FARMERS' PERCEPTIONS AND WILLINGNESS TO ADOPT MAIZE-BASED INTERCROPPING IN KAPCHORWA DISTRICT, UGANDA

BY

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DECLARATION

I hereby declare that this thesis is my original work and effort and has not been submitted for a Degree Course in Makerere or any other University before.

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DEDICATION

I dedicate this thesis to my husband Arthur, my sister Juliana, and my late mother Sanyu Prossy Nsubuga.

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LIST OF ACRONYMS

FFDs:	Farmer Field Demonstrations
FGD:	Focus Group Discussions
IPM:	Integrated Pest Management
MRR:	Marginal Rate of Return
MTIC:	Ministry of Trade Industry and Cooperatives
MVP:	Multivariate Probit
Shs:	Ugandan Shillings
SIMILESA	Sustainable Intensification of Maize and Legume Cropping Systems for Food Security in Eastern and Southern Africa Program
SSA:	Sub-Saharan Africa
UBoS:	Uganda Bureau of Statistics
USD:	The United States Dollar
WAR:	Weighted Average Rank

ABSTRACT

Intercropping is a long-standing crop practice that forms part of smallholder cropping systems in Uganda. Despite knowing some intercrops, farmers in Kapchorwa still widely practice maize monocropping. To popularize maize-based intercropping, the HealthyLAND project introduced intercropping practices of maize-beans, maize-pumpkin, maize-African eggplants, maize-grain amaranth, and maize-lablab through farmer field demonstrations. However, farmers' perceptions on these intercrops, willingness to adopt the practices, and their potential net benefits to the farmer are not known. This study aimed to determine farmers' perceptions of the different demonstrated practices and establish factors that influence farmers' willingness to adopt them. Random and purposive sampling methods were used to collect data on 108 smallholder farmers to determine perceptions of both farmer field demonstration participants and non-participants using a semi-structured questionnaire. The data was analyzed using STATA and SPSS. Results showed that both demonstration participants and non-participants had similar positive perceptions such as increased maize yield with an intercrop of maize-beans and negative perception of the reduced yield of companion crops. Results of the multivariate probit model showed revealed that participation in the farmer field demonstrations significantly influenced willingness to adopt maize-pumpkin, maize-African eggplants, and maize-lablab. Age of a farmer, farming experience, number of years of schooling, and number of farming fields accessed by a farmer significantly influenced willingness to adopt maize-grain amaranth. The results of the marginal analysis revealed that in the lower altitude area, except maize-lablab, all the other intercropping practices that were demonstrated showed higher economic benefits compared to maize mono-crop. This study, therefore, recommends that extension workers need to demonstrate different intercrops to farmers. Also, farmers' willingness to adopt less common intercrops can be significantly improved through participating in field demonstrations. Further research can be carried out to establish the actual adoption of the different intercropping practices.

Key words: Maize-based intercropping, perceptions, Willingness to adopt, Multivariate probit

CHAPTER ONE

INTRODUCTION

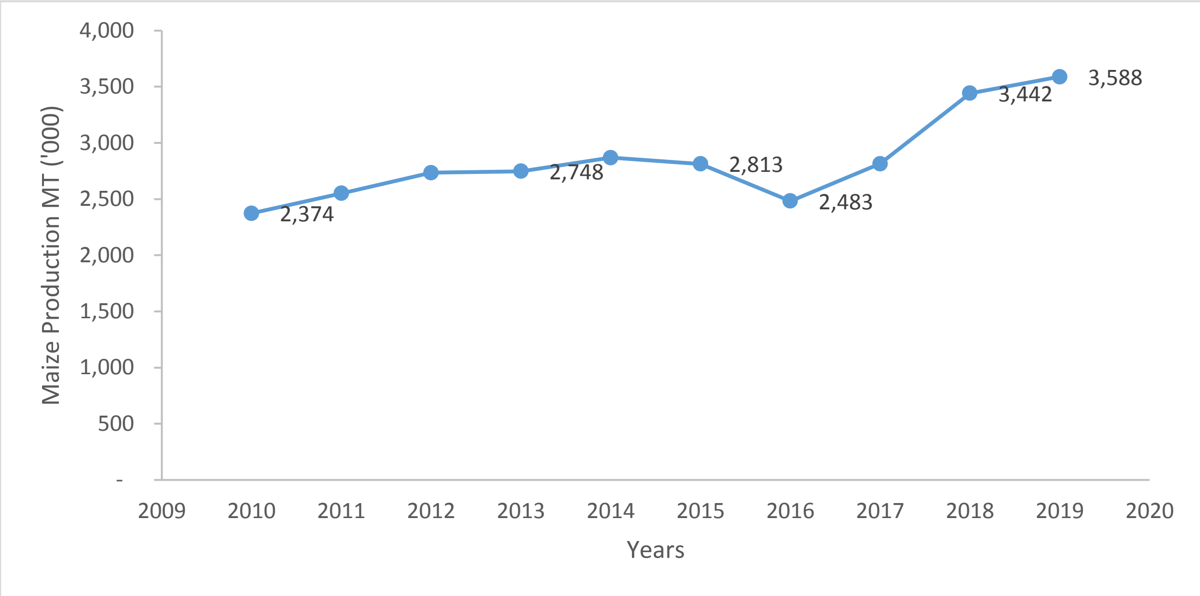
1.1 Background to the study

The world's population is projected to hit 9 billion by 2050 (United Nations, 2019) and this will require an increase of not just food production but also nutritious food to meet both food and nutrition security. In Africa, the agriculture sector is the primary source of food and income. The sector employs 60 percent of the population in Africa (AGRA, 2014), making it the main economic activity on the continent. Most of the food in Africa is produced by small-scale farmers. However, hunger and undernourishment remain as one of the major challenges faced by small-scale farmers. FAO, IFAD, UNICEF, WFP, and WHO (2019) reports that there are 260 million undernourished in Africa and 93.3 percent of these are in Sub-Saharan Africa (SSA). This implies that food production has not kept pace with the increasing population. According to FAO (2015), small-scale farmers are among the people that fail to meet their daily food requirements. This means that they are most likely to suffer hardest from undernourishment. Therefore, increasing agricultural productivity among small-scale farmers is seen as an opportunity to improve food and nutrition security.

Fortunately, the improvement of smallholder agriculture through adoption of agronomic practices that promote crop productivity, diversity, and at the same time conserve the environment offers an opportunity for farming households to have sustainable livelihoods. Practices like crop diversification in form of intercropping provide a habitat for beneficial insects through increasing natural enemies and reduces pest numbers by rendering host crops less apparent for colonization (Poveda *et al.* 2008). Besides, crop diversification increases economic stability by reducing financial risk, stabilizing farm income, and increasing the choice of farm practices (Adjimoti and Kawdzo 2018; Makate *et al.* 2016). For instance in Malawi, a 17-38 percent increase in maize yields was associated with maize intercropping in comparison to sole maize (Maggio *et al.,* 2018).

1.1.1 Maize production systems in Uganda

Maize is one of the most important cultivated staple crops in Uganda. Recent statistics show that the total area under maize production was 2.5 million hectares in 2018 which is 21.68 percent of total area under crop production (UBOS, 2018). Maize production systems are dominated by small scale farmers who produce for both consumption and as a source of income. According to FAOSTAT (2020), maize production has generally increased for the past decade (Figure 1.1). The 2018 agricultural survey showed that production of maize was estimated to be 3.4 million metric tonnes (UBOS, 2018). This was a remarkable increase compared to 2.3 million metric tonnes produced in 2009. The production of maize is highly variable across the country due to the difference in agro-ecological zones and socio-economic conditions.



Source: FAOSTAT, 2020

Figure 1. 1: The trend of maize production in Uganda

Although maize production in Uganda has increased, the sector still suffers numerous challenges that have kept the productivity below it's potential. Low adoption of modern technologies such as fertilizers, pesticides and use of improved seed has negatively affected maize production (Larson *et al.*, 2016). Most of the small scale farmers are unable to invest in these technologies and others are discouraged by the low market prices of maize (Lueng and Jenkins, 2013). In addition, the Fall Army Worm (FAW) has had devastating effects on maize production in many countries in Africa. In the Ugandan, the losses to the maize sector are estimated to be about USD 193 million (Abrahams *et al.*, 2017). Since farmers face resource constraints such as lack of credit to invest in agriculture, promoting proven farm practices like maize-legume intercropping may complement or substitute use of commercial inputs.

1.1.2 Maize production in Kapchorwa district

Crop production is the main source of income for small scale farmers in Kapchorwa district (Oduol *et al.,* 2016). Due to the nature of the landscape, the district has distinctive agro-ecological zones for which the main crops produced differ. In the lower altitude maize is the main crop. The mid lower altitude and mid upper is dominated by bananas and coffee while the upper area mostly produces vegetables such as cabbage and potatoes (Oduol *et al.,* 2016).

Maize in Kapchorwa takes long to mature and therefore is is grown for only one season per year. The agriculture census of 2008/09 reported that an estimated 49,904 MT of maize were produced from 6,074 hectares in Kapchorwa district (UBOS, 2010). Major constraints to maize production in the district include poor soil fertility accruing from poor farming practices like continuous cultivation, lack of access to input markets due to poor roads, fake seeds, pesticides and fertilizers (Oduol *et al.,* 2016).

1.1.3 The HealthyLAND project

HealthyLAND project (Crops for Healthy Diets: Linking Agriculture and Nutrition) was a three-year project that started in 2015 and ended in 2018. The objective of the project was to determine the link between agro biodiversity and nutritional diversity. Specifically, the project aimed at examining to what extent and how a more diverse cropping system would contribute to nutrition security. The project considered alternatives in farming systems in resource poor areas in Uganda, Kenya and Malawi.

The project used an experimental approach to promote crop diversification through intercropping in Kapchorwa district, Uganda. Different agricultural and nutrition interventions with education were implemented through Farmer Field Demonstrations (FFDs). Intercrops included maize as the main crop and companion crops of multiple use-value (that is, grain amaranth, African eggplants, pumpkin, climbing beans, carrots, and lablab). Randomly selected farmers from villages in four sub-counties in the district participated separately in the agricultural and nutritional education. The focus of this thesis was only in the areas where the main crop was maize and that was in three sub-counties out of the four in which the project activities were implemented.

1.1.4 Perceptions and willingness to adopt technologies

Given that the farmers received the knowledge about the different intercrops from the HealthyLAND project, it is imperative that the perceptions that have been formed about these intercropping practices are understood. Awareness of the practices precedes indication of likelihood of adoption. When faced with new interventions, farmers may not right away take them up but rather give an implication of their likelihood of doing so in the future. Liu *et al*. (2018) refer to this as the second stage in farmer adoption process after awareness and before trying and evaluating the practices. Farmers will adopt practices that best suit them given their circumstances (Zeweld *et al.*, 2017).

Farmers have perceptions of what intercropping systems would be beneficial to them depending on their farming objectives. Although farmers may be aware of the benefits of intercropping practices, farmers may be unwilling to practice them especially if the crop is not consumed by the household (FAO, 2015). Therefore, to understand farmers' heterogeneity in the choices regarding their willingness to adopt intercropping practices, it is imperative that not only socio-economic characteristics are considered but also their perceptions on the demonstrated practices. In their review, Liu *et al*. (2018) discusses that farmers' adoption decisions are subject to change. However, perceptions are crucial influence on farmers' initial adoption decision. The benefit of considering farmers' perceptions is that changes can be made in the process where possible such that it increases the likelihood of taking up the interventions.

In Uganda, many farmers have been practicing intercropping but the composition and spatial arrangement of the component crops coupled with management practices have limited the potential production of these systems. In addition, continuous ploughing has led to reduced soil fertility. For example, the coffee-banana intercrop requires nutrient replenishment because both coffee and banana have a high demand for potassium with manure or inorganic fertilizers to sustain yields (Asten *et al.* 2015). Such incidences have affected farmer's perceptions about different intercropping systems they are exposed to and the risks involved (Jassogne *et al.* 2012). The 2018 annual agricultural survey by UBOS revealed that 25% of farmers believed that the soils were fertile enough and do not require fertilizers while 40% could not afford to purchase fertilizers (UBOS, 2018). Therefore, farmers as the primary beneficiaries of these promoted practices, it is important that their perceptions are not overlooked.

1.2 Problem statement

Agricultural production in the Uganda suffers from limited adoption of modern agricultural practices and technologies coupled with low soil fertility, prolonged drought, pests, and diseases that have kept crop yields low (Nabuuma and Bahiigwa, 2003). The average yield of maize (key food security crop) in Uganda ranges from 2.2 to 2.7tonnes per acre compared to the potential 8tonnes of maize per acre (UBOS, 2014). Statistics show that there was an increase in the production of maize from 1.0million tonnes in 2000 to 2.5million tonnes in 2018 (FAOSTAT, 2018). However, the increase was attributed to increased acreage rather than productivity (Ajambo *et al.*, 2017). Despite the recent increase in adoption of improved maize varieties in

Uganda such as the drought-resistant varieties (FAO, 2017), lack of proper cropping practices and good management are major barriers to farmers realizing benefits (Rocktsröm *et al.*, 2009).

Intercropping practices such as maize-legume have been found to have numerous benefits to farmers (Kermah *et al.* 2017; Jaleta *et al.*, 2020). However, adoption of these intercropping practices largely depends on the farmers' perceived economic risks since most small-scale farmers are resource-constrained. A report by WFP (2009) revealed that 80% of Ugandan households that practiced intercropping involved a legume. Implying that most efforts have been placed on common intercrops such as maize-legume for example SIMLESA-Uganda project (Mubiru *et al.* 2019) and less emphasis put on maize-vegetables and others. Intercrops such as maize-grain amaranth or maize-lablab that were demonstrated for the farmers in Kapchorwa under the HealthyLAND project are rare and therefore perceptions of farmers towards them are not known. A few intercropping studies in Uganda have focused on economic evaluation of maize-bean intercropping (Kasenge *et al.* 2001) and legume based-intercropping (Epeku and Tririvanhu 2016), none on farmers' perceptions of the practices.

To ensure that farmers realize the benefit of the maize intercrops being promoted by the project, it is important to understand whether the intended beneficiaries perceive the importance of the specific intercropping practices. Besides, it is also not known how much of farm inputs/costs farmers will have to incur and or save, and how much benefit they will realize and /or forego if they adopt the intercropping practices. Therefore, this study is addressing the knowledge gap and documenting farmers' perceptions on maize-based intercropping practices in relation to their current farm practices and establish the factors that influence farmers' willingness to adopt the demonstrated practices.

1.3 Objectives of the study

The main objective of the study was to assess farmers' perceptions and an economic evaluation of the proposed maize-based intercropping practices in Kapchorwa district, Uganda. The specific objectives were:

1. To examine perceptions of farmers on demonstrated maize-based intercropping practices in relation to their current farm practices
2. To determine factors that influence farmers' willingness to adopt the demonstrated maize-based intercropping practices
3. To determine the potential net benefit of adopting the demonstrated maize-based intercropping practices

1.4 Hypotheses

The hypotheses tested in this study were:

1. Farmers that did not participate in farmer field demonstrations have negative perceptions on intercropping maize with other crops
2. Farmer's maize production objective (subsistence or commercial) significantly influences their willingness to adopt maize-based intercropping
3. The net benefit of maize-based intercropping is higher than maize sole cropping

1.5 Justification of the study

Changing agricultural farming systems to the benefit of smallholder farmers is important for Uganda. Previous research shows that intercropping comes with numerous benefits such as increased farm output and improvement in access to sufficient food for overall household consumption (Mutenje *et al.*, 2016; Nchanji *et al.*, 2016). However, depending on the composition of the intercropping practice, different inputs and management practices are required for a farmer to benefit. Therefore, a farmer would be willing to adopt an intercropping practice that best suits them.

Establishing farmers' perceptions of different alternatives gives insights into the unobserved factors that affect farmers' utility of the intercropping practices. The study provides an understanding of the farmers' perception of crop diversification through maize-based intercropping and the potential benefits that each practice would provide if it were adopted by a farmer. In that way, the most desired and efficient intercropping practices can be promoted through enhancement of the positive perceptions and reducing the negative ones. Failure to consider the farmers' perception would lead to wastage of government resources through the promotion of unsuitable combinations of crops. Finally, the study will help in improving the implementation of future interventions in the area and elsewhere.

1.6 Theoretical framework

Rational choices made by individuals or households are explained based on utility maximization Greene (2002). The random utility framework explains that an individual chooses an alternative among a set of possible outcomes, basing on the level of utility derived from that alternative. For this study, the expectation was that a given farmer would be willing to adopt a given intercropping practice that they think will give higher benefits than their current practices in terms of yield as well as potential to improve their income.

From the random utility model, a discrete choice model can be derived to model a farmer's choice to be willing to adopt a given maize-based intercropping practice. The study assumed that a farmer is exposed to choose between J intercropping practice alternatives, indexed j=1, 2, 3…, j.

Considering the utility level that a farmer *i* attaches to the jth demonstrated intercropping practice, which is unobserved, is given by U_{ij}. Whereas the utility that the farmer derives from their current practices is represented by U_o

Therefore, the net benefit(U^*_{ij}) that a farmer derives from adopting the jth intercropping practice is a latent variable determined by both observed and unobserved characteristics $\mathcal{E}_{ij}$ is given by:

$$U^*_{ij} = \mu_{ij} - \mathcal{E}_{ij} \qquad (1)$$

Where $\mu_{ij}$is a linear function of observable explanatory variables

$$\mu_{ij} = x'_{ij}\beta \qquad (2)$$

The probability that a farmer chose an intercropping practice *j* which maximizes his /her utility is such that;

$$P\{y_{ij} = j\} = P\left\{U_{ij} = max\{U_{i1}, \dots \dots, U_{iJ}\}\right\} \qquad (3)$$

$= p\{U_{\square j} - \mathcal{E}_{ij}\} > \{U_{ik} - \mathcal{E}_{ik}\}$

Where k=1…J

And k$\neq j$

$$P\{y_{ij} = j\} = \frac{exp\{U_{ij}\}}{exp\{U_{i1}\} - exp\{U_{i2}\} - \cdots . -exp\{U_{iJ}\}} \quad (4)$$

$$0 \leq P\{y_{ij} = j\} \leq 1$$

Such that;

$$\sum_{j=1}^{J} P\{y_{ij} = j\} = 1$$

$$\square\{y_{ij} = j\} = \frac{exp\{x'_{ij}\beta\}}{1 - exp\{x'_{i2}\beta\} - \cdots . -exp\{x'_{iJ}\beta\}} \quad (5)$$

$$U_{i1} is\ normalized\ to\ 0$$

Using the indicator function the unobserved willingness to adopt is a binary choice

$$Y = \begin{cases} 1 & if\ Y_{ij}^{*} > 0 \\ 0 & otherwise \end{cases} \quad (6)$$

Considering possible adoption of intercropping practices there simultaneously, the error terms jointly follow the multivariate normal distribution (MVN) where:

$$(U_{i1}, U_{i2}, U_{i3}, U_{i4}, U_{i5}) \sim \text{MVN } (0, \Omega)$$

and the assumes the covariance matrix below:

$$\Omega = \begin{bmatrix} 1 & \cdots & \rho_{15} \\ \vdots & \ddots & \vdots \\ \rho_{51} & \cdots & 1 \end{bmatrix} \quad (7)$$

The diagonal elements in the matrix are normalized to 1 for identification. The off-diagonal elements in the covariance matrix represent the unobserved correlation between the stochastic components of the farmer's willingness to adopt the different maize-based intercropping practices.

1.7 Conceptual framework

The conceptual framework for this study assumed that farmers' perceptions influence the choice of a given maize-based intercropping practice (Figure 3.1). A farmer who participated in the project activities formed perceptions about the intercropping practices. Farmers' stated willingness to take-up a given any of the maize-based intercropping practices is influenced by several factors that relate to the farmers' objectives and constraints linked to farming.

A farmer would choose an intercropping practice if the potential benefit of adopting outweighs the potential cost of not adopting. Furthermore, the study assumed that a farmer would choose to adopt if their expected utility of adopting an intercropping practice is higher than that of not adopting. Furthermore, the farmer's perceptions about the different attributes of the maize-based intercropping practice form part of the factors that drive their choice of a given maize-based intercropping.

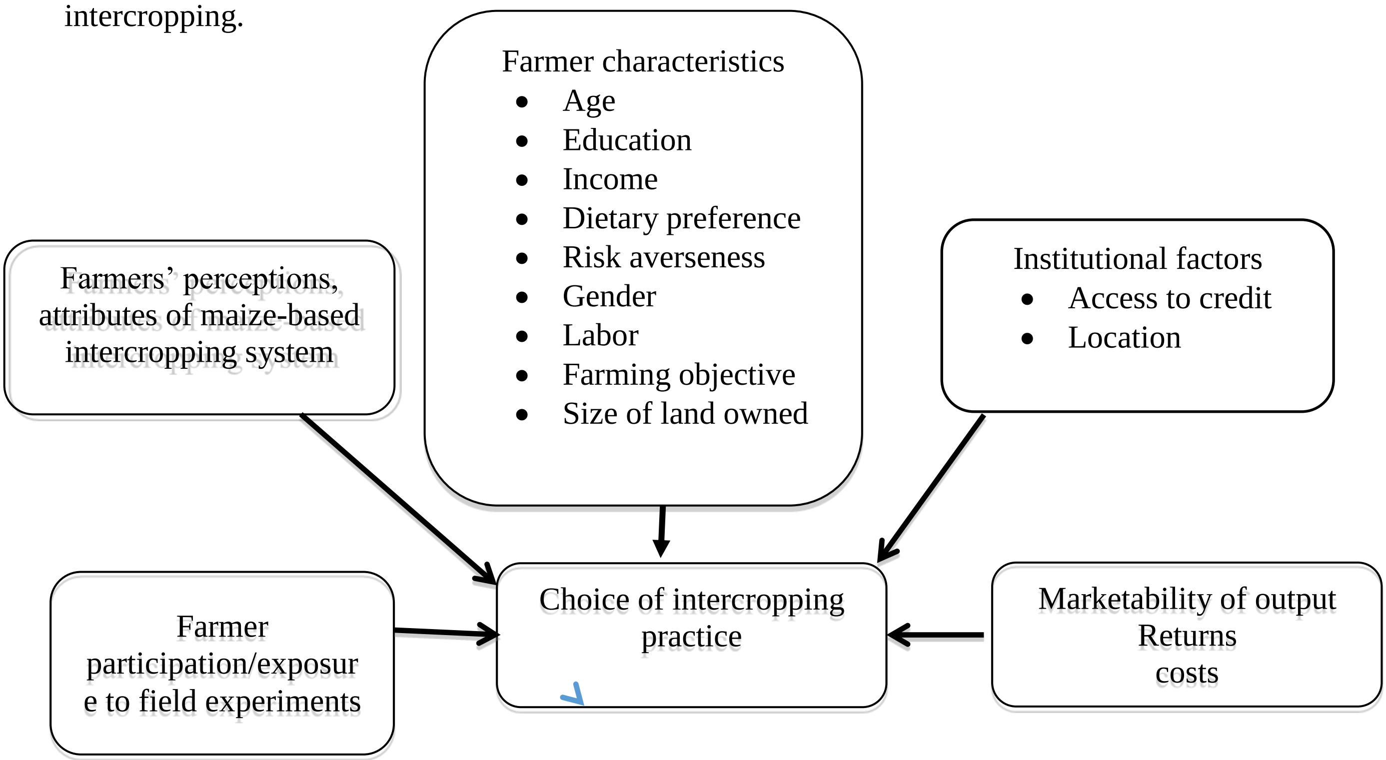


Figure 1. 2: The conceptual framework of the study

CHAPTER TWO

LITERATURE REVIEW

This chapter presents a review of literature on farmers' perceptions, choice of agricultural interventions, benefits of intercropping practices, and methods used to measure comparative gains from agricultural systems.

2.1 Why do farmers' perceptions of agricultural practices or technologies matter?

Perceptions refer to the way individuals receive, organize and interpret the particular event in their environment (Ali *et al.*, 2011). When an individual receives information about something new for example a new technology, it then forms the basis of the perceptions and attitudes this individual will have towards it (Meijer *et al.,* 2015). In the case for farmers, their perceptions about innovations are determined by the knowledge they have and past experiences. In agriculture, individual perceptions are used to explain the behavior towards the adoption of new technologies. A review of literature by Meijer *et al.*(2015) explained the importance of perceptions of potential adopters of new agricultural interventions. The authors rationalize that perceptions are intrinsic, but they are formed and tied to the extrinsic influences thereby rendering it indispensable to include them. Similar notions were shared by Mwangi and Kariuki (2015) specifying that farmers' perceptions are a prerequisite in the determination of a household's ability to take on innovations to improve agricultural production.

Lalani *et al.* (2016) discussed the importance of farmers' perception in decision-making, noting that perception may act as signals for farmers who have the intention to apply certain technologies in the future. Understanding how the beneficiaries perceive these different interventions can be used in identifying what expectations they have of the project and to what level have their expectations been met (Oladele and Fawole, 2007). Perceptions can further reveal the relationship between the individual choices of interventions, their attitudes, opinions, socio-cultural settings, and interventions, and how these relationships affect their behavior towards changing farming practices.

Empirical studies such as that by Gembloux *et al.* (2015) find that perceptions are associated with likelihood of adoption. The study assessed farmer's practices and willingness to adopt supplemental irrigation. Results revealed that farmers who did not perceive any changes in the occurrence of the dry spells have a lower probability of adopting. Thrupp (2000) suggests that involving farmers in different stages of intervention using participatory methods yields farmer enablement. Furthermore, it also results in the development of the most suitable practices in terms of agricultural production. Additionally, a recent study by Zeweld *et al.* (2017) revealed that farmers adopt technologies whose values suit their already present conditions. This means that understanding already present farming systems, farm practices, and socio-economic conditions is necessary.

Zeweld *et al.* (2017) highlights the importance of farmer perceptions in speculating adoption: In determining smallholder intentions of adopting row planting and minimum tillage as sustainable practices in an Ethiopian district, results of the study showed that farmers who had previously had obtained advice from extension workers had had a positive attitude towards adoption of the technologies. This result was linked to having prior information from extension workers who might have practically engaged the people during training and trials and therefore they had formed positive perceptions on the technologies thus influencing their decision to adopt (Zeweld *et al.,* 2017). Results by Thierfelder *et al.* (2013) also show that farmers' perception of benefits and costs associated with an intervention such as conservation agriculture and intercropping are likely to influence farmers' adoption of these interventions.

The importance of inclusion of perceptions of new agricultural technology adoption decisions has been researched (Adesina and Zinnah, 1993; Adesina and Baidu-Forson, 1995; Kikulwe *et al.*, 2011). For example, Adesina and Baidu-Forson (1995) found a positive correlation between farmers' perceptions of new sorghum varieties with the likelihood of their adoption. The authors found that farmers' judgment influenced the success of the innovations in the area they were introduced to. Likewise, empirical evidence also shows that the negative perception of the characteristics of the intervention reduces the likelihood of adoption Adesina and Zinnah (1993).

New interventions require different resources to implement them for example labor, whose availability varies from one household to another (Bonabana-Wabbi, 2002). The beneficiaries themselves can be a source such information got from experiences with the different interventions. Therefore, perceptions can provide some sort of feedback that can be used to better the process of finally adopting the innovations that best suit the people, their beliefs, and environment (Mwangi and Kariuki, 2015). Research by Chalak *et al.* (2017) found out that farmers' perceptions regarding the use of conservation agriculture as an intervention influenced its adoption. Significantly, farmers that believed conservation agriculture would lead to a yield increase had a higher likelihood to adopt than those who believed otherwise.

2.2 What drives farmers' choice of agricultural practices?

The adoption of agricultural technology is influenced by several factors which may be categorized into technological, economic, household-specific, and institutional factors (Akudugu *et al.*, 2012). Several studies in the past have modeled farmers' decision making processes when faced with new technologies. Variables that are frequently incorporated in the adoption models include; characteristics of the farmer, of the farm, technology attributes, institutional factors, and farmer perception of technology attributes.

Gender: Studies have found mixed results concerning gender and adoption of technologies. The roles of females and males differ, therefore the likelihood of adopting new intercropping practices is assumed to be equal. In addition, access to resources and cultural normal influence have been found to limit women's adoption of agricultural technologies (Carr, 2014). A study in Uganda found out that men have more opportunities to adopt drought tolerant maize varieties compared to women (Fischer and Doss, 2015). This result was attributed to the fact that men have more access to resources such as land, credit and information. Different results were found by Doss and Morris (2000) who revealed in their study of on adoption of agricultural innovations in Ghana, that gender has no relationship with the adoption of maize varieties or the use of fertilizers. Therefore, it is important to empirically test the influence of gender on adoption of agricultural practices in specific situations separately.

Age: The age of a farmer as a function of human capital plays an important role in influencing the farm decisions. Hall *et al.* (2009) found that the age of a farmer did not influence the likelihood of adopting sustainable horticulture practices. This is contrary to a recent finding by Karidjo *et al*. (2018), the study found out that age had a negative and significant effect on the adoption of soil and water reference technologies in Niger. The authors explain that the younger farmers were more willing to adopt the technologies because they ought to plan for their future since they are likely to face the problems as compared to the older counterparts. The research further revealed that access to information, knowledge, and types of innovation influenced their decision to adopt.

Although older farmers are likely to have more farming experience, their likelihood of adopting new cropping practices is low. Younger farmers are more open to new interventions since they are interested in achieving a secure future and therefore more willing to adopt compared to older farmers Mwangi and Kariuki (2015). Other studies such as that by Vera Castillo *et al.,* (2014) found out that a combination of factors such as market involvement, the existence of livestock on-farm, price and crop diversification significantly affected farmers' willingness to adopt physic nut. However, other factors such as the age of the farmer did not show any significant association with willingness to adopt although the younger farmers are expected to be open to taking up innovations compared to older counterparts.

Participation in technology demonstrations: Participation in field demonstrations is a proxy for awareness of technologies and practices. Olarinde *et al.* (2017) revealed that participation in the demonstration of multiple technologies had a significant positive influence on adoption. Farmers who participated in the farmer field demonstrations are expected to be positively associated with willingness to adopt the intercrops than non-participants. This is because the knowledge and experience that they have got from the training influences their attitude and thus desire to apply the proposed intercropping practices.

Location: A study by Leshem *et al.,* (2010) found that altitude was a significant factor that influenced farmers' choice of crop and consequently predisposed to what kind of agricultural innovation they would adopt. Therefore, farmers within a given location are more willing to adopt crops that thrive in their area as opposed to those crops that would not perform well given the environmental conditions of that particular area.

Farm size and number of parcels: Akudugu *et al.* (2012), discovered that farm size presented a highly significant association with willingness to adopt new technology. The study found out that large scale farmers are more likely to adopt new technologies than small scale farmers. Similar, farmers with more parcels of land are expected to be willing to adopt the demonstrated intercrops. Number of parcels of land owned is a measure of wealth for a household therefore it reduces on the potential risk by relaxing the financial constraints that would arise from adopting a new cropping practice. Feder and Umali (1993) note that other factors such as income, labor requirements and fixed costs influence the relationship between farm and risk.

Access to credit: Sanzidur and Chidiebere (2015) found that access to agricultural credit was a significant determinant of farmers' subsequent adoption of technologies. Farmers with access to credit are expected to have a positive influence on the proposed intercropping practices hence willing to adopt unlike those who are constrained.

Income: Deressa *et al.* (2008) found that increase in both farm and non-farm income significantly increased the likelihood of adopting multiple climate strategies. In most cases farmers engage in off-farm income income generating activities to offset farm costs. This study postulated that farmers with higher income were more willing to invest in a new venture and also would easily cope with problems associated with the new cropping practices as compared to farmers with less income.

Labor: The number of adults actively involved in farm activities is positively associated with willingness to adopt the demonstrated intercropping practices. Labor available in a given household also affects farmers' likelihood of taking up an intervention. McCord *et al.* (2015) found out that when farmers diversify, there is an increase in pesticide use and labor demanded. Furthermore, adoption resulted in male workload reducing unlike the that of females. Therefore, depending on the farmers' household characteristics farmers are faced with uncertainty about the outcomes and have to consider whether they can cope with the change from their practices to new intervention practices thus influencing their willingness to take-up the intervention. Intercropping is associated with increase in labor requirements (Yang *et al.*, 2018), therefore availability of labor would increase probability of adopting intercropping.

Expected benefits: Another factor that has been found to influences farmers' willingness to adopt interventions is the level of expected benefits from adoption (Akudugu *et al.,* 2012). This is explained by the fact that farmers' will determine whether the expected benefits of changing from their current practice to new ones will yield more benefits, if the result is positive then the likelihood of adopting is high. For example, a study in Ethiopia found that farmers' perception of grain yield and marketability were key variables in influencing adoption (Negatu and Parikh 1999). Farmers are willing to adopt a new intervention if they perceive its usefulness (Ayal and Filho, 2017). Although another study reveals that intervention usefulness alone can not influence its uptake especially if the crop involved is not a 'main crop' for the particular region (Vera Castillo *et al.,* 2014). Farmers also highly consider the crop's profitability and labor requirement as important factors.

2.3 Benefits of intercropping practices

Traditionally, most of the rural farms in Sub-Saharan Africa (SSA) are mixed farms (FAO, 2006). This is because of different reasons which include the need to stabilize food production and diversifying household diets (Sirrine *et al.*, 2010). Evidence from literature shows that multiple cropping is SSA is used as a strategy to minimize potential crop loss arising from uncertainties (Matusso *et al.,* 2014). In comparison to mono-crop farms, diverse farms have the potential to increase farmers' farm income, increase resilience and regulation of pests and diseases (McCord *et al.*, 2015).

In comparison to other technologies, intercropping is assumed to be less costly and yet has the potential to improve production sustainably. The importance of intercropping with leguminous crops has twin goals of providing nutrients as well as regulating soil conditions (Brooker *et al.,* 2015). For example, smallholder farmers in Uganda commonly grow the maize-bean intercrop to increase productivity as well as improve soil conditions through nitrogen fixation (Kasenge 2001).

To date, intercropping is long-standing crop practice that forms part of smallholder farming systems in rural communities in Uganda. Some of the common intercrops and their benefits that range from enhancing crop yields to improving the ecological environment are shown in Table 2.1. To add to the benefits, intercropping practices increase productivity per unit hectare of land at a given time as well as reduce the risk associated with crop production.

Table 2. 1: Some common intercrops in Uganda and their benefits

Intercrop	**Benefit**	**Author**
Maize-beans	Reduced nutrient decline	Kasenge (2001)
Maize-cowpea	Reduced pest infestation	Nampala *et al*. (2002)
Banana-coffee	Increased banana yield	Asten *et al.* (2011)
Sorghum-groundnut	High gross margins	Magino *et al.* (2004)
Sunflower-soybean	Efficient land utilization	Obong *et al.* (2016)

Smallholder farmers in the African region commonly grow the maize-bean intercrop to increase productivity as well as improve soil condition through nitrogen fixation. In comparison to mono-crop farms, diverse farms have been found to increase farmers' farm income, increase resilience and regulation of pests and diseases (McCord *et al.,* 2015). Furthermore, crop diversification through intercropping can be important in enhancing agricultural production in marginal lands (McCord *et al*., 2015).

The advantage of intercropping practices can be illustrated by comparing with monocrop of the component crops. A suitable example comes from a study conducted in Southern China that revealed that rubber monocultures had improved the economic status of farmers but made them more susceptible to not only economic but also environmental shocks (Min *et al.*, 2017). When intercrops of rubber-tea and rubber-maize were introduced to the farmers, it was found that these intercrops contributed about 16.5 percent to household income.

Farmers that had bigger sizes of intercropped plots obtained 10 percent more income than those with fewer intercropped plots (Min *et al.,* 2017). In most cases, intercropping systems have been observed to yield more than monocrops especially if different factors such as soil condition and plant nutrient requirements are considered before implementation (Karpenstein-Machan and Stuelpnagel, 2000). Further evidence of improved yield is found in Kheroar and Patra, (2013) who observed that in determining the effect of intercropping on the yield of maize as the main crop in maize-legume intercrop, there was a 7.05 percent and 10.69 percent increase in yield in 1:2 and 1:1 row proportion respectively in comparison to the sole stand of maize.

Research by Karpenstein-Machan and Stuelpnagel (2000) aimed at determining changes in biomass and nitrogen fixation by intercrops of legumes over five years found that although nitrogen fixation was higher in the pure stand of winter pea, the yield was higher in the intercrop. Furthermore, the research revealed that yields of crimson clover were more stable over the years compared to the monocrop. However, this was not for all crop combinations, as it was found out that some crop combinations had less stable yield and this was attributed to the fact that different crop combinations have differed in their competitive abilities. In such cases, the difference is mainly attributed to the fact that component crops either utilize different resources or similar resources at different times thereby reducing competition between the crops.

A review by Brooker *et al.* (2015) emphasizes the importance of selecting the right crop combinations that maximize positive effects in intercrops. When complementary effects occur between intercrops, they result in increased crop yields. For example, in maize-legume intercrops, the beans utilize captured solar radiation more efficiently than when grown solely (Brooker *et al.,* 2015).

Himmelstein *et al.* (2017) reviewed intercropping effects on yield, output, and gross income of Integrated Pest Management (IPM) practices in Africa, analyses showed that legume intercrops that were treated with pesticides, fertilizer, and no or minimum tillage resulted in lower yields compared to intercrops without these applications, however, higher yield were reported were herbicides were applied in the fields. Firstly, the results were attributed to improper management of the crops such as wrong application of the chemicals. Secondly, growing the intercrops with limited spacing leading to a reduction of the number of nutrients received per crop. This demonstrates the undesirable outcome of intercropping if implemented without thorough considerations.

2.4 Methods of measuring comparative gains from agricultural systems

Various methods have been used to compare the benefits of agricultural systems these include cost-benefit analysis, profitability analysis and partial budgeting. The use of these methods depends on an author’s objective. The partial budgeting method involves comparing the profitability of new technologies. The method further involves the calculation of the marginal rate of return, which illustrates what farmers expect from changing technologies. This method was used by Wagoire (2006) to compare methods used in the production of wheat in Uganda, the marginal rate of return was compared between improved varieties and landraces and the results showed that the former was more profitable giving a high MRR of 206 percent.

Shah *et al.* (2011) used a similar method to find out the marginal rate of return (MRR) on different gypsum treatments that were aimed at conserving soil moisture wheat under rain-fed conditions in Pakistan. The study that involved varying amounts of gypsum treatment found out that increasing the amount of gypsum per hectare from zero to 1.25 tons increased returns up to 119 percent but the increased amount of gypsum at the then market price to 2.5 ton per hectare realized much fewer returns. The analysis showed that marginal analysis could be used to establish what farmers who have the intention to adopt an intervention should expect in face of changing input prices. An acceptable minimum amount of return should be established, for as long as the cost of input is lower than that of the corresponding output, the intervention is likely to be adopted by the farmers.

Ekiyar (2003) applied the partial budgeting method to evaluate the use of integrated pest management technologies (IPM) in groundnuts and cowpea cultivation in Eastern Uganda. The study employed marginal rate of return approach to show the changes in net income as farmers shifted from one technology to another. The results of the study highlighted the fact that some IPM technologies were profitable and worth adopting were as others were not (Ekiyar 2003).

Olumide and Adewale (2013) used cost-benefit analysis to determine the profitability of certified cocoa in Ondo state in Ghana. Similarly, Kaizzi *et al.*, (2012) used the benefit-cost ratio to predict the costs and benefits in the use of fertilizers in Uganda's main maize production areas. The advantage of analyzing the costs and benefits related to the demonstrated intercropping systems is that the farmer gets an idea of whether they are likely to make a profit or loss in case of adoption. Furthermore, they would be able to determine whether the extra returns are more than the minimum returns acceptable to the farmers. Alvarado (2013) pointed out that obtaining the net benefits of an intervention is crucial for determining the opportunity cost as well as the willingness of the farmer to pay for it. Net benefits act as incentives for farmers to take-up a given intervention.

Marginal analysis has been used in agriculture to determine optimal farming practices and enterprises (Evans, 2018). It is used to assist farmers in allocating scarce resources to maximize the benefit from producing a given output. The marginal analysis involves a reference variable for which the concept focuses. The reference variable is increased or decreased until a point where the marginal benefits are equal to marginal costs, at this point the net benefits equate to zero. This is explained in a way that a farmer will continue to invest in a given intervention until a point is reached when the return of an additional unit added is equal to the cost of an additional unit.

Marginal benefits will equal the ratio of increase in total benefits to a unit of the reference variable. Similarly, marginal costs would equal the ratio of increase in total cost to a unit of the reference variable. Therefore, the change in net benefits would equal the difference between marginal benefit and marginal cost. Marginal analysis can also be used to compare the profitability of different enterprises over a period of time. An example is shown by De Groote *et al.* (2010) who used multi-period marginal analysis to evaluate the profitability of IPM technologies in *Striga hermonthica* infested areas of western Kenya over six seasons.

Evans (2018) explains that it is important to determine the minimum acceptable rate of return from adopting new technology from farmers' perspective. In this study, the marginal analysis method was used to measure the potential costs and benefits that the farmer would face if they choose to adopt a given maize-based intercropping practice.

Hein *et al.* (1997) used stochastic dominance analysis to rank the riskiness of phosphate fertilizer sources in Burkina Faso. The study applied cumulative distributions of yields to determine technologies that were dominated in a way that the technologies provided less desirable characteristics according to the farmer's objective. Therefore, for each objective of the farmer, different treatments were dominated by others that gave more value to the farmer. Dominance analysis has been used in research to provide the relative importance of predictors of dependent variables.

Tanyima (2015) also applied dominance analysis in comparing the profitability of different levels of fertilizer treatments for soybean in northern and eastern Uganda. A similar approach was used for this study: dominance analysis was done to eliminate the intercropping practices that had higher costs than monocropping but gave lower benefits. The intercropping practices were listed according to costs from lowest to highest and whichever had higher costs and lower benefits was dominated and excluded in the calculation of MRR.

CHAPTER THREE

METHODOLOGY

A description of the research area, research design, sampling procedure, the type of data, and method used in data collection are contained in this chapter. The different methods used in the analysis of the data collected are also discussed.

3.1 Description of the study area

This research was conducted in Kapchorwa district located in eastern Uganda. The district was chosen because it has low level of food self-sufficiency, low food diversity and high malnutrition that is above the national average (UBOS and ICF, 2018). Kapchorwa forms part of the Sebei sub-region which includes other two districts: Kween and Bukwo. The district is home to an estimated 105,186 people with a population density of 588 people per square kilometer (UBOS, 2014). Kapchorwa is divided into seven sub-counties, 39 parishes, and 291 villages (UBOS, 2014).

Household size averages to 4.8 persons per household. The district is at an elevation of about 1900m above sea level and receives a substantial amount of rainfall annually amounting to 1576mm. The average temperature experienced in the area is 18.5°C (MTIC, 2019). The district is also known to experience heavy rains between September and November months, characterized by high erosion and landslides thus threatening food security in the district (Oduol *et al.*, 2016).

Arabica coffee is the main cash crop grown in the district. Other crops grown include; bananas, onions, maize, potato, and beans. In the upper belt of the district, farmers grow a lot of potatoes and cabbages (mainly during the second season of October-December). Farmers in the lower and mid-lower belts mostly grow maize and bush beans. Subsistence agriculture is the main economic activity in Kapchorwa.

3.2 Research design

The study employed mixed approaches utilizing both quantitative and qualitative methods. Both experimental and cross-sectional designs were carried out. Experiments were setup in form of farmer field demonstrations (FFD) with plots of the different intercropping practices and farmers as active participants. Table 3.1 presents the practices that were demonstrated to framers through the FFDs. The HealthyLAND project was implemented specifically in three purposively selected sub-counties of Kaptanya, Tegeres, and Kapchesombe each located on different altitude. Kaptanya is located at a lower altitude, Tegeres in the mid-lower and Kapchesombe in the mid-upper belt of the highland. For each of the three sub-counties was established, one FFD was established.

Table 3. 1: Demonstrated intercropping practices per location

Location	Demonstrated practices
Lower (Kaptanya)	Maize-grain amaranth Maize-African eggplants Maize-pumpkin Maize-bush beans Maize-lablab
Mid lower (Tegeres) Mid upper (Kapchesombe	Maize-grain amaranth Maize-African eggplants Maize-pumpkin Maize-climbing beans Maize-lablab

Source: *HealthyLAND Project Technical Report (2017)*

Each of the plots in the demonstrations measured as shown in Table 3.2. The plots were randomized with two replications and two pure maize plots (see appendix III). Each farmer field demonstration had maize monocrop as reference plots within each block. As we shall see later in this thesis, comparisons were made between maize monocropping and each of the demonstrated intercropping practice. Maize was planted at a spacing of 75cm x30cm with two seeds per hill whereas companion crops: beans 30cm, lablab 60cm, pumpkin 100cm, grain amaranth 30cm, and African eggplants 75cm were planted between rows of maize. The experiments had two forms of arrangements for all crop combinations in main crop and companion crop row ratios: 1:1 and 2:1.

Table 3.2: Dimensions of the farmer field demonstrations

Location	Field dimensions
Lower-Kaptanya*	7m x 5m, 2m alleys between blocks and 1m alley between plots, 2 replications
Mid- lower Tegeres	8m x 4.5m, 2m alleys between blocks and 1m alley between plots, 2 replications
Mid upper-Kapchesombe	8m x 4.5m, 2m alleys between blocks and 1m alley between plots, 2 replications

Source: *HealthyLAND Project Technical Report (2017).* ** shape of plot affected size*

The lower FFD received 10 kg Di-ammonium phosphate (DAP), 30kg of Urea, 20 kg of Calcium Ammonium Nitrate (CAN) ,Vegimax Foliar fertilizer (5mls), Combination of Profenofos + Cypermethrin (30mls). The mid lower FFDF received 10 kg Di-ammonium phosphate (DAP), 30kg of Urea, 20 kg of Calcium Ammonium Nitrate (CAN) , Vegimax Foliar fertilizer (5mls), Combination of Profenofos + Cypermethrin (20mls) and Dimethoate. The mid upper FFD received 10 kg Di-ammonium phosphate (DAP), 50kg of Urea, 20 kg of Calcium Ammonium Nitrate (CAN) , Vegimax Foliar fertilizer (10mls), Combination of Profenofos + Cypermethrin (30mls).

The cross-sectional part of the study, a semi-structured questionnaire was designed to capture perceptions of both FDD participants and non participants. The questionnaire also included demographic variables, socio-economic characteristics of the farmers, farm production, access to credit and decision making.

3.3 Sampling procedure and sample size

To select the sample size for the study, it was intended that every farmer that participated in the farmer field demonstrations was interviewed. In each sub-county, a list of villages was obtained and a total of five villages were selected. Three villages of the five were purposively selected and two were randomly chosen. This was because the three purposively selected villages per sub-county were the ones with the farmers that participated in the farmer field demonstrations. The two villages in each sub-county that were randomly selected had farmers who did not participate in the field demonstrations. Table 3.3 presents the villages from which the study sample was drawn and the respective sub-counties.

Table 3. 3: Sub-counties and villages for the study sample

Sub-county	Villages	Category	Area
Kaptanya	Molok	Treatment	lower
Kaptanya	Toywo	Treatment	lower
Kaptanya	Chebirbei	Treatment	lower
Kaptanya	Kasus	Control	lower
Kaptanya	Kaptandar	Control	lower
Tegeres	Chemuron	Treatment	mid lower
Tegeres	Chebany	Treatment	mid lower
Tegeres	Seron	Treatment	mid lower
Tegeres	Kewe	Control	mid lower
Tegeres	Takwisa	Control	mid lower
Kapchesombe	Kapndaroi	Treatment	mid upper
Kapchesombe	Kawandai/bonio	Treatment	mid upper
Kapchesombe	Chebukat	Treatment	mid upper
Kapchesombe	Kapchesombe	Control	mid upper
Kapchesombe	Mutyoro A	Control	mid upper

Each field demonstration was limited to 15 farmers bringing the total number of participants from lower, midlower and mid upper areas to 45. Due to the limited number of farmers that took part in the field demonstrations, the number of participants for the study was purposively selected from a list that was provided by the project implementers. Out of 45 participants, only 39 farmers were interviewed because six farmers were not available for the interviews and some had moved to other areas outside the district for work.

For the non-participants, a list of farming households was constructed under the guidance of the local leaders in the respective village to produce a sampling frame from which a random selection of farmers was carried out. The sample sample size for the study was determined using the formula below.

Sample size calculation:

$$n = \frac{Z^2}{e^2}\left(\frac{p.q.N}{(N-1)+Z^2.p.q}\right)$$ (Banda *et al.* 2015)

where;

n was the sample size determined,

p= proportion of farmers in Kapchorwa, a proportion of 0.85 (UBOS 2014)

q = the proportion of non-farming households;

Z=was the standard deviation at a given confidence level (i.e. 95 per cent in this study) equal to 1.96, *e* was the acceptance error (0.05)

N=5,352, the estimated number of households in the selected sub-counties,

estimated sample size =196 households.

Only 136 interviews were conducted because many of the farmers were not available for the interviews. A total of 97 non participants were interviewed. Of these 28 questionnaires were discarded during the data cleaning process due to missing information (some of the respondents had attended FFDs once did not have information) bringing the total to 69. The total of non participants included 41 farmers who were from the same villages as those who participated in the farmer field demonstration and 28 farmers who were from villages outside the demonstrations villages and never participated. In this study, the 41 non-participant farmers were referred to as "indirectly exposed" since they were in the same villages as participants (exposed). The 28 farmers from the villages other than those of the exposed group were referred to as the "non-exposed" since they were not exposed to the field demonstrations. This brought the total number of respondents in the study to 108 farmers. Table 3.4 shows the number of farmers sampled disaggregated by location, gender and respondent category.

Table 3. 4: Number of farmers in the study sample per area

Location	**Female**		**Male**	**Total**
Lower (Kaptanya)	23		12	35
Mid lower (Tegeres)	31		4	35
Mid upper (Kapchesombe)	31		7	38
Total	**85(78.7)**		**23(21.3)**	**(100)108**
Number of farmers per respondent category				
Location	**Exposed**	**Indirectly exposed**	**Non exposed**	**Total**
Lower (Kaptanya)	15	12	8	35
Mid lower (Tegeres)	13	10	12	35
Mid upper (Kapchesombe)	11	19	8	38
Total	**39**	**41**	**28**	**108**

The figures in the brackets are percentages

3.4 Data collection and data type

This research used both secondary and primary data. The secondary data were taken from the HealthyLAND project data set: these data include information about the farmer field demonstrations inputs such as seed and fertilizers, weeding, and yield. The project data used in this study were collected within the period April 2017 and September 2017.

Primary data collected in December 2017 was both qualitative and quantitative in nature. A total of eight Focus group discussions (FGDs) were carried out. Due to the interactive nature of FGDs, it is considered to be an effective method of data collection for people’s perceptions (Marris *et al.*, 2001).

FGD participants were randomly selected from the HealthyLAND farmers' list. In each of the farmer field demonstration sub-counties, two FGDs were carried out and the venue was in the village where a farmer field demonstration was implemented. Of the two FGDs per area, one was for farmer field demonstration participants and another for non-participants. A total of 40 farmers participated in the FGD discussions: 15 farmers in the lower belt (Kaptanya), 13 in the mid-lower (Tegeres), and 12 in the mid-upper belt (Kapchesombe). The FGD participants that participated in the farmer field demonstrations ranked the performance of each intercropping practice on a scale of 1 to 5 where 1=very poor, 2=poor, 3=fair, 4=good, and 5=very good.

Individual interviews were conducted using semi–structured questionnaires. A team of experienced enumerators who understood the local language collected data under my supervision. The enumerators underwent training about the objectives of the research to ensure that the questions were correctly translated from English to the local language (Sabiny) while maintaining the original meaning of the question. Data collected included socio-economic characteristics of households, current farming practices, the yield from farmer field demonstrations, and perceptions on maize-based intercropping. Interviews were recorded, transcribed, and analyzed. Additional observational information of the demonstrations particularly regarding labor recorded by farmer field demonstrations' manager was used.

3.5 Data analysis

Data collected were coded entered into Statistical Package for Social Scientists (SPSS) software then edited and cleaned. SPSS was used to analyze the descriptive statistics, whereas STATA software was used to investigate the factors that influence farmers' willingness to adopt maize-based intercropping. Multicollinearity of the independent variables was tested using inflation factors and it was found to be non-existent (see Appendix IV).

3.5.1 Determining farmers' perceptions of maize-based intercropping

The study assumed that each farmer's perceptions contribute largely to the formation of preferences based on the different attributes of the cropping practice such as the crop combinations, layout/arrangement, marketability of output, and yield. For ranking preferences, a weighted average rank (WAR) was used to rank the maize-based intercropping practices according to their preference. The weighting preferences has previously been used to analyze farmers' climate change adaptation strategies (Fagariba *et al.* (2018); Ndamani and Watanabe, (2015)). In this study, the WAR was used to analyze farmers' preferences of the demonstrated maize-based intercrops.

For preferences, a 5-point Likert scale was used rank of intercropping practice as follows: most preferred was given a weight of five (5), second-most preferred was given a weight of four (4), third-most preferred was given a weight of three (3), second least preferred was given a weight of two (2) and the least preferred was given a weight of one (1). The weights are attached in descending order representing the relative importance attached to each rank of preference starting from most preferred.

The formula is given as below.

$$WAR = \frac{\Sigma F_i i}{\Sigma i} \tag{8}$$

Where;

F is the number of farmers that ranked an intercrop

i is the rank position

A given rational farmer would rank an intercropping practice j higher than an alternative k if $U_{ij} > U_{ik}$

Farmers were further asked to express their perceptions of different attributes of the maize-based intercropping practice in comparison to maize monocrop. The attributes as shown in Table 3.5 included: match to household consumption preference, profitability, market availability, the total cost of seed per acre, fertilizer requirement, herbicide requirement, time spent managing crop, and technical skills required.

For perceptions a 3-point Likert scale was used. The farmer response options were on a scale of one to three, where 1 represented more, two represented less, three represented equal and farmers were also given a choice to indicate "I do not know", especially because crops like lablab were new to majority of the farmers. Descriptive statistics such as means and frequencies were used to describe farmers' perceptions. Cross tabulations were used to analyze the different relationships between socio-economic characteristics, preferences, farmers' perceptions of farmer field demonstration participants and non-participants.

Table 3. 5: Variables used to measure farmers' perceptions on maize-based intercropping

Variable name	Definition of variable
Labor requirement	Planting costs, weeding costs, Harvesting costs
Cost of inputs	The cost of required inputs (seeds, fertilizers, and insecticides) per ha
Marketability	Availability of market for crop
Land size	Suitability of land size
Quantity of inputs	Amount of inputs (seeds, fertilizers, and insecticides) required
Consumption preferences	Matched preference to with those demonstrated crops
Knowledge and skills about management	Sufficient knowledge to manage the proposed intercrops
Profitability	Intercropping practice is profitable
Yield	The expected yield per ha is higher compared to own practice
Production Risk	risk of loss due to pest and diseases

3.5.2 Determining factors that influence farmers' willingness to adopt maize-based intercropping practices

This study assumes that the differences in the socio-economic and location factors are likely to influence what choice of intercropping practice a farmer would choose among the demonstrated alternatives. To determine the factors that influence individual farmer's choice of intercropping practice from those that were displayed in the farmer field demonstrations, a discrete choice is estimated. Farmers had binary responses (yes willingness to adopt=1, no =0) for the five categories of intercropping practice. Logit and Probit models can be used to predict the discrete outcomes however, the two models differ in assumptions in distribution.

A farmer had five intercropping practices for which they had to express their willingness to adopt. Using the random utility framework, a farmer is likely to adopt a given intercropping practice if the utility derived from adoption is higher than not adopting. The utility derived by a farmer from each practice is a function of observed characteristics of the farmer, the intercropping attributes, and the unobservable error term. Empirically, a farmer's choice could be modeled using the multinomial regression analysis or the multivariate analysis.

However, there are restrictions for both methods. Multinomial regression undertakes the assumption of independent irrelevant alternatives, if not achieved it would lead to inconsistent and inefficient estimates. By contrast, the multivariate regression analysis allows for a correlation between random error terms. Farmers are willing to adopt multiple intercropping practices simultaneously. The choices for the 5 intercropping practices are not mutually exclusive leading to possible correlation of the random error terms. Although as we shall see later in the thesis, the fifth intercropping practice was eliminated from the model. The multivariate probit model allows for jointly predicting correlated binary outcomes in choices. The model is adopted from Rahman and Chidiebere (2015) who studied factors that influence decisions to adopt modern technologies in Nigeria.

Dependent variable

The dependent variable in the model was a categorical variable with five choices of maize-based intercropping practice. However, only four categories were included in the model: maize-African eggplant, maize-grain amaranth, maize-pumpkin, and maize-lablab. Maize-beans category was excluded because almost every farmer was willing to adopt the practice. Therefore, there was no variation in analysis. The choices among the intercropping practices were not mutually exclusive since farmers would state their willingness to adopt all five practices simultaneously.

The empirical model was specified as:

$$\mathcal{Y}^* = \beta_\circ + \beta_1 GENDER + \beta_2 AGE + \beta_3 EXP + \beta_4 EDUC + \beta_5 PARTI + \beta_6 LOC + \beta_7 INTER + \beta_8 OBJ + \beta_9 PARCEL + \beta_{10} LOBOR + \beta_{11} CREDIT + \beta_{12} lnINCOME + \beta_{13} RISK \varepsilon_\circ$$

$$Y_{i1} = X'_{ij1}\beta 1 - \varepsilon_{i1}$$

$$Y_{i2} = X'_{ij2}\beta 2 - \varepsilon_{i2}$$

$$Y_{i3} = X'_{ij3}\beta 3 - \varepsilon_{i3}$$

$$Y_{i4} = X'_{ij4}\beta 4 - \varepsilon_{i4}$$

Where,

Y_{i1} = 1 if a farmer is willing to adopt maize-pumpkin, 0 if otherwise

Y_{i2} = 1 if a farmer is willing to adopt maize-African eggplants, 0 if otherwise

Y_{i3} = 1 if a farmer is willing to adopt maize-grain amaranth, 0 if otherwise

Y_{i4} = 1 if a farmer is willing to adopt maize-lablab, 0 if otherwise

β = a vector of unknown parameters to be estimated, ε is the error term

X’ = a vector of explanatory variables shown in Table 3.5 that are the same for all intercropping practices

$\mathcal{Y}^*$ = is the marginal probability of adopting a given maize-based intercropping practice

Table 3. 6: Definition of explanatory variables for multivariate probit regression

Variable	Variable name	Variable Description	Expected Sign
X1	GENDER	Dummy, (1=male, 0=female)	+/-
X2	AGE	continuous variable measured in the number of years	-
X3	EXP	Farming experience. Continuous variable measured in number of years	+
X4	EDUC	Continuous variable, number of years spent in school	
X5	PARTI	Dummy, if respondent participated in the field demonstration (1=yes, 0=no)	+
X6	LOC	Location: Dummy, (1=Mid lower/Tegeres 0=otherwise)	+/-
X7	INTER	Previously intercropping maize. Dummy, (1=intercropping, 0=otherwise)	+/-
X8	OBJ	Farming objective. Dummy variable, (1=subsistence only,0=otherwise)	+
X9	PARCEL	Number of parcels	+
X10	LABOR	Number of adults active on the farm	+
X11	CREDIT	Access to credit. Dummy, (1=access,0=otherwise)	+
X12	INCOME	Continuous variable, household annual income	+
X13	RISK	Dummy, 1=perceived high output risk, 0=otherwise	

3.5.3 Determining the net benefits of adopting maize-based intercropping

The marginal analysis was used to determine the net benefits of the maize-based intercropping practices. The marginal analysis concept was birthed by economists William Stanely Jevons, Carl Wenger, and Leon Walras to explain human rationality in decision-making through marginalism (Bloch, 2012). The theory suggests that individuals decide on obtaining a good or service depending on the additional utility they would derive from it. The advantage of marginal analysis as a decision-making tool, is that it determines the optimal level of production. When marginal benefits are higher than marginal costs, investing more in production would result into greater net benefits and the benefits are at maximum when marginal revenue equals marginal cost (Evans, 2018).

In this study, the assumption is that given the proposed intercropping practices, there are added costs or reduced revenue and likewise reduced costs and /or added revenue that is associated with adoption. The sum of added costs and/ or reduced revenue would represent the opportunity cost faced by farmers in case they are to adopt any of the intercropping practices that were demonstrated.

$$OP_i = AC_i + RR_i \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (9)$$

where,

OP= opportunity cost (Shs ha^{-1})

AC= Added costs (Shs ha^{-1}),

RR= Reduced revenue (Shs ha^{-1})

i= maize-based intercropping practice

On the other hand, the sum of added revenue and reduced cost represents the total debits gained by farmers in case of adopting the intercropping practices.

$$TD_i = AR_i + RC_i \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (10)$$

Where,

TD= Total debits (Shs ha^{-1}),

AR= Added revenue (Shs ha^{-1})

RC=Reduced costs (Shs ha^{-1})

The potential net benefits (NB) to a farmer from a given intercropping practice were the comparative economic gain of adopting an intercropping practice instead of monocropping and it was calculated as:

$$NB_i = (AR_i + RC_i) - (AC_i + RR_i) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots. (11)$$

The different costs that were considered for this study included; the cost of seed, labor, and cost fertilizers. The benefits were determined by calculating the value of the output from the farmer field demonstrations.

Marginal analysis was done in a stepwise manner from lower cost intercropping practice to high cost. A farmer would choose a cropping practice with higher costs as long as the rate of return is higher than the minimum acceptable rate of return. Basing on that, to determine potential net benefits change with change in farmers' practices, the marginal rate of return (MRR) was calculated as in Mubanderi *et al.* (1999). MRR attained by changing from monocropping maize to maize-based intercropping practice was calculated as:

$$MRR_i = \frac{(AR_i + RC_i)}{(AC_i + RR_i)} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (12)$$

An MRR of 100 percent means that for each additional shilling that a farmer spends on inputs of a given maize-based intercropping, they would expect one shilling in return. Therefore, a system with an MRR of 100 percent and greater is profitable and can be recommended to the farmers. Marginal benefits were calculated in terms of added yield and marginal costs in terms of added costs as a result of implementing intervention practices. The advantage of using this method for this study is that it considers only costs that vary and therefore can be changed or altered. This method was to enable the promotion of the most profitable systems that are more likely to be adopted by farmers.

To establish the comparative benefits of the different maize-based intercropping practices, production costs and yield data from the farmer field demonstration plots were used. The production costs included land rent, cost of seed, cost of fertilizers, and cost of pesticides. The prevailing market prices of the output in the area at the time of harvest were used. Maize was at Shs. 800 per kg, pumpkin was at Shs. 500 per kg, beans at Shs. 1500 per kg, both amaranth leaves and African eggplants Shs1000 per kg. The price for lablab was zero because farmers did not attach any value to it since their cows did not like it. Therefore, under total revenue for maize-lablab intercrop, only revenue from maize was computed. Data were collected at the plot level and recorded.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Socio-economic and socio-demographic characteristics of farmers based on location

Table 4.1 presents a comparison of characteristics between farmers located at the three different altitudes in Kapchorwa (lower belt, mid-lower, and mid-upper). The mean number of years of schooling for the household head was found to be significantly different at a five percent significance level across the belts. Farmers from the mid-upper belt were found to have spent more years at school than the farmers from lower and mid-lower belts.

There was a significant difference between the average yield of maize from the previous season (Season A 2017) across locations. The mid-upper belt had the highest yield at 1,116 kg per hectare, followed by mid lower and lower had the least. The age of the farmer, household size, farming experience, number of years of schooling, price of maize per kilogram, and size of cropland were not significant across the locations. The mean annual income and quantities of maize produced from the previous harvest were found to be significantly different at a five percent significance level ($p<0.05$). Farmers from the mid-upper belt were found to have a higher annual income than that of mid-lower and lower belts. The mean age of farmers in mid-lower was higher than that of lower and mid-upper, although not significantly different at a five percent significance level ($p>0.05$).

Table 4. 1: Socio-economic and socio-demographic characteristics of farmers by location

	Lower (n=35)	Mid lower (n=35)	Mid upper (n=38)		
Variables	Mean	Mean	Mean	F-value	p-value
Age of farmer (years)	34.7	35.5	32.7	0.388	0.233
Household size (numbers)	6.6	6.7	6.1	1.120	0.330
Number of adults living in the house (numbers)	2.3	2.4	2.20	2.580	0.081
Farming experience (years)	12.4	12.6	10.6	0.720	0.489
The educational level of household head (years)	8.2	9.3	10.7	3.260	0.042
Years of schooling (years)	8.7	8.2	8.5	0.160	0.850
Annual income (million Shs)	2.1	3.1	4.2	0.049	0.001
Maize yield (kg/ha)	564.1	734.5	1,116.6	2.600	0.080
Maize price (Shs/kg)	836	842	840	0.010	0.995
Size of cropland (ha)	2.0	2.4	1.9	0.520	0.595

Source: Field Survey data 2017

4.2 Socio-economic and socio-demographic characteristics of farmers

Table 4.2 presents a description of the general differences between farmers who participated in the farmer field demonstrations (directly exposed) and non-participants (indirectly exposed and non-exposed). Household annual income and size of cropland were significantly different variables across group categories of farmers. Indirectly exposed farmers were found to have a higher income than the exposed and non-exposed farmers' groups. Results also showed that farmers from the non-exposed group were found to have a higher average size of cropland than other farmers in the exposed and indirectly exposed groups. There were no significant differences among the farmer groups in their age, education level, and years of experience in farming.

The farmer household size averaged six persons across the different categories of farmers. The number of people living in each household indicates the availability of labor for the household. The results showed that most of the households had other sources of income other than farming, 73.53 percent of the farmers mentioned farming as their main source of income and only four percent had casual labor as their main income source. The average quantities of maize produced by farmers and prices at which the different groups of farmers sold the previous harvest were not significantly different (p>0.05).

Table 4. 2: Socio-economic characteristics of farmers by group category

	Exposed (participants) (n=39)	**Indirectly exposed (n=41)**	**Non exposed (n=28)**		
Variables	**Mean**	**Mean**	**Mean**	**F-value**	**p-value**
Age of farmer (years)	33.79	49.00	34.57	0.539	0.834
Household size (numbers)	6.48	6.82	6.31	0.566	0.330
Number of adults who are active on-farm (numbers)	2.32	2.39	2.20	0.684	0.151
Farming experience (years)	11.37	12.81	11.71	0.392	0.563
Educational level of household head (years)	8.75	9.53	8.63	0.796	0.804
Years of schooling (years)	8.73	8.16	8.51	0.345	0.983
Annual income (million Shs)	2.74	3.44	3.19	0.694	0.008
Maize yield (kg/ha)	873.14	811.87	815.87	0.864	0.882
Maize price (Shs/kg)	840	812	880	0.526	0.298
Size of cropland (ha)	0.79	0.87	1.04	0.337	0.000

Source: Field Survey data 2017

Results of the study revealed that farmers in all the three locations were largely subsistence (Table 4.3). Most farmers either grew maize for subsistence only or both subsistence and commercial purposes. However, the lower belt had a slightly lower percentage of farmers who grew maize for subsistence purposes only compared to the mid-upper and mid-lower belts. Although the mid-upper belt has the highest average yield per hectare among the locations, it had the least percentage of commercial-only farmers. This is inconsistent with research by Woldeyohanes *et al*. (2016) who found that holding other factors constant, farmers that produced more were more likely to participate in the crop market.

Table 4. 3: Farmer's objectives for growing maize by location

Location	**Objective for growing maize** *Percentage of farmers per location*			
	Subsistence	**Commercial**	**Both commercial and subsistence**	**p-value**
Lower(n=35)	38.2	5.9	55.9	0.328
Mid lower(n=35)	48.4	12.9	38.7	0.275
Mid upper(n=38)	55.9	2.9	41.2	0.335

Source: Field Survey data 2017

These results show that even with increased maize production, farmers in Kapchorwa maintain large portions for household subsistence or still participate less in commercialization. These farmers in mainly grow maize for food and are likely to be lacking connections to maize markets due to poor infrastructure. Although the majority of the farmers are not commercially oriented, they subsequently end up selling part of their produce in storage when they need cash to meet needs like healthcare.

Intercropping of maize was practiced by 69.9 percent of the respondents (Table 4.4). This result implies that more than half of farmers already practice maize intercropping with different crops like bananas. The highest proportion of farmers that practiced maize intercropping was from the lower belt with 82 percent of farmers and the lowest at 50 percent for the mid-upper belt. This could be because of the difference in altitude, the mid-upper belt is on a higher altitude and therefore colder than the lower and mid-lower. Therefore, farmers in Kapchesombe tend to prefer to grow other crops like potatoes, which is largely monocropped hence the preference of the practice. African eggplants were grown by only 17 of the respondents and none of them grew it alone but rather intercropped randomly in banana plantation because it has been found to thrive well in that arrangement.

Table 4. 4: Percentage of farmers that intercropped selected demonstrated crops

Crop	**All locations**	**Percentage of farmers by location**		
		Lower	**Mid lower**	**Mid upper**
Maize	69.90	82.35	77.42	50.00
Beans	72.57	88.24	71.43	58.06
Pumpkin	36.10	50.00	25.00	33.33
African eggplants	71.12	66.67	80.00	66.67

Source: *Field survey data 2017*

It was also observed that 25 percent of the farmers that intercrop planted the main crop in the same hole as the companion crop, particularly for maize and beans. The main reasons given for this practice were that it saves time when planting and some noted that it was just a common practice though they are aware that there were no yield advantages to it. This practice affects the yield negatively because of the intercrop competition due to the reduced space between crops.

On the other hand, farmers gave various reasons for intercropping maize and beans (Figure 4.1), majority of the respondents considered ease of management in terms of weeding, spraying as a main reason for intercropping (40 percent). It was found that better yield was given as the main reason by both farmers that monocrop and those that intercrop maize. However, the number of farmers that believed monocrop of maize yields more than intercrop was higher by 19.21 percent.

Other reasons are given for intercropping included, crop diversity, minimization of resources. These are consistent with the advantages of intercropping provided in the literature (Lithourgidis *et al.* 2011; Tignegre *et al.* (2018); Kermah *et al.* (2017). Of the 64 percent of farmers that practiced maize intercropping, four percent mentioned that intercropping is a known practice that they learned from their parents and that was the main reason to carry out the practice.

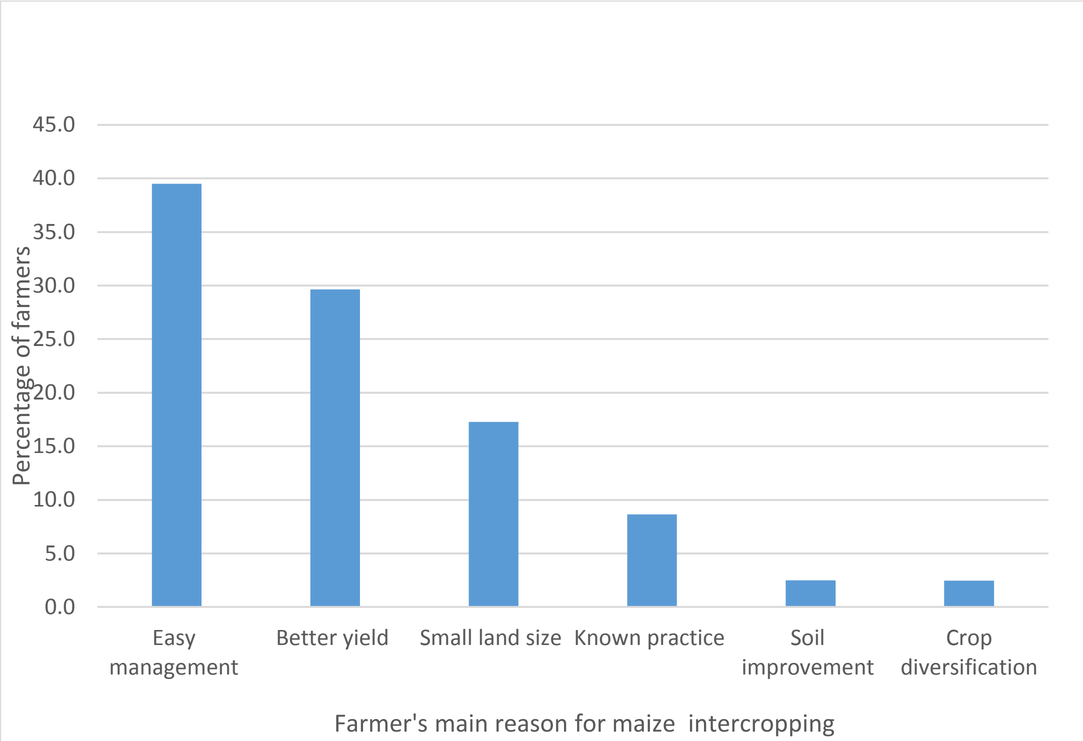


Figure 4. 1: Farmers' main reason for intercropping maize

Table 4.5 presents major crop production and market constraints to farming ranked by farmers in the different locations. Although the constraints were generally similar in all three locations, they varied in terms of perceived severity in each area. This implies that farmers in the different areas have varied problems that present potential threats to the willingness to adopt intercropping practices. Farmers in the lower belt stated that pests and diseases whereas the mid-lower belt reported prolonged drought as major constraints, this suggests that the same intercropping practices would require different levels of management practices to ensure efficient cropping systems across the different areas in Kapchorwa.

Table 4. 5: Rank of major constraints to farming in the different locations

Major constraint	Rank per location		
	Lower	Mid lower	Mid upper
Pests and diseases	1	4	4
Prolonged drought	2	1	2
Lack of capital	3	5	1
Low market prices	4	-	-
Poor roads	5	-	5
Counterfeit inputs	6	3	-
Crop theft	7	7	6
Excess rain and flooding	8	2	-
Cheating middlemen	-	-	-
Shortage of labor	-	6	-
Poor soil fertility	-	-	3

Source: Focus group discussions, 2017

4.2.1 Farmer perceptions of the demonstrated maize intercropping practices

Table 4.6 presents farmers' performance rating of each of the maize-based intercropping practices in the three locations. In the lower belt, farmers rated the performance of maize-bean intercrop as very good due to the absence of competition for nutrients between the component crops. The performance of maize crop in the maize-grain amaranth intercrop was rated as poor. The maize-lablab intercrop was also rated as poor. Farmers perceived that the intercrop results into in the reduction of maize yields compared to maize monocrop.

This was because farmers perceived the winding of lablab on maize as strangulation that could potentially affect the maize yield. Farmers in the lower belt also perceived inadequate spacing between maize-pumpkin resulted in poor performance of the intercrop. The poor performance of maize-African eggplants intercrop was attributed to the poor germination rate of the African eggplants.

The results also showed that farmers from the mid-lower belt rated low performance of maize-African eggplants, maize-grain amaranth, and maize-lablab. This was attributed to perceived poor soil fertility in the field demonstration area. The farmers from the mid-upper belt also stated that the soils in their area are not fertile thus leading to the poor performance of most of the intercrops demonstrated. These farmers' perception results give insight into an apparent soil fertility problem in the mid-lower and mid-upper belts.

Table 4. 6: Farmers' ranking of the performance of the demonstrated practices

Intercropping practice	Lower belt	Mid lower belt	Mid upper belt	Overall average score
Maize-beans	5	5	4	4.6
Maize-African eggplants	2	2	5	3.0
Maize-pumpkin	2	5	5	4.0
Maize-grain amaranth	2	2	2	2.0
Maize-lablab	2	2	2	2.0

1=very poor 2=poor 3=fair 4= good 5=very good. *Source: Focus group discussions, 2017*

Table 4.7 presents farmers' perceptions of the different attributes of the intercropping practices. The results of the study showed that for maize-beans, all farmers regardless as whether they were exposed or non-exposed to the demonstrations, they mentioned that the crop combination matched their household consumption preference. This is consistent with Vera Castillo *et al.* (2014) who argue that farmers choose to mix crops that either has high demand or are domestically consumed. Therefore, they need to grow crops that their household members prefer to consume.

Similarly, all farmers regardless of the farmer category perceived that they had enough knowledge to grow the maize-bean intercrop. This is probably because maize and beans are staples in Kapchorwa. Farmers were found to have a positive perception of the profitability of maize-bean intercrop. All the directly exposed farmers (100 percent) perceive the maize-bean intercropping practice to be profitable, 92 percent of the directly exposed and 96.4 percent of farmers from the non-exposed group.

Results of the study revealed that 92 percent of farmer field demonstration participants agreed that the intercrop of maize-African eggplants met their preference of what their households consume. Possession of enough knowledge to grow the intercrop was found to be a significant variable at one percent significant level across the groups. Furthermore, a higher percentage of farmers from the non-exposed group perceived to have sufficient knowledge to grow maize-African eggplants compared to participants. This could be because African eggplants as the sole crop are not new to farmers and therefore, it was easy for farmers to have a positive perception about the intercrop. These results suggest that farmers regardless of whether they participated in the field demonstrations have positive perceptions about the maize-African eggplants intercrop.

The results indicate that a greater number of farmers that participated in the farmer field demonstration (26 percent) mentioned that their size land was small or inadequate for maize-African eggplants. The farmers that grew African eggplants reported that eggplants need a lot of space to grow and that the demonstrated intercrop would not favor proper growth of the crop. All farmers that grew African eggplants only planted them in a banana plantation or around their rubbish pit but not with maize. These results suggest that farmers grow African eggplants but they are perceived as not a good companion crop for maize and land size is likely to be a limitation to the production of African eggplants.

The majority of the farmers had positive perceptions about the maize-pumpkin intercrop. Farmers mentioned that both crops were part of the household diet and that they possessed the skills to manage the intercrop. This result was similar across the different groups of farmers. However, the perception of profitability of the intercrop was found to be significant at one percent and the appropriateness of the land size at five percent across groups. Compared to non-participants and group farmers, only 67 percent of participants agreed with maize-pumpkin being a profitable intercrop while 69 percent believed that the intercrop is appropriate for their land size. This is because with the demonstrations, pumpkin performed poorly and mainly fruits that were harvested came from the plot boundaries.

The study results show that most of the farmers had negative perceptions about maize-lablab because it was new to them. This is likely to negatively influence farmers' willingness to adopt maize-lablab intercrop. This result is consistent with Yap *et al.* (2016) who found that among alternative intercrop combinations introduced in Northern Thailand, only three percent of farmers had adopted maize-lablab intercrop because they lacked knowledge of experience with the legume. As the results reveal, only 3.6 percent of the non-exposed farmers believed they had the skills to grow the maize-lablab intercrop. Close to half of the participants reported that they were confident that they had got enough knowledge from the farmer field demonstrations to grow the maize-lablab intercrop. These results suggest that access to information about lablab is important in influencing farmer perceptions of maize-lablab intercrop.

Table 4. 7: Farmer perceptions of the demonstrated maize-based intercropping

Intercropping practice attribute	Percentage of farmers that said "yes" Exposed	Indirectly Exposed	Non-exposed	F-value	p-value
Maize -beans					
Household consumption preference	100.0	100.0	100.0	-	-
I have the technical skills required to grow the crops	100.0	100.0	100.0	-	-
It is a profitable practice	92.0	100.0	96.0	1.66	0.054
Crop practice is appropriate for my land size	100.0	100.0	74.0	-	-
Maize-African eggplants					
Household consumption preference	92.3	100.0	100.0	2.8	0.066
I have the technical skills required to grow the crops	82.6	95.4	89.7	7.3	0.001
It is a profitable practice	79.5	92.7	82.1	1.5	0.002
Crop practice is appropriate for my land size	74.4	97.6	100.0	9.2	0.000
Maize-pumpkin					
Household consumption preference	97.4	100.0	100.0	0.9	0.417
I have technical skills required to grow the crops	89.4	100.0	100.0	3.8	0.025
It is a profitable practice	69.2	97.6	85.7	4.7	0.002
System is appropriate for my land size	66.7	90.2	85.7	5.4	0.017
Maize-grain amaranth					
Household consumption preference	94.8	100.0	92.9	1.4	0.417
I have technical skills required to grow the crops	84.6	95.4	89.7	2.0	0.137
It is a profitable practice	66.7	90.2	89.3	6.7	0.000
Crop practice is appropriate for my land size	79.5	97.6	100.0	6.5	0.001
Maize-lablab					
Household consumption preference	18.0	31.7	3.6	4.5	0.000
I have technical skills required to grow the crops	41.0	31.7	3.6	6.5	0.002
It is a profitable practice	35.9	56.1	32.1	2.6	0.950
Crop practice is appropriate for my land size	59.0	73.2	53.6	1.6	0.732

Source: Field Survey data 2017

Table 4.8 presents farmers' perceptions across locations. Results showed that there were no significant differences in farmer perceptions for maize-beans intercrop across the three locations. Specifically, there were no variations in perceptions on household consumption preference, knowledge to grow the crops, and suitability of the land. The results showed that there were variations in farmers' perception of profitability, but it was not significant between the locations. Results of the maize-African eggplants intercrop revealed that there were no significant differences between the variations in perceptions across farmers from the three locations. All the farmers from the mid-upper belt revealed that the crop combination matched their household consumption preference whereas only 94 percent of farmers from lower and 97 percent from mid-lower noted the same.

The results showed that a low percentage of farmers had positive perceptions about maize-lablab. Only 8.9 percent of farmers from the lower belt agreed that the intercrop corresponded to what their preferred household to consume. Slightly higher percentages with similar perceptions were found in mid-lower (22.9 percent) and mid-upper (26.3 percent) areas. On the suitability of the maize-lablab intercrop to the farmer's size of land, 76 percent of farmers in the lower belt perceived that their land size is suitable although the percentages of farmers from mid-lower (57.1 percent) and mid-upper (57.9 percent) were lower. These results imply that if farmers were to adopt the intercrop, farmers in the lower belt are likely to devote bigger portions of their cropland to maize-lablab intercrop compared to the farmers from the mid-lower and mid-upper belts.

Table 4. 8: Farmer perception on maize-based intercropping practice by location

Maize-based Intercropping practice attribute	Percentage of farmers that said "yes"			F-value	p-value
	Lower	ML	MU		
Maize-beans					
Household consumption preference	100.0	100.0	100.0	-	-
I have the knowledge required to grow the crops	100.0	100.0	100.0	-	-
It is a profitable practice	97.1	91.4	100.0	1.94	0.148
Crop practice is appropriate for my land size	100.0	100.0	100.0	-	-
Maize-African eggplants					
Household consumption preference	94.3	97.1	100.0	1.09	0.339
I have the knowledge required to grow the crops	100.0	80.6	91.4	0.01	0.119
It is a profitable practice	85.7	80.0	89.5	0.64	0.528
Crop practice is appropriate for my land size	85.7	94.3	89.5	0.70	0.501
Maize-pumpkin					
Household consumption preference	100.0	97.1	100.0	1.04	0.356
I have the knowledge required to grow the crops	91.4	97.1	100.0	1.94	0.148
It is a profitable practice	85.7	74.3	84.2	0.89	0.413
Crop practice is appropriate for my land size	85.7	91.4	84.2	0.42	0.638
Maize-grain amaranth					
Matches household consumption preference	97.1	97.1	94.7	0.20	0.823
I have the knowledge required to grow the crops	91.4	91.4	92.1	0.01	0.966
It is a profitable practice	82.9	82.9	82.8	0.14	0.866
Crop practice is appropriate for my land size	91.4	91.4	92.1	0.01	0.966
Maize-lablab					
Household consumption preference	8.6	22.9	26.3	2.04	0.135
I have the knowledge required to grow the crops	25.7	31.4	26.3	0.17	0.927
It is a profitable practice	45.7	37.1	44.7	0.31	0.981
Crop practice is appropriate for my land size	74.3	57.1	57.9	1.42	0.719

Source: Field Survey data 2017. ML=midlower, MU=Midupper

It is interesting to note that some of the perception variables for example profitability of farmer and technical skills for the new intercrops such as maize-African eggplants, maize-lablab, the profitability of the crop practices was significant across farmer categories but not significant across the locations. This suggests that other factors held constant, participation in the farmer field demonstrations had a significant effect on farmer perceptions on the maize-based intercropping.

In capturing, farmer perceptions of the attributes of demonstrated maize-based intercropping, farmer preferences were revealed by ranking from most preferred to the least preferred. Maize-beans were the most preferred intercropping practice while maize-lablab was least preferred across all the locations (Table 4.9). This result was similar to those across the exposed, indirectly exposed and non-exposed groups whereas, maize-lablab was the least preferred intercropping practice.

Maize-beans were the most preferred intercrop because maize and beans are staples for the people in Kapchorwa hence the preference. Maize-lablab was the least preferred intercropping for all three locations probably because it was a new crop to almost all farmers. In the mid-lower belt, maize-grain amaranth was least preferred compared to maize-pumpkin. This could be because farmers perceived a low value for grain amaranth compared to the pumpkin. Few farmers noted that a pumpkin with considerable weight could be sold at Ugandan shillings 5000/- and therefore fetches a better income for the farmer compared to grain amaranth. Overall, maize-beans were the most preferred intercrop.

Table 4. 9: Farmers' preferences of demonstrated intercropping practices

Location	Intercropping practice	Frequency of rank					Weighted Average Rank	Overall rank
		5	4	3	2	1		
Lower	Maize-beans	33	1	1	0	0	36.4	1
	Maize-African Eggplants	0	15	12	4	3	20.8	3
	Maize-pumpkin	0	5	8	23	1	10.8	4
	Maize-grain amaranth	2	12	14	8	0	23.2	2
	Maize-lablab	0	2	0	0	35	7.8	5
Mid lower	Maize-beans	30	3	0	2	1	33.6	1
	Maize-African Eggplants	2	12	8	11	2	21.2	2
	Maize-pumpkin	1	10	13	10	1	21.0	3
	Maize-grain amaranth	1	9	11	10	4	19.6	4
	Maize-lablab	1	1	3	2	28	10.0	5
Mid upper	Maize-beans	35	1	0	1	1	36.6	1
	Maize-African Eggplants	1	15	18	3	1	25.2	2
	Maize-pumpkin	1	5	7	24	1	19.0	4
	Maize-grain amaranth	1	17	12	7	1	24.8	3
	Maize-lablab	0	0	1	3	34	9.0	5

The rank 5=most preferred intercrop while 1= least preferred. *Source: Field Survey data 2017*

The results (Table 4.10) show that farmer field demonstration participants perceive equal labor requirements for both maize monocrop and the intercrop with beans. This perception slightly differs from results reported by Witcombe *et al.* (2008) who revealed that the requirements for post sowing maize-legume intercrop were equal to those of the monocrop although after sowing the labor required for managing the intercrop reduces. However, the majority of the farmers from the non-exposed group think that the maize-bean intercrop requires more labor.

Similar results were reported by Yang and Chai (2018) who revealed that maize-pea intercrop had over 50 percent higher labor requirements in comparison to sole maize. This could be due to the differences in the actual intercrop layout between farmers' and the demonstrated layout.

Table 4.10 showed that all farmers perceive reduced bean yield with the intercrop as compared to monocrop. A previous study by Tsubo *et al.* (2005) also found similar results that indicated reduced yield of beans in the maize-bean intercrop. The majority of the farmers mentioned that with maize-bean intercropping, there is less time spent managing the crop in terms of weeding and spraying since they can happen for both crops at the same time. Results show that 87 percent of farmers from the non-exposed group perceive reduced incidence of pests in maize intercrop while a lower percentage of 66 percent of participants perceive the rate to be equal. A lower number of participants for this positive perception would be because of the incidence of fall armyworms that infested the demonstration fields at the time of the experiments.

The results show that more farmers from the exposed(participant) category perceive less yield of African eggplants from maize-African eggplants intercrop as compared to the non-participants. Furthermore, more farmers from the non-participant category perceive that less time is spent managing the African eggplants in the intercrop as compared to participants. The majority of the farmers from the non-exposed category perceive that the maize-African eggplants intercrop has a high incidence of pests. This implies that farmers in Kapchorwa have both positive and negative perceptions about maize-African eggplants intercrop.

The results of the study also show that farmers from all categories perceive more yield of maize from maize-grain amaranth intercrop than sole maize, although the percentage of participants is lower than non-participants. On the other side, farmers perceive reduced yield of grain amaranth from intercropping with maize as compared to sole cropping of grain amaranth.

The results of the study indicated that for the maize-pumpkin intercrop, most farmers across the categories perceive less physical labor required for the intercrop in relation to their practices. Furthermore, the results showed that farmers perceive a high yield of maize from the intercrop as compared with their practices.

Table 4. 10: Farmer perceptions of maize-based intercropping by farmer category

	Percentages of farmers per category											
	Exposed				Indirectly exposed				Non-exposed			
Attribute	**More**	**Less**	**Equal**	**I don't know**	**More**	**Less**	**Equal**	**I don't know**	**More**	**Less**	**Equal**	**I don't know**
Maize-beans												
Physical labor requirement	30.8	23.1	43.6	2.6	48.8	36.6	14.6	0.0	82.1	10.7	7.1	0.0
Maize yield	48.7	20.5	25.6	5.1	95.1	2.4	2.4	0.0	85.7	14.3	0.0	0.0
Bean yield	23.1	41.0	30.8	5.1	7.3	92.7	0.0	0.0	10.7	89.3	0.0	0.0
Time spent in managing maize	23.1	23.1	51.3	2.6	85.4	14.6	0.0	0.0	85.7	14.3	0.0	0.0
Time spent in managing beans	20.5	20.5	56.4	2.6	4.9	95.1	0.0	0.0	25.0	71.4	3.6	0.0
Incidence of pests	12.8	28.2	56.4	2.6	7.3	46.3	53.7	0.0	25.0	50.0	25.0	0.0
Maize-lablab												
Physical labor requirement	30.8	30.8	15.4	23.1	0.0	0	36.6	63.4	7.1	10.7	3.6	78.6
Maize yield	53.9	10.3	10.3	25.6	4.2	2.4	63.4	0.0	17.9	0.0	0.0	82.4
Lablab yield	7.7	53.9	12.8	25.6	2.4	39.0	0.0	58.5	0.0	21.4	0.0	78.6
Time spent in managing maize	18.0	35.9	28.2	18.0	36.6	9.8	0.0	53.7	21.4	0.0	0.0	78.6
Time spent in managing lablab	10.3	43.6	23.1	23.1	0.0	0.0	46.3	53.7	0.0	21.4	0.0	78.6
Incidence of pests	10.3	38.5	30.8	20.5	0.0	24.4	342	41.5	0.0	28.6	3.6	67.9
Maize-African eggplants												
Physical labor requirement	33.3	41.0	23.1	2.7	9.8	85.4	4.9	0.0	10.7	75.0	14.3	0.0
Maize yield	61.5	18.0	15.4	5.1	95.1	4.9	0.0	0.0	75.0	25.0	0.0	0.0
Eggplant yield	7.7	64.1	20.5	7.7	97.6	2.4	0.0	0.0	10.7	89.3	0.0	0.0
Time spent in managing	23.1	23.1	51.2	2.6	85.4	14.6	0.0	0.0	85.7	14.3	0.0	0.0

maize												
Time spent in managing African eggplants	20.5	46.1	30.8	2.6	2.4	97.6	0.0	0.0	17.9	78.6	3.6	0.0
Incidence of pests	12.8	38.5	41.0	2.7	2.4	53.7	43.9	71.4	28.6	0.0	0.0	0.0
Maize-grain Amaranth												
Physical labor requirement	41.0	35.9	20.5	2.6	9.8	80.5	9.8	0.0	25.0	67.9	7.1	0.0
Maize yield	59.0	12.8	23.1	5.1	100.0	0.0	0.0	0.0	75.0	25.0	0.0	0.0
Amaranth yield	10.3	59.0	23.1	7.7	2.4	97.6	0.0	0.0	7.1	92.0	0.0	0.0
Time spent in managing maize	28.2	33.3	35.9	2.6	90.2	9.9	0.0	0.0	82.1	17.9	0.0	0.0
Time spent in managing grain amaranth	25.6	43.6	28.2	2.6	2.4	95.1	2.4	25.0	78.4	3.7	0.0	0.0
Incidence of pests	7.7	41.0	48.7	2.6	2.4	51.2	46.3	7.1	64.3	28.6	0.0	0.0
Maize-pumpkin												
Physical labor requirement	33.3	46.2	18.0	2.6	7.3	87.8	4.9	0.0	10.7	78.6	10.7	0.0
Maize yield	66.7	10.3	18.0	5.1	97.6	2.4	0.0	0.0	71.4	28.6	0.0	0.0
Pumpkin yield	10.3	64.1	15.4	10.3	2.4	97.6	0.0	0.0	7.1	92.9	0.0	0.0
Time spent in managing maize	30.8	41.0	25.6	2.6	90.2	9.8	0.0	0.0	89.3	10.2	0.0	0.0
Time spent in managing pumpkin	12.8	56.4	25.6	5.1	4.1	92.7	2.4	0.0	17.9	78.6	3.6	0.0
Incidence of pests	7.7	48.7	41.0	2.6	2.4	51.2	46.3	0.0	0.0	71.4	28.6	0.0

More, less, equal and I don't know to refer to farmer perception on a given attribute on a demonstrated intercrop in comparison to farmer's practices. Source: Field Survey data 2017

Table 4.11 presents farmer perception by location. Results show that for maize-beans intercrop, the majority of the farmers from all the locations perceive higher labor requirements for the intercrop than farmers' own crop practices. Farmers also perceived increased maize yield from the intercrop compared to their practices although the percentage of farmers from the mid-upper belt was lower compared to mid-lower and lower belts. Results also revealed that farmers generally have a negative perception about the performance of beans under the demonstrated intercropping practices. Furthermore, over 70 percent of farmers in each location revealed that they perceive reduced bean yield compared to their practices of growing beans.

The results also indicate that under the demonstrated intercrop, farmers perceived that more time was likely to be spent managing the maize for example during weeding as farmers have to take caution not to damage the beans. Also, most farmers mentioned that the time spent managing the bean would be less because the presence of beans suppresses weeds. Some farmers explained that this would be because both the maize and beans would be weeded at the same time. The majority of farmers from the lower and mid-lower belts mentioned that the rate of incidence of pests under the demonstrated practices is the same as in farmers' own crop practices. However, 47 percent of farmers believed that there was less incidence of pests under the demonstrated practice.

Results indicate that for maize-lablab intercrop, the majority of the farmers did not know the physical labor required for the intercrop since it was new to them. Although the results show that 20 percent of farmers in lower and mid-lower belts perceive that the intercrop requires more labor than maize monocrop. Most of the farmers were unfamiliar with lablab explains why farmers mentioned that they did not know about the attributes of the intercrop. The results also show that 34 percent of the farmers in the lower belt perceived less pest infestation with the intercrop of maize-lablab as compared to sole maize.

This result is consistent with an observation by one of the farmers in the lower belt that mentioned that he witnessed less fall armyworm infestation in the plots that had lablab compared to other intercrops in the demonstration field.

Farmer perceptions results revealed some insights. First, maize-bean intercrop was the most preferred across farmer categories and locations. Most likely because both maize and beans are frequently grown and consumed in most households in Kapchorwa. Secondly, farmers stated that household consumption preference, expected yield, and profitability were the most important crop attributes, this explains why most farmers grew maize for both subsistence and commercial reasons. Thirdly, the results revealed that regardless of the farmer category and location, farmers had both positive and negative perceptions about intercropping maize with other crops. Therefore, the hypothesis that farmers have negative perceptions about intercropping maize with other crops does not hold. Lastly, there were significant differences in farmers' perceptions across the different categories but not across locations. It can be assumed that farmers that were exposed to field demonstrations had perceptions that differed from those of other farmers.

Table 4. 11: Farmer perceptions of maize-based intercropping by location

	Percentage of farmers per location											
	Lower (Kaptanya)				Mid lower (Tegeres)				Mid upper (Kapchesombe)			
Attribute	**More**	**Less**	**Equal**	**I don't know**	**More**	**Less**	**Equal**	**I don't know**	**More**	**Less**	**Equal**	**I don't know**
Maize-beans												
Physical labor requirement	48.6	25.7	25.7	0.0	48.6	22.9	28.6	0.0	55.3	26.3	15.8	2.6
Maize yield	88.8	8.6	2.9	0.0	71.4	17.1	8.5	2.9	68.4	10.5	18.4	2.6
Bean yield	20.0	74.3	5.7	0.0	14.3	71.4	11.4	2.9	7.9	73.7	13.8	2.6
Time spent in managing maize	60.0	17.1	22.9	0.0	54.3	32.4	14.3	0.0	73.7	5.3	18.4	2.6
Time spent in managing beans	17.1	54.3	28.6	0.0	17.1	65.7	17.1	0.0	13.2	65.7	18.4	2.6
Incidence of pests	8.6	51.4	60.0	0.0	22.9	22.9	51.4	2.9	10.5	47.4	42.1	0.0
Maize-lablab												
Physical labor requirement	20.0	20.0	5.7	54.3	20.0	28.7	11.4	40.0	0.0	34.2	2.6	63.2
Maize yield	40.0	2.9	2.9	54.3	42.9	5.7	5.7	45.7	28.9	5.3	2.6	63.2
Lablab yield	2.9	42.9	5.7	42.9	8.6	42.9	5.7	42.9	0.0	34.2	2.6	63.2
Time spent in managing maize	22.9	14.3	14.3	48.6	28.6	22.9	11.4	37.1	26.3	13.2	5.3	55.3
Time spent in managing lablab	2.9	31.4	11.4	0.0	5.7	48.6	8.6	37.1	2.6	36.8	5.3	55.3
Incidence of pests	5.7	34.3	25.7	34.3	5.7	20.0	28.6	45.7	36.9	21.1	42.1	0.0
Maize-African eggplants												
Physical labor requirement	22.9	62.9	14.3	0.0	22.9	60.0	17.1	10.5	76.3	10.5	2.6	0.0
Maize yield	82.9	14.3	2.9	0.0	74.3	17.1	5.7	2.6	76.3	13.2	7.9	2.6
Eggplant yield	8.6	85.7	5.7	11.4	77.1	5.7	5.7	0.0	0.0	86.8	10.5	2.6
Time spent in managing	60.0	25.7	14.3	68.6	22.9	8.9	0.0	0.0	71.1	15.8	10.5	2.6

maize												
Time spent in managing African eggplants	17.1	68.8	14.3	0.0	14.3	74.3	11.4	0.0	7.9	79.0	10.5	2.6
Incidence of pests	8.6	62.9	28.6	0.0	8.6	34.3	48.6	8.6	0.0	53.0	39.5	0.0
Maize-grain amaranth												
Physical labor requirement	80.0	8.6	11.4	0.0	74.3	17.1	5.7	2.9	81.6	7.9	7.9	2.6
Maize yield	8.6	85.7	5.7	0.0	11.4	77.1	5.7	5.7	0.0	86.8	10.5	2.6
Amaranth yield	60.0	25.7	14.3	0.0	68.6	22.9	8.6	0.0	71.1	15.8	10.5	2.6
Time spent in managing maize	17.1	68.6	14.3	0.0	14.3	74.3	11.4	0.0	76.3	13.2	7.9	7.4
Time spent in managing grain amaranth	22.9	62.9	14.3	0.0	17.1	68.6	14.3	0.0	10.5	79.6	7.9	2.6
Incidence of pests	5.7	57.1	37.1	0.0	8.6	37.1	51.4	2.9	2.6	57.9	39.5	0.0
Maize-pumpkin												
Physical labor requirement	22.0	68.6	8.6	0.0	25.7	60.0	14.3	0.0	5.3	81.6	10.5	2.6
Maize yield	8.5	82.9	8.6	0.0	5.7	80.0	8.5	5.7	5.3	84.2	7.9	2.6
Pumpkin yield	22.9	62.9	14.3	0.0	17.1	68.6	14.3	0.0	7.9	81.6	7.9	2.6
Time spent in managing maize	62.9	25.7	11.4	0.0	68.6	22.9	8.6	0.0	73.9	15.8	7.9	2.6
Time spent in managing pumpkin	14.3	71.4	11.4	2.9	11.4	74.3	14.3	0.0	7.9	81.6	7.9	2.6
Incidence of pests	5.1	65.7	28.6	0.0	5.7	40.0	51.4	2.9	0.0	60.5	39.5	0.0

More, less, equal and I don't know to refer to farmer perception on a given attribute on a demonstrated intercrop in comparison to farmer's practices
Source: Field Survey data 2017

4.3 Farmers' willingness to adopt different maize intercropping

Table 4.12 presents the differences in farmers' willingness to adopt different demonstrated intercropping practices across the lower, mid-lower, and mid-upper belts. Results indicate that with exception of maize-bean and maize-African eggplants intercrops, farmers from the lower belt had the lowest percentages of farmers willing to adopt maize-pumpkin, maize-grain amaranth, and maize-lablab.

Table 4. 12: Percentage of farmers willing to adopt the demonstrated maize-based intercropping

	Location				
Intercropping practice	**Lower**	**Mid lower**	**Mid upper**	**F-value**	**p-value**
Maize-beans	100.00	100.00	100.00	-	-
Maize-grain amaranth	37.50	73.33	91.67	0.530	0.591
Maize-pumpkin	37.50	73.33	50.00	0.840	0.434
Maize-lablab	25.00	53.33	33.00	1.980	0.143
Maize-African eggplants	50.00	66.67	50.00	0.550	0.577

Source: Field Survey data 2017

Results show that 37 percent of farmers in the lower belt were willing to adopt maize-grain amaranth, yet it was the second most preferred crop in the belt after maize-beans. This could be explained by the negative perception reported by the 87 percent of farmers in the lower belt that the maize-grain amaranth intercrop results in reduced maize yield compared to farmer's practices. Farmers from the three locations did not know lablab before the farmer field demonstrations, even with the participants who had a chance to get information about it still felt that the information and knowledge they had gained about the crop was not enough for them to grow it at the time.

Farmers that were willing to adopt the intercropping practice raised concerns about access to planting materials in their local area, seeds in particular since it was a new crop in Kapchorwa.

Table 4.13 presents farmers' willingness to adopt the intercropping practices based on farmer category. The results show that all farmers within the three categories of farmers sampled were willing to adopt maize-beans intercrop demonstrated. This was expected because maize is a staple for the region and is widely intercropped with beans in the area. The results showed significant differences between groups in regards to the willingness to adopt maize-pumpkin and maize-lablab ($p<0.05$).

Table 4. 13: Percentage of farmers willing to adopt the demonstrated maize-based intercropping by farmer category

	Farmer category				
Intercropping practice	**Exposed**	**Indirectly exposed**	**Non-exposed**	**F-value**	**p-value**
Maize - beans	100.0	100.0	100.0	-	-
Maize - grain amaranth	73.3	91.7	37.5	2.140	0.122
Maize - pumpkin	73.3	50.0	37.5	6.550	0.002
Maize - lablab	53.3	33.0	25.0	5.650	0.047
Maize - African eggplants	66.7	50.0	50.0	1.410	0.248

Source: Field Survey data 2017

The percentage of farmers willing to adopt maize-pumpkin and maize-lablab was higher among farmer field demonstration participants than the non-participants. This could be due to the positive perceptions from participating in the field demonstration training. There were no significant differences between percentages of farmers willing to adopt maize-grain amaranth and maize-African eggplants although the percentage of participants who were willing to adopt maize-African eggplants was slightly lower than that of maize-grain amaranth.

These results suggest that potential adoption of the maize-based intercropping practices vary between farmer group categories. Maize-bean has the highest potential adoption across all farmer categories whereas maize-lablab has the lowest.

4.4 Factors that influence farmer's willingness to adopt the demonstrated maize-based intercropping

Table 4.14 presents the categorization of farmers who are willing to intercrop maize or modify their intercropping practice to what had been proposed for them based on whether they had previously grown maize as a monocrop or as an intercrop. The results reveal that 83.33 percent of farmers that had previously monocropped are willing to intercrop maize with beans. Almost all farmers that were already practicing maize intercropping were willing to modify their practice to what had been taught by the HealthyLAND project (93 percent).

Table 4. 14: Percentage of farmers willing to intercrop or modify the intercropping practice

Intercropping practice	Percentage of farmers willing to adopt	
	Previously Monocropping maize	Previously intercropping
Maize-beans	83.33	92.75
Maize-pumpkin	33.33	56.52
Maize-African eggplants	63.33	46.38
Maize-grain Amaranth	76.67	73.91
Maize-lablab	40.00	43.48

Source: Field Survey data 2017

The results also show that only 33 percent of farmers that were previously intercropping maize are willing to intercrop maize with pumpkin whereas a higher percentage (57) of those already intercropping were willing to adopt the practice.

This could be because the combination of maize-pumpkin did not perform well. Therefore, results suggest that fewer farmers are willing to invest in the cropping system since it yields less of the companion crop as compared to growing sole pumpkin.

About 46 percent of the farmers already intercropping maize were willing to grow maize - African eggplants and 63 percent of those who practiced maize monocrop were willing to adopt. This could be because of the poor performance of the African eggplants in the intercrop. Just like the pumpkin, the African eggplants did not grow well. In addition to that, some farmers thought that African eggplant seed was of poor quality and the crop was not given enough time to reach maturity.

Both farmers that monocropped and those that intercropped maize were willing to adopt maize and grain amaranth (77 percent and 74 percent respectively). This could be because grain amaranth performs very well especially when the rains are available. The grain amaranth leaves can be harvested earlier as the crop is growing, this makes it a desirable characteristic of the crop hence more farmers are willing to grow the crop combination.

The results also show that only 40 percent of the farmers that previously monocropped were willing to intercrop maize-lablab whereas 43.5 percent of those that previously intercropped maize were willing to modify or improve the practice to follow what was demonstrated by the HealthyLAND project. This could be because lablab was not familiar to most farmers and probably the farmers need further training for them to choose to grow the intercrop. Furthermore, currently, there is no market for lablab in the area and therefore there is little or no incentive for farmers to adopt the intercropping cropping system of maize-lablab.

Table 4.15 presents pairwise correlations between the different maize-based intercropping. A strong correlation between willingness to adopt maize-grain amaranth and that of maize-pumpkin was found with a significance of p=0.000. Similarly, a 78 percent correlation is found between the adoption of maize-lablab and maize-African eggplants. These results justify the use of the multivariate probit model in determining the factors that influence the choice of intercropping practice by the farmer. The error terms in the farmer choices are significantly correlated.

All the correlation coefficients have positive signs implying complementarity between the intercropping practices. If the correlations were negative, it would imply substitutability (Teklewold *et al.* 2013; Kibrom *et al.* 2016). Therefore, this means that the willingness to adopt one makes it more likely to adopt another practice. This could be because farmers would prefer to adopt more than one intercropping practice to spread the risk associated with the new practice. More to that, farmers derive different benefits from different crops and therefore willing to take on more intercropping practices.

Table 4. 15: Correlations between intercropping practices

Pairwise intercropping correlations	Coef.	p-value
ρ_{21}	0.348	0.029
ρ_{31}	0.756	0.000
ρ_{41}	0.221	0.194
ρ_{32}	0.528	0.001
ρ_{42}	0.757	0.000
ρ_{43}	0.292	0.107

1=Maize -pumpkin, 2=maize-African eggplant, 3=maize – grain amaranth, 4=maize – lablab.
Source: Field Survey data 2017

Using the Multivariate Probit model (MVP) to analyze factors that influence farmers' willingness to adopt the demonstrated intercropping practices, the maize-beans category was eliminated because almost most all farmers (99%) from the three locations were willing to adopt the intercropping practice. In that way, there was no variation amongst farmers as regards willingness to take-up the practice. The results are summarized in Table 4.17.

Participation in the HealthyLAND project agricultural intervention was found to be significant for farmers' willingness to adopt maize-pumpkin. A positive significant coefficient implies that farmers that participated in the demonstrations were more willing to adopt the intercrop than non-participants. This finding is consistent with Olarinde *et al.* (2017). The study results could be explained from the farmer perceptions results that showed that the majority of demonstration participants perceive less time is spent managing the maize under the maize-pumpkin intercrop. In comparison, non-participants did not know the practice, therefore, perceived it to be time costly hence not willing to adopt the maize-pumpkin intercrop.

The study results also show that income was significant in influencing willingness to adopt maize- pumpkin. The negative coefficient indicates that an increase in farmer's income reduces willingness to adopt maize-pumpkin intercrop. This could be because of the negative perception about the crop combination. The study found many of the farmers in Kapchorwa believed that maize-pumpkin were not compatible crops in a way that maize would suppress the pumpkin leading to poor yield. Additionally, the crop combination presents difficulty during the harvest of maize, the pumpkin is prone to be trampled on and destroyed. This can be shown in the numbers of farmers willing to adopt, only 32 percent of farmers from the non-exposed group were willing to adopt. Therefore, with increased income farmers are likely to invest in ventures other than the ones they perceive to bring fewer returns. This finding is consistent with those found by Herath and Tekeya (2003).

Results of the study also show that participation in the demonstrations significantly influenced farmers' willingness to adopt maize-African eggplants. A positive significant coefficient implies that farmers that participated in the field demonstrations were more likely to adopt maize-African eggplants compared to non-participants. This could be because 89 percent of non-participants perceive that the intercrop results in reduced yield of African eggplants compared to what their practices like intercropping with bananas would yield.

Farmer's objective was found to be a significant variable in influencing farmer's willingness to adopt the maize-African eggplants intercrop. The negative significant coefficient implies that farmers that grew maize for subsistence purposes only were less likely to be willing to adopt maize-African eggplants compared to their commercial only or both commercial and subsistence-oriented counterparts. Results of the study revealed that 75 percent of the farmers grew African eggplant and 86.7 percent grew them for home consumption only. Table 4.16 showed that 71.1 percent of those farmers were intercropping the African eggplant. Therefore, one possible rationale for the results of the MVP model is that farmers that are purely subsistence preferred to grow the African eggplant in a different arrangement other than with maize.

Table 4. 16: Factors affecting farmers' willingness to adopt selected demonstrated maize-based intercropping: A Multivariate Probit model

Variables	Maize-pumpkin		Maize-Eggplants		Maize-grain amaranth		Maize-lablab	
	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
Gender of farmer (male=1, female=0)	0.057	0.889	0.405	0.294	0.377	0.387	0.852	**0.030**
Age of farmer	0.028	0.666	0.033	0.277	**-0.071**	**0.036**	0.035	0.266
Farming experience	0.014	0.630	-0.014	0.657	**0.069**	**0.062**	-0.054	0.127
Education of farmer	-0.013	0.928	0.052	0.236	**-0.104**	**0.031**	0.059	0.191
Participation in demonstrations	**0.974**	**0.002**	0.597	**0.057**	-0.218	0.516	**0.797**	**0.018**
Location-Mid lower	-0.113	0.717	0.476	0.133	0.544	0.118	**0.963**	**0.004**
Maize (previously intercropping=1, otherwise=0	0.464	0.154	**-0.618**	**0.059**	-0.208	0.552	-0.224	0.517
Maize farming objective (subsistence only)	-0.052	0.872	**-0.696**	**0.025**	-0.070	0.828	-0.340	0.297
Number of farming fields	-0.068	0.506	-0.160	0.214	**-0.276**	**0.014**	0.008	0.938
Labor (number of adults active on household farm)	-0.014	0.980	0.245	0.301	-0.095	0.715	0.441	**0.086**
Credit access	0.050	0.972	0.394	0.191	0.314	0.340	0.031	0.923
Ln income	**-0.412**	**0.019**	0.054	0.779	-0.072	0.687	-0.182	0.299
Output risk perception	-1.070	0.286	-0.322	0.323	0.195	0.561	**-0.584**	**0.087**
Constant	4.542	0.092	0.676	0.796	4.788	0.101	0.373	0.891
Log likelihood value								-187.65193
Wald chi2 (52)								79.14
Prob >Chi2								0.0090
LR test of ρ_{ki}								43.402
Number of observations								99

Source: Field Survey data 2017

Results indicated that farmers that previously practiced maize intercropping were less likely to adopt maize-African eggplants intercrop. This could be because farmers that intercropped maize mostly intercropped with beans and generally farmers preferred the intercrop of maize-beans to maize-African eggplants, this was reflected in their rank of intercropping practices according to preference. Throughout the study areas, maize-African eggplants consistently ranked lower (less preferred) than maize-beans. These results indicate that farmers appreciate the benefits of maize-based intercropping although they are hesitant to introduce new practices.

The results indicated that the age of a farmer significantly affects willingness to adopt maize-grain amaranth albeit not significant for the rest of the practices. The coefficient for age is negative suggesting that older farmers are less likely to adopt maize-grain amaranth compared to their younger counterparts. This result is consistent with Mwangi and Kariuki (2015) who found that younger farmers are more likely to adopt new technologies compared to older ones. This could be because older farmers are less willing to experiment with new practices and would rather stick to what they are used to.

The results also revealed that the number of parcels of land or farming fields had a significant effect on willingness to adopt maize-grain amaranth. A negative coefficient implies that an increase in the number of parcels a farmer owns is likely to reduce the probability of adoption of maize-grain amaranth. This could be because when farmers obtain more plots, chances are high that they will be further away from their homes. Yet many farmers reported that amaranth can easily be picked from the garden by people other than the farm owner, hence they would prefer growing close to home. This finding suggests that for farmers in the study area, the risk of crop loss to theft outweighs the possible benefits from adopting maize-amaranth.

The gender of a farmer had a significant effect on willingness to adopt maize-lablab ($p<0.05$). A positive and significant coefficient with maize-lablab implies that males were more likely to adopt the intercropping practice as compared to females. This may be because males are usually directly in charge of livestock and therefore, they are likely to care about the feeding of the animals as compared to females. The influence of access to land and decision-making concerning land use could also influence willingness to adopt the intercrop. Men in Kapchorwa usually have more access to land than women (Bomuhangi *et al.,* 2016). Therefore, the men can easily decide to include a fodder crop on the farm, unlike women. This result is consistent with previous literature that shows that men in developing countries have a higher likelihood of adoption of agricultural technologies than women (Doss and Morris, 2001).

Farming experience was found to be significantly influence likelihood of adoption of maize-grain amaranth. The positive significant coefficient implies that a one-year increase in farmer experience increases the probability of adopting maize-grain amaranth. This is in line with results from Sanzidur and Chidiebere (2015) who found that farming experience had a positive significant effect on willingness to adopt multiple food crops in Nigeria. Rahman (2009) argues that when a farmer has many years of farming experience, they are more open to the choice of crops.

The location of a farmer in the mid-lower area(Tegeres) had a highly significant influence ($p<0.01$) on willingness to adopt maize-lablab. A farmer from the mid-lower belt had a higher likelihood of adopting maize-lablab intercrop than a farmer in another location. In Chebany village located in the mid-lower belt, there was a farmer who was already growing lablab, therefore this could suggest that this farmer might have transmitted knowledge and information about lablab to other farmers in the neighborhood. Thus, a higher likelihood of adoption obtained in the results could partly be explained by the fact that some farmers in the area had basic knowledge about the crop hence more willing to take-up the intercrop. This is in agreement with Adesina and Baidu-Forson (1995) who found that farmers tend to share technologies with other farmers that match their preference. Also, the plots of maize-lablab yielded higher than other plots. This could have encouraged farmers in the area.

Participation in the HealthyLAND project agricultural intervention was found to be significant for willingness to adopt maize-lablab. The percentage of farmers willing to adopt maize-lablab was highest in FFD participants(61.54 percent) than the rest of the respondent groups (34.15 percent and 25 percent). The main reasons farmers stated for not adopting the practice were lack of awareness of the lablab and also that it was not edible. Participation in project training forms the basis of knowledge about new intercropping practices like maize-lablab. It also adds to the knowledge the farmer already has about an already familiar intercropping practice such as maize and beans. This result is in line with the findings of Olarinde *et al.* (2017) who found that farmer participation in demonstrations greatly increased adoption.

On the other side, the uncertainty that surrounds the cropping practices as regards non-participants reduces the attractiveness hence the farmers are less willing to adopt the intercropping until they have some experience with the practices.

4.5 Potential benefits of adopting the maize-based intercropping in Kapchorwa

The data used in determining the potential benefits of the maize-based intercrops was collected from the field demonstration plots that were intended to illustrate the predicted outcomes from the crop practices. The data used from the experiments included production costs (seed, fertilizer, pesticides and labor) and yield (quantities of produced). Prevailing market prices at the time were used to calculate potential returns.

Table 4.17 presents results from demonstration plots with the arrangement of 1*1(single row of maize and a single row of companion crop) from the lower, mid-lower, and mid-upper areas. Results indicate that for the planting arrangement of single rows of main and companion crop, the mid-lower belt had the highest average yield of maize from the maize-based intercrops followed by mid-upper and lastly lower belts. In the lower belt, maize-beans gave the least total variable costs per hectare compared to other maize-based intercrops. This could be due to the lower seed cost per acre compared to other companion crops. The change in net benefits was highest in maize-African eggplants (1550 percent). This implies that maize-African eggplants are likely to have more farmers willing to adopt the intercrop in the lower belt on basis of high change in net benefits resulting from high total yield and reduced variable costs. This result is consistent with that of Tinegre *et al.* (2018) who found that the total yield of intercrop of maize-African eggplants under planting arrangement of one maize row to one companion crop was higher than the maize monocrop.

There was zero harvest for grain amaranth and lablab in the upper area because the crop died out. This was attributed to too much rain that destroyed crops. The results of the study showed that considering the single rows of maize and the companion crop, all the maize-based cropping practices in the lower belt with exception of maize-lablab would produce more economic benefits compared to maize monocrop. Increased variable costs and reduced benefits associated with maize-lablab in comparison to maize monocrop meant that the intercrop is dominated. This means that farmers in the lower belt are better off practicing maize monocrop than intercropping maize with lablab.

In the mid-lower belt, only maize-pumpkin and maize-lablab would give higher benefits per hectare compared to maize monocrop. This result is different from a previous study by Silwana and Lucas (2002) who researched the influence of plant combinations and weeding of maize-bean and maize-pumpkin intercrop on yield. Their results revealed that maize-bean intercrop had a higher mean total yield than maize-pumpkin. Maize-lablab had an MRR of 104 percent, implying that for a farmer in the mid-lower belt, for every shilling that the farmer invests in the intercrop, they would recover the cost and an additional Shs. 1.04. This result suggests that the increase in benefits resulting from possible adoption of the intercrop would be high enough to compensate for the increase in costs.

In the mid-upper belt, only maize-African eggplants and maize-lablab produced higher benefits than maize monocrop, hence they would be the most profitable if adopted by farmers. These results indicate that the economic benefits from the maize-based practices vary with the location as well as the component crops. The lower slopes have better soils compared to the higher areas that have soils prone to erosion. Therefore, the lower belt supports a diverse range of crops compared to the high-altitude area hence more practices were able to produce higher yields. Therefore, the hypothesis that the net benefits of maize intercropping are higher than sole cropping is rejected. This is because it is not true for every intercropping practice in all locations.

Table 4. 17: A comparison of net benefits for intercropping under row cropping

	Intercropping arrangement (1 row maize: 1 row companion crop)							
	Yield Kg ha^{-1} (maize)	Yield Kg ha^{-1} (Other)	TVC Million Shs ha^{-1}	Change in TVC Shs ha^{-1}	Total revenue '000 Shs ha^{-1}	Change in total revenue '000 Shs ha^{-1}	Net benefits '000 Shs ha^{-1}	Change in net benefits (MRR in %)
Lower (Kaptanya)								
Maize (monocrop)	5120.00	0.00	3.44	-	4,096	-	652	-
Maize-pumpkin	4662.85	3,000.00	3.36	-87,380	5,230	1,134	1,873	-1298
Maize-African eggplant	6491.43	257.14	3.36	-87,380	5,450	1,354	2,093	-1550
Maize-grain amaranth	6034.28	142.89	3.36	-87,280	4,970	874	1,613	-1001
Maize-beans	5394.28	228.57	3.41	-36,520	4,658	562	1,250	-1540
Maize-lablab	4022.85	857.14	3.87	421,920	3,218	-877	-647	D
Mid lower (Tegeres)								
Maize (monocrop)	7222.85	0.00	3.44	-	5,778	-	2,334	-
Maize-pumpkin	7588.57	1,600.00	3.62	-87,380	6,870	1,092	3,514	-1250
Maize-African eggplant	5668.57	142.86	3.62	-87,380	4,677	-1,100	1,321	D
Maize-grain amaranth	6034.28	28.57	3.59	-87,280	4,855	-922	1,499	D
Maize-beans	5485.72	228.43	3.91	-36,520	4,731	-1,047	1,323	D
Maize-lablab	7771.43	57.14	3.87	421,920	6,217	438	2,351	104
Mid upper (Kapchesombe)								
Maize (monocrop)	8411.43	0.00	3.44	-	6,729	-	3,142	-
Maize-pumpkin	7314.28	2,285.71	3.62	-87,380	6,994	2,651	3,494	-303
Maize-African eggplant	8960.00	228.57	3.62	-87,380	7,396	6,674	3,897	763
Maize-grain amaranth	5120.00	0.00	3.62	-87,280	4,096	-2,633	596	D
Maize-beans	5851.43	228.57	3.91	-36,520	5,023	-1,705	1,473	D
Maize-lablab	8960.00	0.00	4.01	421,920	7,168	4,388	3,159	104

"D" in MRR means that the intercropping practice has higher total variable costs but lower benefits than maize monocrop hence dominated.

Source: HealthyLAND Project Technical report 2017

Table 4.18 presents differences in selected variables between monocrop and each of the intercropping practices under arrangement of 1*1(single row off maize and a single row of companion crop). The results represent means of variables of all the three areas because the analysis at one FFD level was complex due to few entries. The results show that there are no significant differences between yield of maize in maize monocrop and the proposed intercropping practices except with total variable costs of maize-beans and maize-African eggplant.

Table 4. 18: Differences in selected variables of demonstrated intercropping practices under row cropping (1row maize*1row companion crop)

Dependent Variable	(I) practice	(J) practice	Mean Difference (I-J)	p-value
Maize yield	Monocropping	Maize-Pumpkin	396.19	.766
		Maize-A	-121.90	.927
		Maize-G	1188.57	.380
		Maize-beans	1340.95	.324
		Maize-lablab	.00	1.000
Total variable costs	Monocropping	Maize-Pumpkin	-.10	.491
		Maize-A	-.10	.491
		Maize-G	-.08	.538
		Maize-beans	-.30**	.039
		Maize-lablab	-.48***	.003
Total revenue	Monocropping	Maize-Pumpkin	-830.33	.428
		Maize-A	-306.67	.767
		Maize-G	894.00	.395
		Maize-beans	730.33	.484
		Maize-lablab	.00	1.000
Net benefits	Monocropping	Maize-Pumpkin	-917.67	.366
		Maize-A	-394.33	.694
		Maize-G	806.67	.425
		Maize-beans	694.00	.491
		Maize-lablab	421.67	.674

*. The mean difference is significant at the 0.05 level. M-A= Maize-African eggplant, M-G= Maize-Grain amaranth

Table 4.19 presents results from the demonstration plots with the planting arrangement of 2*1 (double rows of maize and a single row of companion crop). The results show that in the lower belt, under the double rows of maize crop and one row of companion crop arrangement, the highest net benefit was obtained from maize-beans. The intercrop of maize-pumpkin is not common amongst farmers in Kapchorwa because many farmers perceive that pumpkin will not perform well since the maize leaves would cover the crop. However, the high yield of maize and pumpkin could be explained by the fact that pumpkin does not have significant above the ground inter-specific competition that would negatively affect the maize. Therefore, the intercrop yielded high quantities of maize.

Generally, in the mid-lower belt, some intercrops like maize-pumpkin yielded higher than maize-beans intercrop. These results suggest that non-traditional intercrops such as maize-pumpkin and maize-grain amaranth are suitable for the mid-lower area (Tegeres) and therefore if adopted could improve farmers' income in comparison to the traditional intercrop of maize-bean.

Table 4. 19: A comparison of net benefits for intercropping under strip cropping

	Intercropping arrangement (2 rows maize: 1 row companion crop)							
	Yield Kg ha^{-1} (maize)	Yield Kg ha^{-1} (Other)	TVC Million Shs ha^{-1}	Change in TVC Shs ha^{-1}	Total revenue '000 Shs ha^{-1}	Change in total revenue '000 Shs ha^{-1}	Net benefits '000 Shs ha^{-1}	Change in net benefits (MRR in %)
Lower (Kaptanya)								
Maize (monocrop)	3,840.00	0.0	3.44	-	3,072	-	-371	-
Maize-pumpkin	5,760.00	2,857.1	3.41	-29,965	603	2,964	2,622	-9893
Maize-African eggplants	3,291.43	114.3	3.41	-29,965	2,747	-324	-666	1003
Maize-grain amaranth	5,668.57	0.0	3.41	-299,965	4,534	1,462	1,390	-488
Maize-beans	4,205.71	114.3	3.42	-18,280	3,478	406	533	-2226
Maize-lablab	4,845.71	200.0	3.44	1,250	3,876	804	88	6436
Mid lower (Tegeres)								
Maize (monocrop)	4,937.14	0.0	3.44	-	3,949	-	505	-
Maize-pumpkin	4,754.28	8,000.0	3.41	-29,965	3,946	4,000	4,297	-13349
Maize-African eggplants	6,765.71	142.9	3.41	-29,965	5,469	1,519	2,141	11
Maize-grain amaranth	4,937.14	57.1	3.41	-29,965	7,949	-3	592	-5072
Maize-beans	4,845.71	85.7	3.42	-18,280	3,876	-73	579	5104
Maize-lablab	5,942.85	142.9	3.44	1,250	4,882	933	966	-5848
Mid upper (Kapchesombe)								
Maize (monocrop)	6,582.85	0.0	3.58	-	5,266	-	1,679	-
Maize-pumpkin	4,937.14	1,514.3	3.56	-29,966	4,706	-559	1,150	-1867
Maize-African eggplants	6,217.14	114.3	3.50	-29,966	5,088	-178	1,531	595
Maize-grain amaranth	5,394.28	85.7	3.56	-29,966	4,401	-865	844	2887
Maize-beans	7,131.43	0.0	3.57	-18,281	5,705	438	2,136	-2401
Maize-lablab	4,937.14	0.0	3.78	1,249	3,949	-1,316	361	D

Source: HealthyLAND Project Technical report 2017

Table 4.20 presents differences in mean values between maize monocrop and each of the intercropping practices under arrangement of 2*1(double row off maize and a single row of companion crop). Results show that there significant difference in net benefits of maize from monocrop and maize-pumpkin intercrop. The results imply that generally maize-pumpkin has potential to give significantly high economic benefits in Kapchorwa.

Table 4. 20: Differences in selected variables of demonstrated intercropping practices under row cropping (2rows maize*1row companion crop)

Dependent Variable	(I) practice	(J) practice	Mean Difference (I-J)	P-value
Maize yield	Monocropping	Maize-Pumpkin	-30.45	0.976
		Maize-A	-304.76	0.760
		Maize-G	-213.33	0.830
		Maize-beans	-274.29	0.783
		Maize-lablab	-121.90	0.903
Total variable costs	Monocropping	Maize-Pumpkin	.03	0.768
		Maize-A	.05	0.607
		Maize-G	.03	0.768
		Maize-beans	.02	0.854
		Maize-lablab	-.07	0.465
Total revenue	Monocropping	Maize-Pumpkin	1010.67	0.432
		Maize-A	-339.00	0.790
		Maize-G	-1532.33	0.242
		Maize-beans	-257.33	0.840
		Maize-lablab	-140.000	0.912
Net benefits	Monocropping	Maize-Pumpkin	-2085.33**	0.035
		Maize-A	-397.67	0.658
		Maize-G	-337.67	0.707
		Maize-beans	-478.33	0.595
		Maize-lablab	132.67	0.882

*. The mean difference is significant at the 0.05 level. M-A= Maize-African eggplant, M-G= Maize-Grain amaranth

In the mid-upper belt, maize-eggplants had the highest net benefit whereas maize-grain amaranth had the lowest. These results present an argument that maize-based intercropping systems in Kapchorwa generally offer better gross margins than maize monocrop although the cost of production is higher for intercrops than sole maize.

Berhanu *et al.* (2017) show that an increase in plant density or rows of a specific crop in an intercropping system increases the yield of that crop. However, in this study, the average harvest of maize from single rows of both maize and the companion crop was generally higher than that of double rows of maize and single row companion crop. These results suggest that yield from intercrops was influenced by the location of the farmer field demonstration, the type of companion crop, and crop arrangement in terms of the ratio of the main crop to companion crop. This agrees with Choudhary and Choudhury (2016) who found that the type of companion crop and plant densities influenced yield in experiments of maize-legume intercrops in India.

These findings also show that increasing the ratio of maize to beans results in a lower yield per plot. In the arrangement of single rows of maize and companion crop, the maize-beans had equal rows whereas, in the planting arrangement of double rows of maize and a single row of companion crop, the rows of beans were reduced by half. This means that the yield of maize would be expected to increase while that of beans reduces. However, the average price of beans in Kapchorwa was Shs. 1500 per kilogram fetching a higher price than maize, which averaged, to Shs. 800 per kilogram. These results suggest that having two rows of maize and one row of beans would increase total yield whereas two rows of beans and one row of maize would increase income.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary and conclusions

The study focused on examining perceptions and farmers' willingness to adopt maize-based intercropping practices in the Kapchorwa district. Specifically, the study aimed at revealing farmers' perceptions of the different maize-based intercropping practices that were established through farmer field demonstrations, the factors that influence farmers' willingness to adopt, and the potential net benefits of adopting the crop practices. The intercropping practices that were demonstrated were: maize-beans, maize-African eggplants, Maize- pumpkin, maize-lablab, and maize-grain amaranth.

Cross-sectional data were collected from three sub-counties at different altitudes: Kaptanya (lower), Tegeres (mid-lower), and Kapchesombe (mid-upper). A total of 108 farmers consisting of participants, non-participants (from participating villages), and non-exposed groups (from non-participating villages) were interviewed. Data collected were analyzed using descriptive statistics to characterize the farmers in the different groups. Secondary data from the HealthyLAND project was used to determine the potential benefits of adopting the intercropping practices.

Results show that farmer perceptions across categories and locations were heterogeneous. Farmer field demonstrations participants and non-participants had both negative perceptions on some intercropping practices but also positive perceptions on others. Results showed that maize-beans were the most preferred intercrop across the three belts whereas maize-lablab was the least preferred. Although farmers are willing to adopt maize-beans intercrop, they perceived increased yield of maize and reduced yield of beans from the intercrop. The majority of the farmers perceived reduced yield of all the companion crops from the demonstrated intercrops compared to their practices. Farmers also perceive that more time is spent managing maize in the intercrops since care must be taken not to damage the companion crops. Results also show that the majority of farmers perceive reduced pest infestation in all the intercrops as compared to their practices.

Results also indicate that farmers from the upper belt had the highest percentage of those willing to adopt the intercrops of maize-grain amaranth. The mid-lower belt had the highest percentage of farmers willing to adopt maize-pumpkin, maize-lablab, and maize-African eggplants. Farmers' willingness to adopt maize-pumpkin was significantly influenced by participation in the field demonstrations, and household annual income. Farmer participation in the field demonstrations, farmer's objective for growing maize (subsistence), and previously intercropping maize significantly influenced farmer's willingness to adopt maize-African eggplants. Age of a farmer, farmer's farming experience (in years), and the number of farming fields were significantly associated with willingness to adopt maize-grain amaranth. Farmer's participation in the demonstrations, a farmer is located in the mid-lower belt, and the number of adults active in the farm significantly influenced farmer's willingness to adopt maize-lablab.

Results of the marginal analysis showed that in the lower area, single rows of main and companion crop except maize-lablab, all the other intercropping practices that were demonstrated showed higher economic benefits compared to maize mono-crop. In the mid lower area, only maize-pumpkin and maize-lablab gave higher benefits than maize mono-crop. In the upper area, it was maize-pumpkin, maize- grain amaranth and maize-lablab that gave higher benefits than maize mono-crop. In the case of double rows of main crop and companion crop, all practices except maize-lablab obtained the highest net benefits than sole maize in the lower area.

In the mid-lower area, all demonstrated practices gave high benefits than sole maize. And finally, in the mid upper area, only maize-beans gave higher benefits than sole maize. However, some intercrops yielded negative net benefits in different locations.

Based on the results of this study, several conclusions can be drawn. Farmers' most preferred maize-based intercrop practices were maize-beans and maize-grain amaranth (lower belt), maize-beans, and maize-African eggplants (mid-lower and mid-upper belts). The farmer's responses of "I do not know" on perceptions on maize-lablab was due to lack of awareness of the lablab. This implies that farmer's experience with a crop influences their perceptions of that particular crop. These results also suggest that farmers value the yield of the component crops and that is why fewer percentages of farmers are willing to adopt the crops perceived to reduce the yield of the companion crop. The positive perceptions on some of the intercrops imply that farmers understand the relevance of the intercrops and they are valued. Therefore, the hypothesis that non participants have negative perceptions on intercropping maize with other crops is rejected because this was not the case entirely. Results also suggest that farmers are more likely to adopt maize-African eggplants and maize-grain amaranth mainly for consumption consequently saving on household food purchases.

These results of the study suggest that the profitability of the maize-based intercrops vary by location and intercrop component crops therefore the assumption that maize-based intercropping has higher benefits than sole maize is not justified hence the hypothesis is rejected. It should be noted that several reasons such as late plating and excess rain led to the poor yield of companion crops across locations. Although yield from some maize-based intercrops was lower than the maize monocrop, with the right management practices the intercropping practices have the potential to produce better benefits through diverse harvest in comparison to maize monocropping.

5.2 Policy recommendations

Based on the findings of this study, farmer participation in farmer field demonstrations is associated with positive perceptions and willingness to adopt some intercropping practices. This implies that participatory approaches are helpful and likely to give positive results in promoting maize-based intercropping especially for the uncommon intercrops like maize African eggplants and maize-grain amaranth that give higher net benefits than sole maize. Therefore, farmers should always be willing to participate in training programs to gain knowledge and understanding of possible technologies that would benefit them. In order to increase farmer participation in such training programs, they need to be first sensitized on recommended alternative practices that have potential to improve their crop yield, then tailor the programs to meet farmers' needs or aspirations.

There is need to demonstrate different maize-based intercrops to farmers such that they get knowledge about the practices. That way, awareness of potentially beneficial intercrops would be increased. If the most preferred crops are promoted in the right areas, it would be beneficial to both the farmers and also ensure efficient use of government resources.

5.3 Suggestions for future studies

Further research can be carried out to determine the actual adoption of the intercropping practices by the different groups of farmers in this study. Particularly, knowledge spillover effects from farmer field demonstration participants to non-participants could be analyzed. Furthermore, it would be interesting to find out to what extent different practices have been taken up.

Another aspect that can be explored is the potential of lablab to reduce pest infestation in maize-lablab intercrops. Farmers reported that pests and diseases as a crop production constraint but also that they noted low incidence of fall army worm in maize-lablab plots compared to the rest of the intercrops. Research in this area could help influence policy decisions enable farmers to integrate lablab in their farm practices as a complementary practices to use of pesticides.

REFERENCES

Abrahams, P., Bateman, M., Beale, T., Clottey, V., Cock, M., Colmenarez, Y., Corniani, N., Day R., Early, R., Godwin, J and Witt, A. (2017). Fall Armyworm: Impacts and Implications for Africa. Evidence Note, September Report to DFID. Wallingford: CABI

Adesina, A. A., and Zinnah, M. M. (1993). Technology characteristics, farmers' perceptions and adoption decisions: A Tobit model application in Sierra Leone. *Agricultural Economics*, *9*(4), 297–311. https://doi.org/10.1016/0169-5150(93)90019-9

Adesina, A.A.; Baidu-Forson, J. (1995). Farmers' perceptions and adoption of new agricultural technology: Evidence from analysis in Burkina Faso and Guinea, West Africa. *Agric. Econ.*, *13*, 1–9.

Adjimoti, G. O., and Kwadzo, G. T. M. (2018). Crop diversification and household food security status: Evidence from rural Benin. *Agriculture and Food Security*, *7*(1). https://doi.org/10.1186/s40066-018-0233-x

AGRA- Alliance for a Green Revolution in Africa (2014). African Agriculture. Status Report: Climate Change and Smallholder Agriculture in sub-Saharan Africa. AGRA Report Issue Number 2, pp6-34

Ajambo, R., Elepu, G., Bashaasha, B., Okori, P. (2017). Farmers' preferences for maize attributes in eastern and Western Uganda. *African Crop Science Journal* 25(2): 177-87.

Akudugu, M. A., Guo, E., & Dadzie, S. K. (2012). Adoption of Modern Agricultural Production Technologies by Farm Households in Ghana: What Factors Influence their Decisions? *Journal of Biology, Agriculture and Healthcare*, *2*(3), 1–13.

Ali. S., Sophie. R., Imam. M. I., Faisal I. K, Ali. S , Shaikh. A., and Farid-ul-Hasnain. S.(2011). Knowledg, perceptions and myths regarding infertility among selected adult population in Pakstan: A cross-secyional study. *Public Health***11**:760 https://doi.org/10.1186/1471-2458-11-760

Alvarado, E. (2013). Cost-Benefit Analysis of an Agricultural Project Involving a Smallholder Production System. A thesis submitted to McGill University in partial fulfillment of the requirements of the degree of Master of Science. Department of Agricultural Economics McGill University, Montreal

Asten, v., P.J.A., Wairegi, L.W.I., Mukasa, D. and Uringi, N.O. (2011) Agronomic and economic benefits of coffee-banana intercropping in Uganda's smallholder farming systems. *Agricultural Systems*, **104**, 326– 334.

Ayal, D. Y., and Leal Filho, W. (2017). Farmers' perceptions of climate variability and its adverse impacts on crop and livestock production in Ethiopia. *Journal of Arid Environments*, *140*, 20–28. https://doi.org/10.1016/j.jaridenv.2017.01.007

Banda, T. F. (2015). *Determinants of household resilience to dry spells and drought in Malawi:*

A case of Chipoka. (Masters of Science in Agriculture and Applied Economics Masters), Uninversity of Malawi.

Berhanu, H. (2017). Determination of Plant Density on Groundnut (Arachis hypogaeaL.) Intercropped with Sorghum (Sorghum Bicolor L. Moench) at Fadis and Erer of Eastern Hararghe Zone. *Agricultural Research & Technology: Open Access Journal*, *9*(3). https://doi.org/10.19080/artoaj.2017.09.555763

Bloch, H. (2012). Marginalism. In *The Elgar Companion to Post Keynesian Economics, Second Edition* (pp. 383–387). Edward Elgar Publishing Ltd. https://doi.org/10.4337/9781849803182.00080

Bomuhangi, A., Nabanoga, G., Namaalwa, J., Jacobson, M., and Gombya-Ssembajjwe, W. (2016). Gendered decision making and adaptation to climate change in Mt. Elgon Region, Eastern Uganda. I*nternational Research Journal Of Environmental Sciences And Studies (Vol. 1).*https://doi.org/10.1080/23311843.2016.1168276

Bonabana-Wabbi, J. (2002). Bonabana-Wabbi, J. (2002). Assessing factors affecting adoption of agricultural technologies: The case of integrated pest management (IPM) in Kumi district, Eastern Uganda (Doctoral dissertation, Virginia Polytechnic Institute and State University). *Thesis*, 146.

Brooker, R.W., Bennett, A.E., Cong, W.-F., Daniell, T.J., George, T.S., Hallett, P.D., Hawes, C., Iannetta, P.P.M., Jones, H.G., Karley, A.J., Li, L., McKenzie, B.M., Pakeman, R.J., Paterson, E., Schöb, C., Shen, J., Squire, G., Watson, C.A., Zhang, C., Zhang, F., Zhang, J. and White, P.J. (2015), Improving intercropping: a synthesis of research in agronomy, plant physiology and ecology. New Phytol, 206: 107-117. https://doi.org/10.1111/nph.13132

Carr, E.R., Thompson, M. C., (2014). Gender and Climate Change Adaptation in Agrarian Settings: Current Thinking, New Directions, and Research Frontiers. *Geography Compass* 8(3), 182–197.

Chalak, A., Irani, A., Chaaban, J., Bashour, I., Seyfert, K., Smoot, K., & Abebe, G. K. (2017). Farmers' Willingness to Adopt Conservation Agriculture: New Evidence from Lebanon. *Environmental Management*, *60*(4), 693–704. https://doi.org/10.1007/s00267-017-0904-6

Choudhary, V. K. and Choudhury, B. U. (2016). A staggered maize-legume intercrop arrangement influences yield, weed smothering and nutrient balance in the eastern himalayan region of India. *Experimental Agriculture*, *54*(2), 181–200. https://doi.org/10.1017/S0014479716000144

De Groote, H., Kimenju, C. S., Munyua. B., Palmas. S., Kassie, M., Bruce, A. (2019). Spread and impact of fall armyworm (Spodoptera frugiperda J.E. Smith) in maize production areas of Kenya. *Agriculture, Ecosystems & Environment*,Volume 292, 2020, 106804, ISSN 0167-8809. https://doi.org/10.1016/j.agee.2019.106804.

De Groote H, Vanlauwe B, Rutto E , Odhiambo G , Kanampiua F. and Khan. Z. (2010).

Economc analysis of different options in intergrated pest and soil fertility management in maize systems of western Kenya. *Agricultural Economics* (41) 471–482 **https://doi.org/10.1111/j.1574-0862.2010.00459.x**

Doss, C and Morris, M. L. (2001). How does gender affect the adoption of agricultural innovations?: The case of improved maize technology in Ghana, *Agricultural Economics*, 25, issue 1, p. 27-39, https://EconPapers.repec.org/RePEc:eee:agecon:v:25:y:2001:i:1:p:27-39.

Ekiyar, V.(2003). Economic Evaluation of Pest Management Technologies in Cowpea and Groundnut Growing in Eastern Uganda. A Thesis submitted for award of the degree of Master of Science in Agricultural Economics of Makerere University.

Evans, A.E., (2018). Marginal Analysis: An Economic Procedure for Selecting Alternative Technologies/Practices. Food and Resource Economics Department; UF/IFAS Tropical Research and Education Center, Homestead. https://edis.ifas.ufl.edu/fe565

Fagariba, C. J., Song, S., and Baoro, S. K. G. S. (2018). Climate change adaptation strategies and constraints in Northern Ghana: Evidence of farmers in Sissala West District. *Sustainability (Switzerland)*, *10*(5). https://doi.org/10.3390/su10051484

FAO (2006). Farming Systems and Poverty, Food and Agriculture Organization of the United Nations (FAO) & World Bank Global Map of Irrigation Areas, FAO, NRLW & Johann Wolfgang Goethe University, Frankfurt am Main, Germany

FAO (2006). Food and Agriculture Organization of the United Nations (FAO) Transboundary agro-ecosystem management report on crop/farming systems in Uganda.

FAO (2015). Designing nutrition-sensitive agriculture investments. Retrieved from http://www.fao.org/documents/card/en/c/6cd87835-ab0c-46d7-97ba-394d620e9f38/

FAO, IFAD, UNICEF, WFP and WHO (2019). The State of Food Security and Nutrition in the World 2019. Safeguarding against economic slowdowns and downturns. Rome, FAO.

FAOSTAT. (2018). Food and Agriculture Organization of the United Nations. Production crops Available from: http://www.fao.org/faostat/en/#data/QC

FAOSTAT. (2020). Food and Agriculture Organization of the United Nations. Production crops Available from: https://www.fao.org/faostat/en/#data

Feder. G., Umali. D. L. (1993). The adoption of agricultural innovations*: A review. , 43(3-4), 0–239.* doi:10.1016/0040-1625(93)90053-a

Feed The Future. (2018). *Global food security strategy (GFSS) Uganda country plan* (September 2018). D.C.: Wasnhington.

Gembloux, L., Tech, A., Gembloux, P., Barbier, B., and Dogot, T. (2015). Farmers ' practices and willingness to adopt supplemental irrigation in Burkina Faso. I*nternational Journal of Food and Agricultural Economics* ISSN 2147-8988 Vol. 3 No. 1, (2015), pp. 101-117

Green, H. W., (2002). Ecomometric Analysis, 5th edition, Prentice-Hall, Upper Saddle River, New Jersey

Hall, T.J., Dennis, J.H., Lopez, R.G. and Marshall, M.I. (2009). Factors affecting growers' willingness to adopt sustainable floriculture practices *Horticultural Science* 44 1346 1351

Herath, P. H. M. U. and Tekaya, H. (2003). Factors determining intercropping by rubber smallholders in Sri Lanka: A logit analysis. *Agricultural Economics*, 29(2), 159–168.

Hien, V.P., Kaboré, D.P., Youl, S. and Lowenberg-DeBoer, J.M. (1997). Stochastic dominance analysis of on-farm-trial data: The riskiness of alternative phosphate sources in Burkina Faso. *Agricultutral Economics* 1997, vol. 15, issue 3, 213-221

Himmelstein, J., Ares, A., Gallagher, D., and Myers, J. (2017). A meta-analysis of intercropping in Africa: impacts on crop yield, farmer income, and integrated pest management effects. *International Journal Agricultural Sustainability* 15, 1–10. doi: 10.1080/14735903.2016.1242332

Jaleta, M., Merenya, P., Beshir, B, and Erenstein, O., (2020)."Does crop diversification reduce downside risk of external maize yield-enhancing technology? Evidence from Ethiopia," African Journal of Agricultural and Resource Economics, *African Association of Agricultural Economists*, vol. 15(2), June.

Jassogne L, van Asten PJA, Wanyama I and Baret P V (2013). Perceptions and outlook on intercropping coffee with banana as an opportunity for smallholder coffee farmers in Uganda. Internatinal Journal *Agricultural. Sustainability* 11(2): 144-158

Jones, A. D., Shrinivas, A., and Bezner-Kerr, R. (2014). Farm production diversity is associated with greater household dietary diversity in Malawi: Findings from nationally representative data. *Food Policy*, *46*, 1–12. https://doi.org/10.1016/j.foodpol.2014.02.001

Kaizzi, K.C., J. Byalebeka, O. Semalulu, I. Alou, W. Zimwanguyizza, A. Nansamba, P. Musing uzi, P. Ebanyat, T. Hyuha, and C.S. Wortmann . (2012). Sorghum response to fertilizer and nitrogen use efficiency in Uganda. *Agronomy*. J. 104:83–9 0

Karidjo BY, Wang Z, Boubacar Y, Wei C (2018) Factors influencing farmers’ adoption of soil and water control measures in Keita valley, a semi-arid area of Niger. Sustainability 10(288):2e13. https://doi.org/10.3390/su10020288

Karki, L B and Bauer, S. (2004). Assessment of impact of project intervention and factors determining technology adoption at small farm households level. *The Deutscher Tropentag to Be Held on 5 - 7 October*, *2004*, 1–8. Retrieved from www.tropentag.de/2004/abstracts/full/107.pdf

Karpenstein-Machan, M., Stuelpnagel, R. (2000). Biomass yield and nitrogen fixation of legumes monocropped and intercropped with rye and rotation effects on a subsequent maize crop. *Plant and Soil* **218,** 215–232. https://doi.org/10.1023/A:1014932004926

Kasenge, V., Taylor D., Kyamanywa, S., Bigirwa, G., and Erbaugh, M. (2001). Farm-level Evaluation of Monocropping and Intercropping Impacts on Maize Yields and Returns in Iganga District-Uganda. *Eastern Africa Journal of Rural Development* **17** 1.

Kermah. M., Franke, A.C., Adjei-Nsiah. S. Ahiabor, B.D.K., Abaidoo, R.C., and Giller, K.E. (2017*). M*aize-grain legume intercropping for enhanced resource use efficiency and crop productivity in the Guinea savanna of northern Ghana. *Agricultural Ecosystems Environment Jul 1; 261:201-210.*

Kheroar, S., and Patra, B.C. (2014). Productivity of maize-legume intercropping systems under rainfed situation. *African Journal of Agricultural Research*, 9(20), 1610-1617.

Kikulwe, E. M., Birol, E. , Wesseler, J. and Falck-Zepeda, J. (2011), A latent class approach to investigating demand for genetically modified banana in Uganda. *Agricultural Economics,* 42: 547-560. doi:10.1111/j.1574-0862.2010.00529.x

Lalani, B., Dorward, P., Holloway, G. and Wauters, E. (2016). Smallholder farmers' motivations for using Conservation Agriculture and the roles of yield, labour and soil fertility in decision making. *Agricultural Systems*, 146. pp. 80-90. ISSN 0308-521X

Larson D. F, Savastano S, Murray S, Palacios-López. A. (2016). On the determinants of low productivity in maize farming in Uganda: the role of markets, fertilizer use and gender. In: In pursuit of an African green revolution *Springer*, Tokyo, pp 165–182

Leshem, A., Aenis, T., Grötz, P., Darnhofer, I., and Grötzer, M. (2010). Can intercropping innovations bring ecological and economic goals together? The case of Nabanhe Nature Reserve, China. Paper presented at the 9th European IFSA Symposium, Vienna,Austria,pp.11031108.Retrievedfromhttp://ifsa.boku.ac.at/cms/fileadmin/Proceeding2010/2010_ WS2.3_Leshem.pdf

Lithourgidis, AS; Dordas, CA; Damalas, CA and Vlachostergios, DN (2011). Annual Intercrops: An Alternative Pathway for Sustainable Agriculture [online]. *Australian Journal of Crop Science,* Vol. 5, No. 4, Apr 2011: 396-410. Availability:<https://search.informit.com.au/documentSummary;dn=281409060336481;res=IELHSS> ISSN: 1835-2693. [cited 01 Aug 19].

Liu, T., Bruins, R. J. F., and Heberling, M. T. (2018). Factors influencing farmers' adoption of best management practices: A review and synthesis. *Sustainability (Switzerland)*. MDPI. https://doi.org/10.3390/su10020432

Maggio, G., Sitko, N. and Ignaciuk, A. (2018). Cropping system diversification in Eastern and Southern Africa: Identifying policy options to enhance productivity and build resilience. FAO Agricultural Development Economics. Working Paper 18-05. Rome, FAO.

Magino, H.N., Mugisha, J., Osiru, D.S.O., and Oruko, O. L. (2004). Profitability of sorghum-legume cropping practices among households in Eastern Uganda, Uganda, *Journal of Agricultural sciences*, National Agricultural Research Organization Vol. 9(1), 688- 692

Makate, C., Wang, R., Makate, M., and Mango, N. (2016). Crop diversification and livelihoods of smallholder farmers in Zimbabwe: adaptive management for environmental change. *SpringerPlus*, *5*(1), 1135. https://doi.org/10.1186/s40064-016-2802-4

Marris, C., Wynne, B., Simmons, P., and Weldon, S. (2001). Public Perceptions of Agricultural Biotechnologies in Europe. *Final Report of the PABE Research Project*, *3844*(December), 1–113.

Matusso, J. M. M. (2014). Effects of Maize (Zea Mays L.)-Soybean (Glycine Max (L.) Merrill). Intercropping patterns on yields and Soil Properties in two contrasting sites of Embu and Meru Counties,Kenya. A Thesis Submitted in Partial Fulfillment of the Requirements for the Award of the degree of Master of Science (Integrated Soil Fertility Management) in the School of Agriculture and Enterprise Development of Kenyatta University"

McCord, P.F., Cox, M., Schmitt-Harsh, M. and Evans, T. (2015). Crop Diversification as a Smallholder Livelihood Strategy within Semi-Arid Agricultural Systems near Mount Kenya. *LandUse Policy*, 42, 738-750. https://doi.org/10.1016/j.landusepol.2014.10.012

Meijer, S. S., Catacutan, D., Ajayi, O. C., Sileshi, G. W., & Nieuwenhuis, M. (2015). The role of knowledge, attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub-Saharan Africa. *International Journal of Agricultural Sustainability*, 13 (1), 40–54.

Min,S., Huang, J., Bai, J., and Waibel , H. (2017). Adoption of intercropping among smallholder rubber farmers in Xishuangbanna, China, *International Journal of Agricultural Sustainability*, 15:3, 223-237, DOI: 10.1080/14735903.2017.1315234

MITC (2019). Ministry of Trade Industry and Cooperatives. Kapchorwa distric economic profile.http://mtic.go.ug/2016/index.php?/The-Project/kapchorwa-district-economic-profile/

Mubanderi, K., Mariga, L., Mugwira, M. and Chivenge, A. (1999). Maize response to methods and rates of manure application. *African Crop Science Journal* 7.:407-413

Mubiru D.N., Namakula J., Lwasa J., Otim G.A., Kashagama J., Nakafeero M. and Nanyeenya W. (2019). Enhancing Agricultural Resilience And Sustainability In Eastern And Southern Africa: Key Findings and Recommendations for Uganda. https://simlesa.cimmyt.org/wp-content/uploads/ugandaB-min-1-1.pdf

Mutenje, M., Kankwamba, H., Mangisonib, J., and Kassie, M. (2016). Agricultural innovations and food security in Malawi: Gender dynamics, institutions and market implications. *Technological Forecasting and Social Change*, 103,240-248.

Mwangi, M. and Kariuki, S. (2015). Factors Determining Adoption of New Agricultural Technology by Smallholder Farmers in Developing Countries. *Journal of Economics and Sustainable Development*. ISSN 2222-1700 (Paper).Vol.6, No.5.

Nabbumba, R and Bahiigwa, G (2003). "Agricultural Productivity Constraints in Uganda: Implications for Investment," Research Series 151127, Economic Policy Research Centre (EPRC).

Nampala, P., Ogenga-Latigo, M., Kyamanywa, S., Adipala, E., Oyobo, N., Jackai, L., (2002). Potential Impact of Intercropping on Major Cowpea Field Pests in Uganda. *African Crop Science Journal*, 10, Pp. 335-344.

Nchanji, Y. K., Nkongho, R. N., Mala, W. A., and Levang, P. (2016). Efficacy of oil palm intercropping by smallholders. Case study in South-West Cameroon. *Agroforestry Systems*, *90*(3), 509–519. https://doi.org/10.1007/s10457-015-9873-z

Ndamani, F., and Watanabe, T. (2015). Farmers' perceptions about adaptation practices to climate change and barriers to adaptation: A micro-level study in Ghana. *Water (Switzerland)*, *7*(9), 4593–4604. https://doi.org/10.3390/w7094593

Negatu, W., and Parikh, A. (1999). The impact of perception and other factors on the adoption of agricultural technology in the Moret and Jiru Woreda (district) of Ethiopia. *Agricultural Economics*, *21*(2), 205–216. https://doi.org/10.1016/S0169-5150(99)00020-1

Obong Y, Lem D.C and Ogwang O.C (2016). Effect of intercropping sunflower with soybean at different interrow and intra-row spacing on land use efficiency. *Uganda Journal of Agricultural Sciences*, 17 (1): 33 - 41

Oduol J, Tanui J, Buyinza J, Isubikalu P, O. C. and K. E. (2016). Scoping study report on potential value chains and institutional arrangements for Kapchorwa district , Uganda, (April), 56.

Okoboi, G. (2010). Of what merit is improved inputs use in Uganda's maize productivity? Joint Third African Association of Agricultural Economists (AAAE) and 48 th Agricultural Economists Association of South Africa (AEASA) Conference, Cape Town, South Africa, September 19-23, 2010.

Oladele, O. I., and Fawole, O. P. (2007). Farmers Perception of the Relevance of Agriculture Technologies in South-Western Nigeria. *Journal of Human Ecology*, *21*(3), 191–194. https://doi.org/10.1080/09709274.2007.11905971

Olarinde, L., Binam, J., Fatunbi, A. O., Diagne, A., Adekunle, A., and Ayanwale, A. (2017). Participatory research demonstration and its impact on the adoption of improved agricultural technologies in the savannas of West Africa. *African Crop Science Journal*, 25(1), 21–41. doi:10.4314/acsj.v25i1.3S

Olumide, J, O., and Adewale, Q, A. (2013). Cost Benefit Analysis of Certified Cocoa Production in Ondo State, Nigeria. Invited paper presented at the 4th International Conference of the African Association of Agricultural Economists, September 22-25, 2013, Hammamet, Tunisia

Poveda, K., Gomez, M.I., Martinez, E., (2008). Diversification practices: their effect on pestregulation and production. Rev. Colomb. *Entomology*. 34, 131–144.

Rajendran, S., Afari-Sefa, V., Shee, A., Bocher, T., Bekunda, M., dominick, I., and Lukumay, P. J. (2017). Does crop diversity contribute to dietary diversity? Evidence from integration of vegetables into maize-based farming systems. *Agriculture and Food Security, 6*(1). https://doi.org/10.1186/s40066-017-0127-3

Rockström, J., Kaumbotho, P., Mwalley, J., Nzabi, A.W., Temesgen, M., Mawenya, L., Barron, J., Mutua, J. and Damgaard-Larsen, S., (2009). Conservation farming strategies in East and Southern Africa: yields and rain water productivity from on-farm action research. *Soil &Tillage Research*. 103, 23–32.

Shah, H., Khan, M. A., Azeem, T., Majid, A., and Mehmood, A. (2012). The Impact of Gypsum Application on Groundnut Yield in Rainfed Pothwar: An Economic Perspective" Lahore Journal of Economics 17 (1): 83-100.

Silwana, T.T., & Lucas, E.O. (2002). The effect of planting combinations and weeding on the growth and yield of component crops of maize/bean and maize/pumpkin intercrops. *The Journal of Agricultural Science, 138*, 193-200.

Sirrine, D., Shennan, C., and Sirrine, J. R. (2010). Comparing agroforestry systems’ ex ante adoption potential and ex post adoption: On-farm participatory research from southern Malawi. *Agroforestry Systems* 79:253–266.

Tambo A J, Day R K, Lamontagne-Godwin J, Silvestri S, Beseh K P, Oppong-Mensah B, Phiri N and Matimelo M (2020). Tackling fall armyworm (*Spodoptera frugiperda*) outbreak in Africa: an analysis of farmers’ control actions, International Journal of Pest Management, 66:4, 298-310, DOI: 10.1080/09670874.2019.1646942

Tanyima E (2015). Economic evaluation of soybean genotypes under soil fertility variability in northern and eastern uganda. MSc. Thesis. Makerere University.

Thierfelder, C., Cheesman, S., and Rusinamhodzi, L. (2013). Benefits and challenges of crop rotations in maize-based conservation agriculture (CA) cropping systems of southern Africa. *International Journal of Agricultural Sustainability*, *11*(2), 108–124. https://doi.org/10.1080/14735903.2012.703894

Thrupp, L. A. (2000). Linking Agricultural Biodiversity and Food Security: the Valuable Role of Agrobiodiversity for Sustainable Agriculture. *International Affairs*, *76*(2), 283–297. https://doi.org/10.1111/1468-2346.00133

Tignegre J.B. S, LARBI A, Tenkouano A, Nurudeen A, Asante M.(2018). Optimization of Maize-Vegetable (African Eggplant and Pepper) Intercrops in Northern, Upper West and Upper East Regions of Ghana. JOJ Hortic Arboric. 2018; 1(2): 555557. DOI: 10.19080/JOJHA.2018.01.555557

Tsubo, M., S. Walker, and H.O. Ogindo. (2005). A simulation model of cereal-legume intercropping systems for semi-arid regions. II. Model application. *Field Crops Research*. 93(1): 23-33.

Uganda Bureau of Statistics (UBOS), (2014). Uganda Bureau of Statistics, National census report. Downloadable at: https://www.ubos.org/wp.

content/uploads/publications/03_20182014_National_Census_Main_Report.pdf

Uganda Bureau of Statistics, (2010). Uganda Census of Agriculture 2008/09 Volume 4: Crop area and production report. Kampala, Uganda

Uganda Bureau of Statistics, (2018). Uganda Annual Agricultural Survey. Kampala, Uganda; UBOS

Uganda Bureau of Statistics (UBOS) and ICF. (2018). Uganda Demographic and Health Survey 2016. Kampala, Uganda and Rockville, Maryland, USA: UBOS and ICF.

United Nations, Department of Economic and Social Affairs, Population Division (2019). World Population Prospects 2019: Highlights (ST/ESA/SER.A/423).

Vera Castillo, Y. B., Pritchard, H. W., Frija, A., Chellattan Veettil, P., Cuevas Sanchez, J. A., Van Damme, P., and Van Huylenbroeck, G. (2014). Production viability and farmers' willingness to adopt Jatropha curcas L. as a biofuel source in traditional agroecosystems in Totonacapan, Mexico. *Agricultural Systems*, *125*, 42–49. https://doi.org/10.1016/j.agsy.2013.12.003

Wagoire, W.W. (2006). Quantification of the Value of Improved Wheat Production Options in South-Western Uganda. Uganda Journal of Agricultural Sciences, Vol. 12 No.1.

Witcombe,J.R., Billore, M., Singhal, H.C., Patel, N.B., Tikka, S.B., S, Saini, D.P., Sharma, L.K., Sharma, R., Yadav, S.K., Pyadavendra, J. (2008). Improving the food security of low-resource farmers: Introducing horsegram into maize-based cropping systems. E*xperimental Agriculture*. 43:339-348.

Woldeyohanes, T., Heckelei, T., and Surry, Y. (2017). Effect of off-farm income on smallholder commercialization: panel evidence from rural households in Ethiopia. *Agricultural Economics*. 48 (2), 207–218.

World Bank (2005). Uganda Policy Options for Increasing Crop Productivity and Reducing Soil Nutrient Depletion and Poverty. Report No. 32971-UG

World Food Programme (2009). Comprehensive Food Security & Vulnerability Analysis (CFSVA) Uganda.

Yang, C., Fan, Z. and Chai, Q. (2018). Agronomic and Economic Benefits of Pea/Maize Intercropping Systems in Relation to N Fertilizer and Maize Density. *Agronomy*, *8*(4). https://doi.org/10.3390/agronomy8040052

Yap, V. Y., de Neergaard, A., and Bruun, T. B. (2016). "To Adopt or not to Adopt?" Legume Adoption in Maize-Based Systems of Northern Thailand: Constraints and Potentials. *Land Degradation & Development, 28(2), 731–741*.doi:10.1002/ldr.2546

Zeweld, W., Van Huylenbroeck, G., Tesfay, G., and Speelman, S. (2017). Smallholder farmers' behavioural intentions towards sustainable agricultural practices. *Journal of Environmental Management*, *187*, 71–81. https://doi.org/10.1016/j

APPENDICES

Appendix II: Total variable costs for lower and mid lower FFDs

Cropping system L &ML	1st ploughing	2nd ploughing	Seed Kg/ha	Seed Shs Per ha	Fertilizers Shs per ha	Agro-chemicals Shs per ha	Total variable costs
Maize mono	100,000	100,000	36.57	219,420	2,771,428	252,976.75	3,443,824.75
M-B (RC)	100,000	100,000	18.29-18.29	182,900	2,771,428	252,976.75	3,407,304.75
M -A (RC)	100,000	100,000	18.29-1.12	132,140	2,771,428	252,976.75	3,356,544.75
M - P (RC)	100,000	100,000	18.29- 0.22	132,040	2,771,428	252,976.75	3,356,444.75
M- L (RC)	100,000	100,000	18.29- 18.29	841,340	2,771,428	252,976.75	3,865,744.87
M- E (RC)	100,000	100,000	18.29-0.22	132,040	2,771,428	252,976.75	3,356,444.75
M -B (SC)	100,000	100,000	27.43-9.14	201,140	2,771,428	252,976.75	3,425,544.75
M -A (SC)	100,000	100,000	27.43-0.56	189,505	2,771,428	252,976.75	3,413,909.75
M - P (SC)	100,000	100,000	27.43- 0.11	189,455	2,771,428	252,976.75	3,413,859.75
M- L (SC)	100,000	100,000	27.43 - 9.14	420,670	2,771,428	252,976.75	3,445,074.75
M- E (SC)	100,000	100,000	27.43-0.11	189,455	2,771,428	252,976.75	3,413,859.75

Total variable costs for mid upper FFD

Cropping system M-upper	1st ploughing	2nd ploughing	Seed Kg/ha	Seed Shs Per ha	Fertilizers Shs per ha	Agro-chemicals Shs per ha	Total variable costs
Maize mono	100,000	100,000	36.57	219,420	2,771,428	395,833.87	3,586,681.87
M-B (RC)	100,000	100,000	18.29-18.29	182,900	2,771,428	395,833.87	3,550,161.87
M -A (RC)	100,000	100,000	18.29-1.12	132,140	2,771,428	395,833.87	3,499,401.87
M - P (RC)	100,000	100,000	18.29- 0.22	132,040	2,771,428	395,833.87	3,499,301.87
M- L (RC)	100,000	100,000	18.29-18.29	841,340	2,771,428	395,833.87	4,008,601.87
M- E (RC)	100,000	100,000	18.29-0.22	132,040	2,771,428	395,833.87	3,499,301.87
M -B (SC)	100,000	100,000	27.43-9.14	201,140	2,771,428	395,833.87	3,568,401.87
M -A (SC)	100,000	100,000	27.43-0.56	189,505	2,771,428	395,833.87	3,556,716.87
M - P (SC)	100,000	100,000	27.43- 0.11	189,455	2,771,428	395,833.87	3,556,716.87
M- L (SC)	100,000	100,000	27.43-9.14	420,670	2,771,428	395,833.87	3,587,931.87
M- E (SC)	100,000	100,000	27.43-0.11	189,455	2,771,428	395,833.87	3,556,716.87

Appendix II: Questionnaire

MAKERERE UNIVERSITY

SCHOOL OF AGRICULTURAL SCIENCES

DEPARTMENT OF AGRIBUSINESS AND NATURAL RESOURCE ECONOMICS

Farmers' perceptions and willingness to adopt agricultural interventions in Kapchorwa district, Uganda.

A household survey questionnaire (Dec 2017)

Corresponding address: Kisakye Josephine

Email: kisakyejk@gmail.com

Phone: 0781 549 442

Greeting, My name is **…………………………………………**I am hereon behalf of Makerere University and the HealthyLAND project. I am conducting a research on farmers' perceptions and willingness to adopt agricultural interventions proposed by the HealthyLAND project. I will ask you some questions about your household and Farmer Field Demonstrations (FFDs) activities for those who participated in the project. By continuing with the interview indicates your willingness to participate in the research. The information you provide is confidential and it's for academic purposes only. For any questions please ask me or you may contact Prof. Johnny Mugisha on 0773155702 or Miss Kisakye Josephine on 0781549442.

PART A: IDENTIFICATION

Table 1: Questionnaire identification

A1: Questionnaire Identification	**A2: Sub-county**	**A3: Village**	**A4: Parish**	**A5: Altitudinal area; *1=lower, 2=mid lower, 3=mid upper, 4=upper***

Table 2: Identification of the respondent and household

A6: Name of the farmer	**A7: Phone contact:**	**A8: Sex of the farmer:**	**A9: Age of farmer** *(years)*	**A10: Farming experience** (*years)*	**A11: Education level of farmer** (*Years spent in school)*
A12: Are you the household head:	**A13: Sex of the household head:**	**A14: Education level of household head** *(Years spent in school)*	**A15: Marital status of the household head**		**A16: Religion of household head**
1=Yes 2=No. If yes skip to question A16	*1=male 2=female*		*1=married, 2=single, 3=divorced/ separated 4= widowed*		*1=Christian, 2=Islam, 3=other*

PART B: FARMERS' PARTICIPATION AND PERCEPTIONS ON FARMER FIELD DEMONSTRATIONS

B1. Did you participate in the FFDs?…….1=yes, 2=no ***(If yes skip to question B3)***

B2. If no, who in your household participated?............1= spouse, 2= other (specify)

B3. If yes, did you attend all the 10 training sessions?............1=yes, 2=no.....***(If yes skip to question B6)***

B4. If no, how many did you attend?..............

B5. Why were you not able to attend all?...

B6. Table 3: A comparison between the each of the FFD practices and maize monocrop. *(The enumerator will explain the meaning of "crop practice")*

FFD Practice Layout[1]= Main crop *other crop	**Farmers' practice**	**Preference FFD practice or farmer's practice?**	**Reason for preference**	**Are you willing to adopt? 1=yes, 2=no**	**If yes, why? If no, why not?**
Maize - beans 1= 1*1 2=2*1					
Maize -lablab					

1= 1*1 **2=2*1**					
Maize - pumpkin **1= 1*1** **2=2*1**					
Maize =grain amaranth **1= 1*1** **2=2*1**					
Maize - African eggplants **1= 1*1** **2=2*1**					
Climbing beans -carrots **1= 1*1** **2=2*1**					
Climbing beans - grain amaranth **1= 1*1** **2=2*1**					
Climbing beans - pumpkin **1= 1*1** **2=2*1**					
Climbing beans - African eggplants **1= 1*1** **2=2*1**					

[1] **layout= rows of main crop * rows of other crop**

B7. What is your view on the following crop practice attributes? Questions B7.1 to B7.2 please answer 1=yes or 2= no and for B7.5 to B7.13 please compare with your own crop practice indicate whether the requirements are 1=more, 2= less, 3= equal, 4= 1 do not know)

Table 4: Farmers' perceptions on crop practice attributes

			Maize - lablab	*Maize - African eggplants*	*Maize - grain amaranth*	*Maize - pumpkin*	*Maize - lablab*	*Climbing beans - carrots*	*Climbing beans - pumpkin*	*Climbing beans - amaranth*	*Climbing beans- African eggplants*
B7.1	Matches Consumption preference										
B7.2	I have the technical skills required										
B7.3	Profitable practice										
B7.4	Practice is appropriate for my land size										
B7.5	Time spent managing crops										
B7.6	Physical labor requirement										
B7.7	Quantity of output	Main crop									
		Companion crop									
B7.8	Market for output is available	Main crop									
		Companion crop									
B7.9	Incidence of pest and diseases										
B7.10	Cost of seed per acre										
B7.11	Quantity of fertilizer required										
B7.12	Quantity of pesticide required										
B7.13	Quantity of herbicide										

PART C: HOUSEHOLD SIZE AND SOCIO ECONOMIC CHARACTERISTICS

C1. How many people currently live in the household?................

C2. How many of the people that live in the household are actively involved in farm activities?.................

C3. How many of those that live in the household earn income?...............

C4. What is the total income for the household per month......... (Shs)

C5. What is the main source of income for the household?.................

C6. Please rank other sources of income for the household in terms of how much they contribute to total income? (1)......................(2)…............(3)………………

Table 5:

<table>
<tr><td rowspan="3">C7</td><td rowspan="3">What foods have you consumed in your household in the last 1week?</td><td colspan="2">Food</td><td colspan="2">Frequency</td><td colspan="2">Reason for frequency</td></tr>
<tr><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>C8</td><td>How much land do you currently have access to?</td><td>(Acres)</td><td colspan="5">E9. How many parcels of land do you have?</td></tr>
<tr><td>C10</td><td colspan="2">Where are the parcels located? (Altitudinal area)</td><td colspan="5"></td></tr>
<tr><td>C11</td><td>What is the type of ownership of the land you have access to?</td><td>1=Owner/ private</td><td>2=borrowed</td><td>3=government</td><td>4=communal /public</td><td>5=rented</td><td>6=others (specify)</td></tr>
<tr><td>C12</td><td>If rented, how big?</td><td colspan="6">Acres</td></tr>
<tr><td>C13</td><td>How much rent are you paying for the land per year?</td><td colspan="2"></td><td>C15</td><td colspan="3">What portion of land you have access is for crop growing?.......acres</td></tr>
<tr><td rowspan="3">C14</td><td rowspan="3">What crops were grown on the land you have access to in the last season?</td><td>Crop</td><td>Area (acres)</td><td colspan="2">Reason for growing crop
1=subsistence
2=Commercial
3=Both subsistence and commercial
4=other (specify)</td><td>Planting arrangement
1=monocrop
2=intercrop
3=mixed crop
(If intercrop and mixed indicate with what crops)</td><td>Reason For arrangement</td></tr>
<tr><td></td><td></td><td colspan="2"></td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="2"></td><td></td><td></td></tr>
<tr><td rowspan="5">C15</td><td rowspan="5">Please rank the four most serious challenges you face in growing crops at your farm and the main coping strategies.
(Each strategy should match the challenge stated)</td><td colspan="2">Challenge</td><td colspan="4">Coping strategies</td></tr>
<tr><td colspan="2"></td><td colspan="4"></td></tr>
<tr><td colspan="2"></td><td colspan="4"></td></tr>
<tr><td colspan="2"></td><td colspan="4"></td></tr>
<tr><td colspan="2"></td><td colspan="4"></td></tr>
</table>

PART D. FARM PRODUCTION INPUTS FOR THE LAST SEASON

Table 6: Input requirements for last season

Crop	Input	Rate of application	Quantity	Unit Cost	Total cost
Maize	Land size				
	Seed				
	Pesticide				
	Fungicide				
	Herbicide				
	Fertilizer (inorganic)				
	Organic fertilizer				
Bush Beans	Land size				
	Seed				
	Pesticide				
	Fungicide				
	Herbicide				
	Fertilizer (inorganic)				
	Organic fertilizer				
Pumpkin	Land size				
	Seed				
	Pesticide				
	Fungicide				
	Herbicide				
	Fertilizer (inorganic)				
	Organic fertilizer				
African Eggplants	Land size				
	Seed				
	Pesticide				
	Fungicide				
	Herbicide				
	Fertilizer (inorganic)				
	Organic fertilizer				
Fodder crops	Land size				
	Seed				
	Pesticide				
	Fungicide				
	Herbicide				
	Fertilizer (inorganic)				
	Organic fertilizer				
Carrots	Land size				
	Seed				
	Pesticide				
	Fungicide				

	Herbicide				
	Fertilizer (inorganic)				
	Organic fertilizer				
Climbing beans	**Land size**				
	Seed				
	Pesticide				
	Fungicide				
	Herbicide				
	Fertilizer (inorganic)				
	Organic fertilizer				
Grain amaranth	**Land size**				
	Seed				
	Pesticide				
	Fungicide				
	Herbicide				
	Fertilizer (inorganic)				
	Organic fertilizer				

Table 7: Labor allocation and costs

Family labor					
Activity	**Crop**	**Number of people**	**Plot size**	**Number of days**	**Wage rate per day**
Land preparation	Maize				
	Beans				
	Pumpkin				
	African eggplants				
Ploughing	Maize				
	Beans				
	African eggplants				
Planting	Maize				
	Beans				
	Pumpkin				
	African eggplants				
Weeding	Maize				
	Beans				
	Pumpkin				
	African eggplants				
Spraying	Maize				
	Beans				
	Pumpkin				

	African eggplants				
Harvesting	Maize				
	Beans				
	Pumpkin				
	African eggplants				
Marketing and transporting	Maize				
	Beans				
	Pumpkin				
	African eggplants				
Others (specify)	Maize				
	Beans				
	Pumpkin				
	African eggplants				
Do you use hired labor? 1= yes, 2=no (if no skip to Part G) **Total cost= Number of people*wage rate per day* number of days worked**					
Activity	**Crop**	**Number of people**	**Plot size**	**Wage rate per day**	**Number of days worked**
Land preparation	Maize				
	Beans				
	Pumpkin				
	African eggplants				
Ploughing	Maize				
	Beans				
	Pumpkin				
	African eggplants				
Planting	Maize				
	Beans				
	Pumpkin				
	African eggplants				
Weeding	Maize				
	Beans				
	Pumpkin				
	African eggplants				
Spraying	Maize				
	Beans				
	Pumpkin				
	African eggplants				
Harvesting	Maize				
	Beans				
	Pumpkin				

	African eggplants				
Marketing and transporting	Maize				
	Beans				
	Pumpkin				
	African eggplants				
Others (specify)	Maize				
	Beans				
	Pumpkin				
	African eggplants				

PART E. FARM YIELD

Table 8: Farm output and marketing

Crop	Crop area (acres)	In the last rainy season, what was….					
		Total Output (kg)	Amount consumed (kg)	Amount sold (kg)	Unit price (Ushs)	Place of sale*1=farm gate 2=village market,3=nearby trading center,4=outside the district*	Amount of output given out (kgs)
Maize							
Beans							
Pumpkin							
African eggplants							
Fodder crops							
Carrots							
African eggplants							
Grain amaranth							

PART F. Information on diversity cropping

F1. Do you have access to extension services? ……1=yes, 2= no

F2. If yes, who provides the extension services?.........1= NGO (specify), 2= government 3=both, 4= other (specify)

F3. If no, why not?................

F4. Have you or any other member of the household ever received any information on diversified cropping prior to participation in project? *1=yes…………….2=no……………….*

F5. If yes, please name the source?.................

F6. How long ago?........................(*years)*

F7. What was the mode of delivery of this information?......1=group training 2=individual training 3= from a friend, 4=media, 5= model farmers, 6= other(specify)

F8. Was the knowledge acquired useful?.....................1=yes, 2=no

F9. If yes, how useful? 1=very useful, 2=useful, 3= not useful

F10. If no, why not?...........................

F11. Did you apply any of the information received? 1=yes, 2= no

F12. If yes, what particular information related to crop diversification did you apply?

……………………………………………………………………………………….

………………………………………………………………………………………..

F13. What do you think are the benefits of crop diversification to your household?

……………………………………………………………………………………….

PART H CREDIT *(If participated skip to part J)*Table 9: Credit access

H1	Did you or any member of your household receive credit in the last one year? *(If yes, skip to Question G3*)	1=*yes* *2=no*
H2	If no, why do you not have access to credit? *(After this question skip to part H)*	
H3	If yes, how much?	(Shs)
H4	What proportion of this loan was used for agricultural purposes?	
H5	What is the source of credit?	*1=SACCO,2=VSLA,3=microfinance* *4=Commercialbank,5=others(specify*)

PART I: *(for non participants skip to PART J)* Farmers perceptions on agricultural intervention topics

I1.What was your level of satisfaction with the project topics?

Level of satisfaction (1=very dissatisfied, 2=dissatisfied, 3=Neutral, 4=satisfied, 5=very satisfied)

Table 10:

Topics	Rank	What you particularly liked	Reason for liking	What you particularly did not like	Reasons for not liking
1= planning for season					
2=planting and cropping systems					
3=Infant feeding, meal planning and preparation (*nutritionas part of agricultural intervention)*					
4=crop management					
5=timing of harvest and post harvest handling					
6= record keeping					

I2. Was the information given during training useful? 1=yes, 2= no. (*If no skip to I4)*

I3. If yes, how? ……………………………………………………………

I4. If no, why? …………………………………………………………

I5. Which of the practices are you planning to use in the next season? **(1)………………(2)……………..**

PART J. Decision making for the household

Table 11: Decision-making

	Who makes decisions on…?	If HH Head, to what extent do you influence the HH decision 1=no reference 2=minimal 3=much	If not HH Head, to what extent do you influence the HH decision 1=no reference 2=minimal 3=much	Are there any negotiations among HH members 1=Yes 2=no	Of what nature are the negotiations? 1=mutual 2=dictatorship
Site selection to plant					
Use of household land for cropping					
Choosing the crops to be grown					
How the crops should be arranged of farm					
Allocating time for farm activities					
Physically working on land during production					
Who does what activity at the farm					
How much to save for seed					
Managing the seed saved					
How much farm produce to sell					
Marketing and selling output					
Setting price for out put					
Sharing of income from sell of farm output					

PART K: Please indicate to what extent you agree with the following statements. 1= strongly disagree, 2= disagree, 3= neither agree nor disagree, 4= agree, 5= strongly agree.

I do not intercrop maize with any other crop because it lowers the output

1. I do not want to invest in the farm because I do not think my farm will give more returns
2. I fear to take credit to invest in farm because I might to be able to pay it back
3. I would rather invest in off-farm investments than farm
4. I fear to introduce new crops to my farm because of the associated costs of inputs

Thank you for taking time to participate in this study

Appendix III Field layout for lower, mid lower and mid upper fields

Block A RC	M-B-M-B-M-B-M-B	M-A-M-A-M-A-M-A	M-P-M-P-M-P-M-P	M-L-M-L-M-L-M-L	M-E-M-E-M-E-M-E	M-M-M-M-M-M-M-M
	M-B-M-B-M-B-M-B	M-A-M-A-M-A-M-A	M-P-M-P-M-P-M-P	M-L-M-L-M-L-M-L	M-E-M-E-M-E-M-E	M-M-M-M-M-M-M-M
	M-B-M-B-M-B-M-B	M-A-M-A-M-A-M-A	M-P-M-P-M-P-M-P	M-L-M-L-M-L-M-L	M-E-M-E-M-E-M-E	M-M-M-M-M-M-M-M
	M-B-M-B-M-B-M-B	M-A-M-A-M-A-M-A	M-P-M-P-M-P-M-P	M-L-M-L-M-L-M-L	M-E-M-E-M-E-M-E	M-M-M-M-M-M-M-M
	M-B-M-B-M-B-M-B	M-A-M-A-M-A-M-A	M-P-M-P-M-P-M-P	M-L-M-L-M-L-M-L	M-E-M-E-M-E-M-E	M-M-M-M-M-M-M-M
	M-B-M-B-M-B-M-B	M-A-M-A-M-A-M-A	M-P-M-P-M-P-M-P	M-L-M-L-M-L-M-L	M-E-M-E-M-E-M-E	M-M-M-M-M-M-M-M
	M-B-M-B-M-B-M-B	M-A-M-A-M-A-M-A	M-P-M-P-M-P-M-P	M-L-M-L-M-L-M-L	M-E-M-E-M-E-M-E	M-M-M-M-M-M-M-M
	M-B-M-B-M-B-M-B	M-A-M-A-M-A-M-A	M-P-M-P-M-P-M-P	M-L-M-L-M-L-M-L	M-E-M-E-M-E-M-E	M-M-M-M-M-M-M-M
Block ASC	M-M-L-M-M-L-M-M	M-M-E-M-M-E-M-M	M-M-M-M-M-M-M-M	M-M-B-M-M-B-M-M	M-M-A-M-M-A-M-M	M-M-P-M-M-P-M-M
	M-M-L-M-M-L-M-M	M-M-E-M-M-E-M-M	M-M-M-M-M-M-M-M	M-M-B-M-M-B-M-M	M-M-A-M-M-A-M-M	M-M-P-M-M-P-M-M
	M-M-L-M-M-L-M-M	M-M-E-M-M-E-M-M	M-M-M-M-M-M-M-M	M-M-B-M-M-B-M-M	M-M-A-M-M-A-M-M	M-M-P-M-M-P-M-M
	M-M-L-M-M-L-M-M	M-M-E-M-M-E-M-M	M-M-M-M-M-M-M-M	M-M-B-M-M-B-M-M	M-M-A-M-M-A-M-M	M-M-P-M-M-P-M-M
	M-M-L-M-M-L-M-M	M-M-E-M-M-E-M-M	M-M-M-M-M-M-M-M	M-M-B-M-M-B-M-M	M-M-A-M-M-A-M-M	M-M-P-M-M-P-M-M
	M-M-L-M-M-L-M-M	M-M-E-M-M-E-M-M	M-M-M-M-M-M-M-M	M-M-B-M-M-B-M-M	M-M-A-M-M-A-M-M	M-M-P-M-M-P-M-M
	M-M-L-M-M-L-M-M	M-M-E-M-M-E-M-M	M-M-M-M-M-M-M-M	M-M-B-M-M-B-M-M	M-M-A-M-M-A-M-M	M-M-P-M-M-P-M-M
	M-M-L-M-M-L-M-M	M-M-E-M-M-E-M-M	M-M-M-M-M-M-M-M	M-M-B-M-M-B -M-M	M-M-A-M-M-A-M-M	M-M-P-M-M-P-M-M
Block BRC	M-A-M-A-M-A-M-A	M-L-M-L-M-L-M-L	M-P-M-P-M-P-M-P	M-M-M-M-M-M-M-M	M-E-M-E-M-E-M-E	M-B-M-B-M-B-M-B
	M-A-M-A-M-A-M-A	M-L-M-L-M-L-M-L	M-P-M-P-M-P-M-P	M-M-M-M-M-M-M-M	M-E-M-E-M-E-M-E	M-B-M-B-M-B-M-B
	M-A-M-A-M-A-M-A	M-L-M-L-M-L-M-L	M-P-M-P-M-P-M-P	M-M-M-M-M-M-M-M	M-E-M-E-M-E-M-E	M-B-M-B-M-B-M-B
	M-A-M-A-M-A-M-A	M-L-M-L-M-L-M-L	M-P-M-P-M-P-M-P	M-M-M-M-M-M-M-M	M-E-M-E-M-E-M-E	M-B-M-B-M-B-M-B
	M-A-M-A-M-A-M-A	M-L-M-L-M-L-M-L	M-P-M-P-M-P-M-P	M-M-M-M-M-M-M-M	M-E-M-E-M-E-M-E	M-B-M-B-M-B-M-B
	M-A-M-A-M-A-M-A	M-L-M-L-M-L-M-L	M-P-M-P-M-P-M-P	M-M-M-M-M-M-M-M	M-E-M-E-M-E-M-E	M-B-M-B-M-B-M-B
	M-A-M-A-M-A-M-A	M-L-M-L-M-L-M-L	M-P-M-P-M-P-M-P	M-M-M-M-M-M-M-M	M-E-M-E-M-E-M-E	M-B-M-B-M-B-M-B
	M-A-M-A-M-A-M-A	M-L-M-L-M-L-M-L	M-P-M-P-M-P-M-P	M-M-M-M-M-M-M-M	M-E-M-E-M-E-M-E	M-B-M-B-M-B-M-B
Block BSC	M-M-P-M-M-P-M-M	M-M-A-M-M-A-M-M	M-M-E-M-M-E-M-M	M-M-B-M-M-B-M-M	M-M-P-M-M-P-M-M	M-M-L-M-M-L-M-M
	M-M-P-M-M-P-M-M	M-M-A-M-M-A-M-M	M-M-E-M-M-E-M-M	M-M-B-M-M-B-M-M	M-M-P-M-M-P-M-M	M-M-L-M-M-L-M-M
	M-M-P-M-M-P-M-M	M-M-A-M-M-A-M-M	M-M-E-M-M-E-M-M	M-M-B-M-M-B-M-M	M-M-P-M-M-P-M-M	M-M-L-M-M-L-M-M
	M-M-P-M-M-P-M-M	M-M-A-M-M-A-M-M	M-M-E-M-M-E-M-M	M-M-B-M-M-B-M-M	M-M-P-M-M-P-M-M	M-M-L-M-M-L-M-M
	M-M-P-M-M-P-M-M	M-M-A-M-M-A-M-M	M-M-E-M-M-E-M-M	M-M-B-M-M-B-M-M	M-M-P-M-M-P-M-M	M-M-L-M-M-L-M-M
	M-M-P-M-M-P-M-M	M-M-A-M-M-A-M-M	M-M-E-M-M-E-M-M	M-M-B-M-M-B-M-M	M-M-P-M-M-P-M-M	M-M-L-M-M-L-M-M
	M-M-P-M-M-P-M-M	M-M-A-M-M-A-M-M	M-M-E-M-M-E-M-M	M-M-B-M-M-B-M-M	M-M-P-M-M-P-M-M	M-M-L-M-M-L-M-M
	M-M-P-M-M-P-M-M	M-M-A-M-M-A-M-M	M-M-E-M-M-E-M-M	M-M-B-M-M-B-M-M	M-M-P-M-M-P-M-M	M-M-L-M-M-L-M-M

M= maize; **B**= beans; **A**= Amaranth; **P**= pumpkin; **L**=lablab; **E**= African eggplants

Appendix IV STATA models and pairwise correlations

```
. corr GENDER AGE EXP group1 location2 maizesub ARRANGE_MAIZE EDUC PARCEL FARM_ABOVE CREDACC_B lnincome RISK_4
(obs=99)
```

	GENDER	AGE	EXP	group1	locati~2	maizesub	ARRANG~E	EDUC	PARCEL	FARM_A~E	CREDAC~B	lnincome	RISK_4
GENDER	1.0000												
AGE	-0.0215	1.0000											
EXP	-0.1140	0.8389	1.0000										
group1	0.2755	-0.0947	-0.0531	1.0000									
location2	-0.1905	0.1310	0.1147	0.0329	1.0000								
maizesub	-0.1469	0.0333	0.0689	0.0382	0.0123	1.0000							
ARRANGE_MA~E	0.0733	0.1063	0.0409	0.0872	0.1135	-0.0774	1.0000						
EDUC	0.1639	-0.4386	-0.4246	0.0935	-0.1096	-0.1753	-0.1112	1.0000					
PARCEL	-0.1051	0.0328	0.0001	0.1219	0.1865	-0.2918	0.0164	0.0619	1.0000				
FARM_ABOVE	-0.1112	0.3777	0.3480	-0.0630	0.1198	0.0405	0.1648	-0.1640	0.0287	1.0000			
CREDACC_B	0.0944	0.0141	0.0607	0.0631	-0.1087	-0.1854	-0.0551	0.0741	-0.0252	-0.0209	1.0000		
lnincome	-0.2759	-0.0001	0.0872	-0.0538	0.1188	0.0640	-0.2344	0.0834	0.2121	0.1149	0.1975	1.0000	
RISK_4	-0.0298	-0.1951	-0.1704	0.1198	-0.0018	0.1953	0.0641	0.1684	-0.0328	0.0528	-0.1782	0.1000	1.0000

```
.

. vif
```

Variable	VIF	1/VIF
AGE	3.90	0.256416
EXP	3.70	0.270099
EDUC	1.39	0.718125
lnincome	1.37	0.728941
GENDER	1.34	0.746711
maizesub	1.30	0.768326
PARCEL	1.28	0.779202
FARM_ABOVE	1.25	0.799776
group1	1.20	0.832388
RISK_4	1.20	0.833862
CREDACC_B	1.20	0.836713
ARRANGE_MA~E	1.16	0.860637
location2	1.13	0.885374
Mean VIF	1.65	

```
.  mvprobit (ADOPT_PUMPKIN =GENDER AGE EXP group1 location2 maizesub ARRANGE_MAIZE EDUC P
> ARCEL FARM_ABOVE CREDACC_B lnincome RISK_4) (ADOPT_EGGPLANT=GENDER AGE EXP group1 locat
> ion2 maizesub ARRANGE_MAIZE EDUC PARCEL FARM_ABOVE CREDACC_B lnincome RISK_4) (ADOPT_AM
> A=GENDER AGE EXP group1 location2 maizesub ARRANGE_MAIZE EDUC PARCEL FARM_ABOVE CREDACC
> _B lnincome RISK_4) (ADOPT_LAB =GENDER AGE EXP group1 location2 maizesub ARRANGE_MAIZE
> EDUC PARCEL FARM_ABOVE CREDACC_B lnincome RISK_4), dr(15)

Iteration 0:   log likelihood = -209.35296
Iteration 1:   log likelihood = -190.95344
Iteration 2:   log likelihood = -187.71292
Iteration 3:   log likelihood = -187.65205
Iteration 4:   log likelihood = -187.65193
Iteration 5:   log likelihood = -187.65193

Multivariate probit (MSL, # draws = 15)          Number of obs   =         99
                                                 Wald chi2(52)   =      79.14
Log likelihood = -187.65193                      Prob > chi2     =     0.0090
```

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
ADOPT_PUMPKIN						
GENDER	.056766	.4072763	0.14	0.889	-.7414809	.8550129
AGE	.0128538	.0297867	0.43	0.666	-.045527	.0712346
EXP	.0152225	.0315813	0.48	0.630	-.0466758	.0771207
group1	1.021715	.3280052	3.11	0.002	.3788371	1.664594
location2	-.1132951	.3130164	-0.36	0.717	-.726796	.5002057
maizesub	-.0522924	.3238816	-0.16	0.872	-.6870887	.5825038
ARRANGE_MAIZE	.4641941	.3252683	1.43	0.154	-.1733201	1.101708
EDUC	-.0039244	.0436621	-0.09	0.928	-.0895004	.0816516
PARCEL	-.068325	.1027307	-0.67	0.506	-.2696736	.1330235
FARM_ABOVE	.005567	.2268558	0.02	0.980	-.4390622	.4501961
CREDACC_B	-.0107397	.3060103	-0.04	0.972	-.6105089	.5890295
lnincome	-.3878288	.165319	-2.35	0.019	-.7118481	-.0638094
RISK_4	-.353744	.3312255	-1.07	0.286	-1.002934	.2954461
_cons	4.317982	2.563314	1.68	0.092	-.7060205	9.341984
ADOPT_EGGPLANT						
GENDER	.4052642	.3860316	1.05	0.294	-.3513438	1.161872
AGE	.033377	.0307207	1.09	0.277	-.0268344	.0935884
EXP	-.0143658	.0323443	-0.44	0.657	-.0777594	.0490278
group1	.5979448	.3144579	1.90	0.057	-.0183814	1.214271
location2	.4761041	.3166469	1.50	0.133	-.1445124	1.096721
maizesub	-.6959978	.3108035	-2.24	0.025	-1.305161	-.0868343
ARRANGE_MAIZE	-.6184459	.327285	-1.89	0.059	-1.259913	.0230208
EDUC	.0524598	.0442379	1.19	0.236	-.0342448	.1391645
PARCEL	-.1601581	.1289646	-1.24	0.214	-.4129241	.0926079
FARM_ABOVE	-.2448819	.2365563	-1.04	0.301	-.7085237	.21876
CREDACC_B	-.3940276	.3013501	-1.31	0.191	-.984663	.1966077
lnincome	.045512	.1619136	0.28	0.779	-.2718328	.3628568
RISK_4	-.3221808	.3260462	-0.99	0.323	-.9612197	.3168581
_cons	.6765474	2.615321	0.26	0.796	-4.449387	5.802482
ADOPT_AMA						
GENDER	.3774469	.4365485	0.86	0.387	-.4781725	1.233066
AGE	-.0707235	.0337337	-2.10	0.036	-.1368404	-.0046066
EXP	.0697995	.0374292	1.86	0.062	-.0035604	.1431594
group1	-.218522	.3361852	-0.65	0.516	-.8774329	.4403888
location2	.5444298	.3486111	1.56	0.118	-.1388354	1.227695
maizesub	-.0696449	.3203224	-0.22	0.828	-.6974653	.5581754
ARRANGE_MAIZE	-.2081527	.350269	-0.59	0.552	-.8946673	.478362
EDUC	-.1093558	.0507381	-2.16	0.031	-.2088007	-.0099109
PARCEL	-.2722031	.1107144	-2.46	0.014	-.4891993	-.0552069
FARM_ABOVE	-.0956019	.2621897	-0.36	0.715	-.6094843	.4182806
CREDACC_B	.3145779	.3295122	0.95	0.340	-.3312541	.96041
lnincome	-.0723774	.1797543	-0.40	0.687	-.4246894	.2799345
RISK_4	.1951427	.3353412	0.58	0.561	-.462114	.8523995
_cons	4.787897	2.921022	1.64	0.101	-.9372018	10.513
ADOPT_LAB						
GENDER	.8520614	.3928115	2.17	0.030	.082165	1.621958
AGE	.0349904	.0314458	1.11	0.266	-.0266422	.096623
EXP	-.0539701	.0353237	-1.53	0.127	-.1232033	.0152631
group1	.7968999	.3357451	2.37	0.018	.1388517	1.454948
location2	.9627544	.3382219	2.85	0.004	.2998516	1.625657
maizesub	-.3399525	.3258002	-1.04	0.297	-.9785092	.2986043
ARRANGE_MAIZE	-.2235051	.3445579	-0.65	0.517	-.8988261	.451816
EDUC	.0591028	.0451791	1.31	0.191	-.0294466	.1476522
PARCEL	.0082754	.1064387	0.08	0.938	-.2003407	.2168915
FARM_ABOVE	.4406928	.2568359	1.72	0.086	-.0626963	.9440818
CREDACC_B	.0310461	.3191845	0.10	0.923	-.594544	.6566361
lnincome	-.1816832	.1750941	-1.04	0.299	-.5248615	.161495
RISK_4	-.5842913	.3414339	-1.71	0.087	-1.25349	.0849069
_cons	.3734764	2.71361	0.14	0.891	-4.945102	5.692055

```
. probit ADOPT_AMA GENDER AGE EXP group1 location2 maizesub ARRANGE_MAIZE EDUC PARCEL FARM
> _ABOVE CREDACC_B lnincome RISK_4

Iteration 0:   log likelihood = -55.944153
Iteration 1:   log likelihood = -45.252196
Iteration 2:   log likelihood = -45.016349
Iteration 3:   log likelihood = -45.016204
Iteration 4:   log likelihood = -45.016204

Probit regression                                 Number of obs   =         99
                                                  LR chi2(13)     =      21.86
                                                  Prob > chi2     =     0.0576
Log likelihood = -45.016204                       Pseudo R2       =     0.1953

------------------------------------------------------------------------------
   ADOPT_AMA |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      GENDER |   .3125135   .4330557     0.72   0.471      -.53626    1.161287
         AGE |  -.0829706   .0348147    -2.38   0.017    -.1512061   -.014735
         EXP |   .0886449   .0395715     2.24   0.025     .0110861    .1662036
      group1 |  -.2249781     .34922    -0.64   0.519    -.9094367    .4594805
   location2 |   .4240558    .364671     1.16   0.245    -.2906862    1.138798
    maizesub |  -.0759388   .3321814    -0.23   0.819    -.7270025    .5751248
ARRANGE_MAIZE|  -.2150016   .3811313    -0.56   0.573    -.9620053    .5320021
        EDUC |  -.1102432   .0532902    -2.07   0.039    -.2146901   -.0057963
      PARCEL |  -.2672187    .117609    -2.27   0.023    -.4977281   -.0367093
  FARM_ABOVE |  -.2005528   .2634634    -0.76   0.447    -.7169315    .3158259
   CREDACC_B |   .2120018    .343608     0.62   0.537    -.4614575     .885461
    lnincome |  -.0209652   .1921519    -0.11   0.913     -.397576    .3556455
      RISK_4 |   .2371549   .3377279     0.70   0.483    -.4247796    .8990894
       _cons |   4.710983   3.019144     1.56   0.119    -1.206431     10.6284
------------------------------------------------------------------------------

. mfx

Marginal effects after probit
      y  = Pr(ADOPT_AMA) (predict)
         =  .79082329
------------------------------------------------------------------------------
variable |      dy/dx    Std. Err.     z    P>|z|  [    95% C.I.   ]      X
---------+--------------------------------------------------------------------
 GENDER*|    .0831463      .10581    0.79   0.432  -.124233  .290526   .212121
     AGE |   -.023857      .00983   -2.43   0.015   -.04312 -.004594   34.5152
     EXP |   .0254886      .01105    2.31   0.021   .003833  .047144   12.0707
 group1*|   -.0662293      .10476   -0.63   0.527  -.271548  .139089   .363636
locati~2*|    .113817      .09087    1.25   0.210  -.064289  .291923   .313131
maizesub*|  -.0218672      .09582   -0.23   0.819  -.209671  .165937   .474747
ARRANG~E |  -.0618207      .10905   -0.57   0.571  -.275552   .15191   1.69697
    EDUC |  -.0316989       .0149   -2.13   0.033  -.060909 -.002489   8.55556
  PARCEL |  -.0768351      .03444   -2.23   0.026  -.144345 -.009325   2.27273
FARM_A~E |  -.0576662      .07581   -0.76   0.447  -.206245  .090913   2.33333
CREDAC~B |   .0609582      .09889    0.62   0.538  -.132857  .254773   1.62626
lnincome |  -.0060283      .05527   -0.11   0.913  -.114353  .102296   14.4978
 RISK_4*|    .0700266      .10174    0.69   0.491  -.129374  .269428   .646465
------------------------------------------------------------------------------
(*) dy/dx is for discrete change of dummy variable from 0 to 1
```

```
. probit ADOPT_LAB GENDER AGE EXP group1 location2 maizesub ARRANGE_MAIZE EDUC PARCEL FARM
> _ABOVE CREDACC_B lnincome RISK_4

Iteration 0:   log likelihood = -67.480819
Iteration 1:   log likelihood = -51.934034
Iteration 2:   log likelihood = -51.758471
Iteration 3:   log likelihood =  -51.75841
Iteration 4:   log likelihood =  -51.75841

Probit regression                                 Number of obs   =         99
                                                  LR chi2(13)     =      31.44
                                                  Prob > chi2     =     0.0029
Log likelihood =  -51.75841                       Pseudo R2       =     0.2330
```

ADOPT_LAB	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
GENDER	.9324189	.3953353	2.36	0.018	.157576	1.707262
AGE	.0234715	.0308453	0.76	0.447	-.0369841	.0839271
EXP	-.0437472	.0338247	-1.29	0.196	-.1100423	.022548
group1	.6639159	.3252131	2.04	0.041	.0265099	1.301322
location2	.9588907	.3338235	2.87	0.004	.3046087	1.613173
maizesub	-.2480598	.3234716	-0.77	0.443	-.8820525	.3859328
ARRANGE_MAIZE	-.3342055	.3327078	-1.00	0.315	-.9863007	.3178898
EDUC	.0322183	.0444046	0.73	0.468	-.0548131	.1192498
PARCEL	.0194988	.0992556	0.20	0.844	-.1750386	.2140363
FARM_ABOVE	.4940576	.2558363	1.93	0.053	-.0073724	.9954875
CREDACC_B	.0462233	.3198174	0.14	0.885	-.5806073	.6730538
lnincome	-.2228989	.1742799	-1.28	0.201	-.5644812	.1186834
RISK_4	-.5459139	.3374833	-1.62	0.106	-1.207369	.1155413
_cons	1.45982	2.600119	0.56	0.574	-3.636321	6.55596

```
. mfx

Marginal effects after probit
      y  = Pr(ADOPT_LAB) (predict)
         =     .40514
```

variable	dy/dx	Std. Err.	z	P>|z|	[95%	C.I.]	X
GENDER*	.3588003	.14036	2.56	0.011	.083692	.633908	.212121
AGE	.0090978	.01194	0.76	0.446	-.014305	.032501	34.5152
EXP	-.0169569	.01308	-1.30	0.195	-.042585	.008671	12.0707
group1*	.2572916	.12313	2.09	0.037	.015958	.498625	.363636
locati~2*	.3677468	.1196	3.07	0.002	.133329	.602164	.313131
maizesub*	-.0957735	.12413	-0.77	0.440	-.339058	.147511	.474747
ARRANG~E	-.1295416	.12874	-1.01	0.314	-.381867	.122784	1.69697
EDUC	.0124882	.01722	0.73	0.468	-.021257	.046234	8.55556
PARCEL	.0075579	.03847	0.20	0.844	-.067838	.082954	2.27273
FARM_A~E	.1915019	.09935	1.93	0.054	-.003213	.386217	2.33333
CREDAC~B	.0179166	.12395	0.14	0.885	-.225018	.260852	1.62626
lnincome	-.086398	.06747	-1.28	0.200	-.21863	.045834	14.4978
RISK_4*	-.212441	.12967	-1.64	0.101	-.466594	.041712	.646465

(*) dy/dx is for discrete change of dummy variable from 0 to 1

. probit ADOPT_PUMPKIN GENDER AGE EXP group1 location2 maizesub ARRANGE_MAIZE EDUC PARCEL

```
Iteration 0:   log likelihood =  -68.61652
Iteration 1:   log likelihood = -55.100957
Iteration 2:   log likelihood = -54.987949
Iteration 3:   log likelihood = -54.987795
Iteration 4:   log likelihood = -54.987795

Probit regression                                 Number of obs   =         99
                                                  LR chi2(13)     =      27.26
                                                  Prob > chi2     =     0.0115
Log likelihood = -54.987795                       Pseudo R2       =     0.1986
```

ADOPT_PUMPKIN	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
GENDER	.0384287	.396522	0.10	0.923	-.7387402	.8155976
AGE	.0071759	.030392	0.24	0.813	-.0523913	.066743
EXP	.0177279	.0325093	0.55	0.586	-.0459891	.0814449
group1	.9550841	.3227117	2.96	0.003	.3225807	1.587587
location2	-.0134474	.3139319	-0.04	0.966	-.6287427	.6018478
maizesub	.0281491	.3258471	0.09	0.931	-.6104994	.6667977
ARRANGE_MAIZE	.4433407	.3264885	1.36	0.174	-.1965651	1.083246
EDUC	-.0089528	.043623	-0.21	0.837	-.0944523	.0765466
PARCEL	-.0682963	.1013913	-0.67	0.501	-.2670195	.130427
FARM_ABOVE	-.0182144	.2360127	-0.08	0.938	-.4807908	.444362
CREDACC_B	.0568138	.3106279	0.18	0.855	-.5520056	.6656333
lnincome	-.4148245	.17022	-2.44	0.015	-.7484496	-.0811994
RISK_4	-.3522939	.3234439	-1.09	0.276	-.9862323	.2816446
_cons	4.819862	2.614811	1.84	0.065	-.3050728	9.944798

. mfx

```
Marginal effects after probit
      y  = Pr(ADOPT_PUMPKIN) (predict)
         =  .48994033
```

variable	dy/dx	Std. Err.	z	P>|z|	[95%	C.I.]	X
GENDER*	.0153283	.15817	0.10	0.923	-.294671	.325328	.212121
AGE	.0028618	.01212	0.24	0.813	-.020895	.026618	34.5152
EXP	.0070702	.01297	0.55	0.586	-.018342	.032482	12.0707
group1*	.3651538	.11291	3.23	0.001	.143855	.586453	.363636
locati~2*	-.0053626	.12518	-0.04	0.966	-.250714	.239989	.313131
maizesub*	.0112261	.12995	0.09	0.931	-.243466	.265919	.474747
ARRANG~E	.1768111	.13022	1.36	0.175	-.078414	.432036	1.69697
EDUC	-.0035705	.0174	-0.21	0.837	-.037668	.030527	8.55556
PARCEL	-.0272376	.04043	-0.67	0.501	-.106488	.052012	2.27273
FARM_A~E	-.0072642	.09413	-0.08	0.938	-.191748	.17722	2.33333
CREDAC~B	.0226582	.12389	0.18	0.855	-.220152	.265469	1.62626
lnincome	-.1654384	.06785	-2.44	0.015	-.298423	-.032454	14.4978
RISK_4*	-.1397733	.12681	-1.10	0.270	-.388323	.108776	.646465

(*) dy/dx is for discrete change of dummy variable from 0 to 1

```
. probit ADOPT_EGGPLANT GENDER AGE EXP group1 location2 maizesub ARRANGE_MAIZE EDUC PARCEL
> FARM_ABOVE CREDACC_B lnincome RISK_4

Iteration 0:   log likelihood = -68.576109
Iteration 1:   log likelihood =  -57.63957
Iteration 2:   log likelihood = -57.590565
Iteration 3:   log likelihood = -57.590547
Iteration 4:   log likelihood = -57.590547

Probit regression                                 Number of obs   =         99
                                                  LR chi2(13)     =      21.97
                                                  Prob > chi2     =     0.0558
Log likelihood = -57.590547                       Pseudo R2       =     0.1602
```

ADOPT_EGGPLANT	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
GENDER	.519754	.391154	1.33	0.184	-.2468938	1.286402
AGE	.0250035	.0298119	0.84	0.402	-.0334267	.0834337
EXP	-.0087307	.0319029	-0.27	0.784	-.0712593	.0537978
group1	.520703	.3162554	1.65	0.100	-.0991462	1.140552
location2	.5293105	.3217668	1.65	0.100	-.1013408	1.159962
maizesub	-.7088615	.3090739	-2.29	0.022	-1.314635	-.1030877
ARRANGE_MAIZE	-.6076872	.3241322	-1.87	0.061	-1.242975	.0276003
EDUC	.0418735	.0432997	0.97	0.334	-.0429924	.1267395
PARCEL	-.1533582	.1040473	-1.47	0.141	-.3572871	.0505708
FARM_ABOVE	-.2206139	.2341142	-0.94	0.346	-.6794694	.2382415
CREDACC_B	-.4121476	.3055958	-1.35	0.177	-1.011104	.1868091
lnincome	.0577503	.1620574	0.36	0.722	-.2598764	.375377
RISK_4	-.3206117	.3148216	-1.02	0.308	-.9376506	.2964272
_cons	.7368329	2.515935	0.29	0.770	-4.194309	5.667975

```
. mfx

Marginal effects after probit
      y  = Pr(ADOPT_EGGPLANT) (predict)
         =  .51862396
```

variable	dy/dx	Std. Err.	z	P>|z|	[95%	C.I.]	X
GENDER*	.2012141	.14369	1.40	0.161	-.080414	.482842	.212121
AGE	.0099641	.01188	0.84	0.402	-.013323	.033251	34.5152
EXP	-.0034793	.01271	-0.27	0.784	-.028397	.021439	12.0707
group1*	.204021	.12013	1.70	0.089	-.031435	.439476	.363636
locati~2*	.2065745	.12107	1.71	0.088	-.030722	.443871	.313131
maizesub*	-.2768738	.11583	-2.39	0.017	-.5039	-.049848	.474747
ARRANG~E	-.2421679	.12916	-1.87	0.061	-.495312	.010977	1.69697
EDUC	.0166869	.01726	0.97	0.334	-.017136	.050509	8.55556
PARCEL	-.0611144	.04148	-1.47	0.141	-.142409	.02018	2.27273
FARM_A~E	-.0879163	.09332	-0.94	0.346	-.270811	.094978	2.33333
CREDAC~B	-.1642439	.12173	-1.35	0.177	-.402826	.074338	1.62626
lnincome	.0230139	.06458	0.36	0.722	-.103556	.149583	14.4978
RISK_4*	-.1268072	.12287	-1.03	0.302	-.36762	.114006	.646465

(*) dy/dx is for discrete change of dummy variable from 0 to 1