survey. The major challenges in this research involved the time taken to

train the staff as well as the translation scheme, which had contextual problems as Nakuru County is quite large with diverse cultures. The challenges the researcher experienced were not difficult to overcome, but they underscored the need to be sensitive and flexible in conducting community-based research. It is also worth noting that the age and research experience of the survey staff is very important, as training more experienced individuals would take a shorter time and they could carry out the interviews faster and more accurately. The researcher hopes that the lessons learned from this study will provide guidance for doing future research in this region, and improve accuracy by factoring in the challenges in advance.

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APPENDIX I: QUESTIONNAIRE

PART A: DEMOGRAPHIC INFORMATION

Instructions: The questionnaire seeks to collect data on the various aspects of the study. It will only be used for the study purposes.																					
1	State your name (Optional) _____ Mobile no. _____																				
2	Indicate your gender																				
	Male <input type="checkbox"/> Female <input type="checkbox"/>																				
3	Indicate your age in years:.....																				
4	Indicate the highest level of education/training attained (Tick one box, as appropriate)																				
	Technical <input type="checkbox"/> <input type="checkbox"/> a <input type="checkbox"/> Diplom <input type="checkbox"/> Bachelor's degree																				
5	Please indicate the size of your farm in Acres:.....																				
6	Does your household have any of the following: <div style="float: right; text-align: right; margin-right: 20px;"> <i>1 = Yes</i> <i>2 = No</i> <i>0 = Do not know</i> </div>																				
	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 70%;">Mobile phone</td> <td style="width: 5%;"></td> <td style="width: 5%;"></td> <td style="width: 10%;"></td> </tr> <tr> <td>Tractor</td> <td></td> <td></td> <td></td> </tr> <tr> <td>Chisel</td> <td></td> <td></td> <td></td> </tr> <tr> <td>Harrow</td> <td></td> <td></td> <td></td> </tr> <tr> <td>Others _____</td> <td></td> <td></td> <td></td> </tr> </table>	Mobile phone				Tractor				Chisel				Harrow				Others _____			
Mobile phone																					
Tractor																					
Chisel																					
Harrow																					
Others _____																					
7	Indicate the number of years you have been farming maize																				
	Less than 5 yrs <input type="checkbox"/> 5-10yrs <input type="checkbox"/> 10-15yrs <input type="checkbox"/> Over 15yrs <input type="checkbox"/>																				
8	Are you the head of this household?																				

	Yes <input type="checkbox"/> No <input type="checkbox"/> Don't know <input type="checkbox"/>
9	What house type does the household occupy?
	1= Temporary house <input type="checkbox"/> 2= Permanent house <input type="checkbox"/> 3=Other, specify <input type="checkbox"/>
1	How much income did your household earn in the last year from maize farming?
0	
	<i>Enter amount, in Kshs</i>
1	How much income did your household earn in the last year <u>from other crops</u> ?
1	
	<i>Enter amount, in Kshs</i>

PART B: INTENTION TO ADOPT MECHANISED MAIZE DRYING TECHNOLOGIES

12. Have you ever used a mechanised maize dryer before?

Yes

I'm currently using a mechanised dryer

No

PART C: FACTORS AFFECTING INTENTION TO ADOPT MAIZE DRYING TECHNOLOGIES

	(QUESTIONS 13-14) The following statements will assess your opinions on the extent to which you intend to adopt a mechanised maize dryer.	1	2	3	4	5
		No t at all	To a small extent	To a mode rate extent	To a larg e exte nt	To a very large exten t
13	I plan on using a mechanised maize dryer.					

TECHNOLOGIES

14	I want to use a mechanised maize dryer					

FINANCIAL RESOURCES

	(QUESTIONS 10-13) The following statements describe the relationship between financial resources and adoption of mechanised maize drying machines within your county.	1	2	3	4	5
		Not at all	To a small extent	To a moderate extent	To a large extent	To a very large extent
15	The mechanised maize dryers are expensive to buy.					
16	The mechanised maize dryers incur high running costs.					
17	It's difficult to get loans from the bank.					
18	I don't have enough money to purchase a mechanised dryer.					

19. How many bags did you harvest in your last season? And how much did you sell it for?

.....

20. How much income did you get from other activities in the last year?

.....

21. What assets do you intend to purchase to mechanize farming in your household?

.....

22. What other financial factors affect your intention to adopt mechanised maize drying technologies?

.....

PERSONAL ATTITUDES

	(QUESTIONS 15-19) The following statements describe the relationship between personal attitudes and intention to adopt portable maize drying machines within your county.	1	2	3	4	5
		Not at all	To a small extent	To a moderate extent	To a large extent	To a very large extent
23	I like mechanised maize dryers					
24	Mechanised drying does not suit my farming activities.					
25	Mechanised drying is not convenient.					
26	I need to try using a mechanised dryer first.					
27	Using the system increases productivity.					

KNOWLEDGE

	(QUESTIONS 21-24) The following statements describe the relationship between knowledge and the adoption of mechanised maize drying machines within your county.	1	2	3	4	5
		Not at all	To a small extent	To a moderate extent	To a large extent	To a very large extent
28	I understand how mechanised dryers work.					
29	I understand the costs and benefits of mechanised dryers.					

30	I can read to educate myself on post-harvest management practices, due to my level of education.					
31	I am aware that the mechanised drying technologies exists					

32. What other factors affect your intention to use mechanised dryers?

.....

.....

.....

.....

.....

.....

NORMS

	(QUESTIONS 21-24) The following statements describe the relationship between your norms and the adoption of mechanised maize drying machines within your county.	1	2	3	4	5
		Not at all	To a small extent	To a moderate extent	To a large extent	To a very large extent
33	Do you think your relatives would allow you to use mechanised maize drying technologies?					
34	Do you think mechanised maize dryers are usable by all gender?					

PERCEIVED BEHAVIOURAL CONTROL

	(QUESTIONS 21-24) The following statements describe the relationship between behavioural control and the adoption of mechanised maize drying machines within your county.	1	2	3	4	5
		Not at all	To a small extent	To a moderate extent	To a large extent	To a very large extent
35	The size of my farm is large enough to allow use of mechanised maize dryers.					
36	Mechanised maize drying technology is not difficult to use.					

37. What other views do you have regarding the use of mechanised maize dryers?

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