ECONOMIC ANALYSIS OF THE CHOICE OF AFLATOXIN CONTROL PRACTICES AMONG MAIZE FARMERS IN KILIFI COUNTY, KENYA

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DECLARATION

This thesis is my original work and has not been submitted for award of a degree in any other University.

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DEDICATION

This thesis is dedicated to my late beloved parents, Mr. and Mrs. Uzel, my dear wife and friend, Dr. Jean Uzel, and my lovely daughters, Catherine, Esther and Glory, whose sincere love and support has continually inspired my academic life.

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ACRONYMS AND ABBREVIATIONS

AFB1:	Aflatoxin B1
CIMMYT:	International Maize and Wheat Improvement Center
DRC:	Democratic Republic of Congo
FAO:	Food and Agriculture Organization of the United Nations
GoK:	Government of Kenya
HCC:	Hepatocellular Carcinoma
IFPRI:	International Food Policy Research Institute
IITA:	International Institute of Tropical Agriculture
KALRO:	Kenya Agricultural and Livestock Research Organization
MNL:	Multinomial Logit
MNP:	Multinomial Probit
MoALD:	Ministry of Agriculture, Livestock and Fisheries Development
MVP:	Multivariate Probit
NCPB:	National Cereals and Produce Board
NFSCC:	National Food Safety Coordination Committee
PACA:	Partnership for Aflatoxin Control in Africa
PCA:	Principal Component Analysis
RUM:	Random Utility Model
RUT:	Random Utility Theory
SSA:	Sub-Saharan Africa
TV:	Television
VIF:	Variance Inflation Factor
WHO:	World Health Organization
WTP	Willingness to Pay

ABSTRACT

Globally, aflatoxin contamination remains a major concern for food safety, agricultural production, and health implications. Kenya has repeatedly experienced cases of acute and chronic aflatoxin poisoning over the years. Farmers respond to such incidents of Aflatoxin contamination using a myriad of agricultural practices that are believed to vary across farmers and regions. This study this study sought to analyze the choice of aflatoxin control practices among small scale maize farmers in Kilifi County, an aflatoxin hotspot in the Coast region of Kenya. The study sought to identify the aflatoxin contamination control practices and assess the factors influencing the number of control practices adopted by small scale maize farmers in Kilifi County. A Poisson regression model was employed on a sample of 270 farmers, selected using a multistage sampling technique. The main aflatoxin control practices used by smallholder farmers in Kilifi County include pre-harvest practices (timely planting, pest and disease control, use of improved maize variety, early harvesting), and post-harvest practices (sorting, proper drying, and use of insecticides and fumigants). The Poisson results show gender and age of the household head, extension services, wealth index and farmers aflatoxin awareness significantly influenced the choice of aflatoxin control practices in Kilifi County. Targeted interventions should be central to aflatoxin control strategies in the County, taking into account the socioeconomic characteristics of the farming households. This will ensure that more farmers are using postharvest practices to complement pre-harvest practices.

CHAPTER ONE: INTRODUCTION

1.1 Background information

Aflatoxin is a highly toxic substance produced as secondary metabolites by *Aspergillus flavus* and *Aspergillus parasiticus* fungi (Lizárraga-Paulín *et al*., 2011; Hell *et al*., 2008). There are about 18 types of aflatoxins produced by the fungi, but B1, B2, G1, and G2 are the major aflatoxin types that affect food crops and are known to be dangerous to both humans and livestock (Strosnider *et al*., 2006; WHO, 2018). Although many food crops are affected by aflatoxin contamination, most human exposure is from contaminated nuts and cereals (WHO, 2018). Other than food crops, humans may be exposed to aflatoxin through contaminated milk and milk products. When Aflatoxin B1 (AFB1) contaminates animal feeds, it is metabolized into Aflatoxin M1 and excreted in cow milk (Unnevehr & Grace, 2013).

Aflatoxin contamination has significant public health and economic implications. The ingestion of food with a medium to a high level of aflatoxin contamination may lead to acute poisoning, causing acute liver damage, haemorrhage, and even death (Groopman *et al*., 1988; Bbosa *et al*., 2013). Similarly, chronic (prolonged) exposure to low-level aflatoxin may cause liver cancer and other types of cancer (Eaton & Gallagher, 1994; Strosnider *et al*., 2006), immunosuppression (Strosnider *et al*., 2006), and stunting in children (Khlangwiset *et al*., 2011). In addition to health challenges, aflatoxin has a direct economic impact on smallholder farmers. The economic challenges include a high cost of preventing aflatoxin contamination; low productivity in livestock production when fed with contaminated feeds; trade restrictions; and loss of market value for contaminated crops and livestock products (Charmley *et al.*, 1995; Otsuki *et al*., 2001).

In sub-Saharan Africa (SSA), maize, and groundnuts are the most susceptible crops to aflatoxin contamination (Yard *et al*., 2013). Ordinarily, the aflatoxin-causing fungus colonizes the crops before harvesting and spreads into the stores when conditions are conducive for the fungi to thrive (Lizárraga-Paulín *et al*., 2011). Several activities predispose food crops to the fungi infestation in the field. They include drought stress, inadequate crop nutrition, pests and diseases, and grain damage during harvesting and transportation from the farm. Postharvest contamination is majorly due to inadequate drying, poor storage conditions, and attacks from pests (Munkvold, 2003).

Aflatoxin contamination is a significant challenge in Kenya, where recurrent aflatoxin outbreaks have caused acute illness and deaths (Nyaga, 2010). According to Yard *et al*.. 2013, aflatoxin exposure is widespread across all regions in Kenya, with the exception of Nairobi and North Eastern regions. Kenya recorded the highest morbidity and mortality in the 2004 outbreak in the Eastern region, where 123 deaths occurred out of the 341 reported cases (Nyaga, 2010; CDC, 2004). The government responded by initiating public campaigns on aflatoxin prevention, surveillance for acute aflatoxicosis, and using National Cereals and Produce Board (NCPB) to mop up the contaminated cereals (Nyaga, 2010).

Chronic exposure in Kenya is markedly high since the contamination is associated with major food staples such as maize and groundnuts (Bbosa *et al*., 2013; Mutegi *et al*., 2009). Maize accounts for about 36 percent of total caloric intake (Kirimi *et al*., 2011), and this may have significant health implications if the maize consumed is contaminated with aflatoxin. Unlike the acute aflatoxicosis outbreaks, chronic exposure has not received much attention despite the widespread prevalence and its resulting consequences on the human health (Daniel *et al*., 2011; Lizárraga-Paulín *et al*., 2011).

Aflatoxin is also considered as a food safety problem in Kenya and is usually regulated under the food safety regulations coordinated by the Ministry of Health. Most countries apply the FAO/WHO standards whose threshold for the aflatoxin B1 is 50 parts per trillion (ppt). The Kenyan threshold is 10 parts per billion (ppb) for cereals and stricter for milk because it is likely to be consumed by children who are more vulnerable to aflatoxin than adults (Sirma *et al*, 2018).

At the farm-level, several aflatoxin control practices exist in SSA. Because fungi infestation of the crop begins during the pre-harvest period, pre-harvest practices can reduce incidences of aflatoxin fungal infections in the field (IFPRI, 2012). For instance, the pests attack causes crop damage and allows fungi to infect the crop, causing aflatoxin contamination (Hoffmann, 2009). Drought stress and insufficient plant nutrition are also associated with the growth of aflatoxin-causing fungi in crops (Bruns, 2003). Improved crop management practices such as timely planting, pest management, fertilizer use, irrigation, and weeding can be used to significantly reduce the chances of fungi contamination in the field.

Similarly, postharvest contamination often occurs when the grain is damaged (as a result of insect damage, post-harvest handling or plant stress) and when the favorable moisture and temperature conditions exist for the fungi growth. Methods that reduce physical damage of grain during harvesting, transportation, and shelling may reduce the vulnerability of the grain to potential aflatoxin infection (Bruns, 2003). Reduced grain damage may be complemented with other postharvest practices such as sorting to remove damaged grains, proper drying of the grains, use of aerated stores, cleaning storage structures and fumigation to control insects (Hell *et al*., 2008).

Novel control practices, particularly the biological control methods are now available to farmers. The use of non-toxigenic *Aspergillus* strain to compete and exclude the toxigenic strain, reduces the chances of contamination (Dorner, 2009). Aflasafe is an example of an innovative biological control product developed by several partners led by the International Institute of Tropical Agriculture (IITA). Aflasafe reduces aflatoxin contamination in maize and groundnuts by over 80 percent (Grace *et al.*, 2015). The product is now registered for commercial use in Kenya, and it is distributed through the Kenya Agriculture and Livestock Research Organization (KALRO) research centers.

Kilifi County is one of the aflatoxin prone counties in Kenya (Nyaga, 2010; Mutegi *et al.,* 2018). In 2009, public health officials destroyed aflatoxin-contaminated maize in several counties, including Kilifi. The government of Kenya, through the National Food Safety Coordination Committee (NFSCC) made efforts to prevent aflatoxin contamination in aflatoxin-prone counties by promoting aflatoxin control technologies; developing the capacity of low-cost aflatoxin testing, and training farmers in 17 counties (Kilifi included), where aflatoxins are prevalent (Mutegi *et al*., 2018).

A number of studies have been done on aflatoxin-control practices. For instance, Udomkun *et al*. (2017) evaluated the practices used to manage aflatoxin levels in food and feed. Maina *et al.* (2016) compared the level of aflatoxin between the traditional woven polypropylene bag and the modern hermetic bags as a post-harvest control practice. However, the socioeconomic and institutional factors influencing the choice of these practices have been rarely examined, yet when rightly applied, these aflatoxin-control practices could not only be effective in reducing aflatoxin contamination but could also be affordable to many smallholder farmers.

1.2 Statement of the Problem

Aflatoxin contamination is becoming a major concern for agriculture stakeholders globally due to its enormous cost and health implications. Kenya, in particular, has repeatedly experienced cases of acute and chronic aflatoxin poisoning over the years. The Government of Kenya and non-governmental organizations have been promoting different aflatoxins contamination control practices to ensure sustainable food security and improved public health. Key among these includes the use of pre-harvest practices (timely planting, use of improved variety, pest management, fertilizer use, irrigation, and weeding), proper postharvest handling and novel practices such as biological control.

Farmers on their part have had traditional methods of managing aflatoxin but have in the recent past been exposed to the control practices being advocated for by the government especially after the 2004 outbreak of aflatoxin in Kenya. While attempts have been made to evaluate the aflatoxin control practices adopted by farmers, the factors influencing farmer's choice of these aflatoxin control practices in Kenya are not well understood. Yet such information is important in informing policy and practice especially in Kenya where aflatoxin exposure is becoming a major concern.

This study sought to bridge the existing knowlegde gap by evaluating the factors influencing smallholder maize farmer's choice of aflatoxin control practices in Kilifi County, Kenya. The information generated will be useful to policymakers and development partners promoting aflatoxin control technologies at the household level. The findings of the study can be applied in other counties facing similar aflatoxin contamination challenges.

1.3 Purpose and Objectives of the Study

The purpose of this study was to evaluate the factors influencing the choice of aflatoxin control practices among smallholder maize farmers in Kilifi County.

The specific objectives of the study were:

i. To characterize the existing aflatoxin control practices among smallholder maize farmers in Kilifi County.
ii. To assess the factors influencing the number of aflatoxin control practices adopted by smallholder maize farmers in Kilifi County.

1.4 Hypothesis

The following hypotheses were tested.

i. That there are no differences in the choice of aflatoxin control practices used by smallholder maize farmers in Kilifi County.
ii. That socioeconomic factors do not influence the number of aflatoxin control practices used by smallholder maize farmers in Kilifi County.

1.5 Justification of the Study

Aflatoxin contamination has considerable implications in agricultural productivity, health, and trade, affecting major crops (PACA, 2013). About 4.5 billion people are chronically exposed to aflatoxin, which causes about 26,000 deaths annually in SSA (Unnevehr & Grace, 2013). Yet the majority of the smallholder farmers have a low awareness level of aflatoxin exposure (Bandyopadhyay *et al*., 2016). Maize and groundnuts are the two major sources of human exposure to aflatoxin (Hell *et al*., 2010). This study evaluates aflatoxin contamination control practices among smallholder maize famers given that maize is the staple food crop in Kenya. Aflatoxin exposure is prevalent in the Country because of the low adoption of aflatoxin control practices.

Assessing aflatoxin control practices in maize farming was therefore critical in generating knowledge that will help to reduce aflatoxin exposure in Kenya. The study was undertaken in Kilifi county because it is a major maize growing County in the coast region and one of aflatoxin prone counties in Kenya (Wekesa, *et al.*, 2003; Mutegi *et al*., 2018), but very limited research has been carried out in the County to understand how farmers use the existing aflatoxin control practices and what factors influence the choice of their practices.

1.6 Organization of the Thesis

The thesis is organized into five chapters. Chapter one provides background information for the study, the research problem and states the objective. Chapter two presents a review of literature. Chapter three present the methodology including theoretical framework, empirical framework, sampling procedure, study area and data needs. Chapter four provides the findings of the study, while chapter five presents the summary, conclusions and policy recommendations of the study.

CHAPTER TWO: LITERATURE REVIEW

2.1 Review of Aflatoxin Control Practices

Several aflatoxin control practices, such as pre-harvest practices, postharvest practices, and biological control methods have been considered as effective interventions to reduce the prevalence of aflatoxin in food (Gnonlonfin *et al*., 2013). Pre-harvest practices are mainly agronomic activities or strategies adopted to prevent crops from aflatoxin contamination in the field (Munkvold, 2003). Management practises and a wide range agronomic practices that control or reduce contamination of crops exist in the literature (Rachaputi & Krosch, 2002; Strosnider *et al*., 2006; Hell *et al.,* 2010).

Bruns (2003) highlighted a number of pre-harvest aflatoxin control practices including timely planting, use of improved seed varieties, proper plant nutrition, irrigation, pest control, weeding and early harvesting. Similarly, Falade (2018) identified insect and pest control and early harvesting as crop management strategies for effective control of aflatoxin on the farm. These practices increase crop productivity. However, adoption of these practices is usually low mainly because of the their costs well as other adoption barriers that may deter smallholder farmers from taking up pre-harvest practices (Grace *et al*., 2015).

Early harvesting complements the benefits of pre-harvest practices in reducing aflatoxin contamination, where aflatoxin risk is high. Rachaputi and Krosch (2002) demonstrated that delay in harvesting and threshing of peanuts in Australia resulted in high aflatoxin contamination. Similarly, results from Kaaya *et al*. (2005) showed that delaying maize harvest by four weeks after the physiological maturity in Uganda increased aflatoxin contamination and insect damage. The delayed harvesting did not significantly reduce grain moisture as perceived by most farmers who practice delayed harvesting to dry the grains.

Crop rotation was found to have a significant effect on the proportion of Aspergillus species in the field, and an effective method of aflatoxin control (Munkvold, 2003). Jaime-Garcia & Cotty (2010) found that soils previously cropped with sorghum had significantly lower quantities of *A flavus* than soils previously cropped with maize and cotton. Other factors that increase colonization of grain by molds in crops are physical grain damage during harvesting, transportation, and shelling of grain (Munkvold, 2003; Wangacha & Muthomi, 2008).

Postharvest practices are interventions aimed to reduce aflatoxin contamination in grains after harvesting. They include drying, storage, sorting of grains, and using insecticide or fumigants to control the postharvest pest attack. Contamination can increase ten times within three days when the maize grain is not properly dried to a safe level of about 10-13 percent moisture content for cereals (Hell *et al*., 2008). Turner *et al*. (2005) reported that practices such as hand sorting, sun drying, drying on the mat, and storage in natural fibre bags reduced aflatoxin exposure by more than half in intervention villages as compared to control villages in Guinea. Moreover, proper handling during harvesting and storage prevents grain damage and subsequently reduces aflatoxin contamination.

Most maize farmers in Kenya use polypropylene bags as packaging materials during storage, but these bags provide an optimal condition for fungal growth. Grains stored in these bags are also susceptible to aflatoxin contamination and pest attack compared to the other innovative packaging materials such as hermetic bags (Gitonga *et al*., 2013). Maina *et al*. (2016) compared the efficacy of different storage bags on the incidence of aflatoxin in maize among the maize farmers in the Kaiti sub-county in Kenya. The study revealed that the level of contamination significantly differed by the type of storage bag. The hermetic bags reduced contamination by over 50 percent compared to the commonly used polypropylene bags.

The use of biological control to reduce aflatoxin contamination is a novel approach that has recently received significant attention. One example is the use of non-toxigenic strains to competitively exclude the toxigenic strain of *A flavus*, consequently reducing aflatoxin contamination (Abbas *et al*., 2006). This method has been widely used in the USA to control aflatoxin in cotton and peanuts and has recently been explored in some parts of sub-Saharan Africa (Dorner, 2009; Bandyopadhyay *et al*., 2016). Aflasafe™ was initially designed in Nigeria to promote the growth of a naturally occurring population of non-toxigenic *Aspergillu*s strains through the competitive exclusion of toxin-producing *Aspergillus* species.

2.2 Review of Theoretical Approaches for Analyzing Choice

The theories that underpin farmer decision-making processes include the theory of planned behaviour, expected utility theory and random utility theory. The theory of planned behaviour posits that an individuals decision to engage in a particular activity is influenced by their subjective evaluation of the benefits and risk of an expected outcome of that activity (Ajzen, 1985). However the theory of planned behaviour does not adequately predict the probabilities of participation like the expected utility and random utility theory (Sniehotta *et al.*, 2014).

The theory of expected utility has been applied to explain production choices under risk and uncertainty (Feder *et al*., 1985). This theory hypothesizes that, individuals will choose the alternative with the highest expected utility under risk and uncertainty. Similarly, the random utility theory (RUT) has also been widely applied to estimate the utility an individual derives from using certain type of technologies. An individual is assumed to be a rational decision maker, maximizing utility relative to the set of alternative choices availaible but the utility value is not known with certainty.

2.3 Review of the Past Related Studies

Several empirical studies have assessed the socioeconomic factors that influence the uptake of aflatoxin control practices. Martey *et al.* (2020) assessed factors influencing the intensity of use of improved storage structure as an aflatoxin control practice in Northern Ghana using a double hurdle model. The authors found that socioeconomic variables, including the number of household members who are economically active, marital status, and awareness of aflatoxin control significantly influenced the use of improved storage. This study uses a similar theoretical approach, but adopts a poisson regression model to analyze choice.

Udomkun *et al.* (2018) evaluated the incidence of aflatoxin, farmer knowledge on aflatoxin contamination (causes and effects), as well as the control measures in Eastern Democratic Republic of Congo (DRC) using an Ordinary Least Squares (OLS) model. The results indicated that aflatoxin contamination was prevalent, with 68 percent of the samples having aflatoxin levels beyond the maximum tolerable level. Furthermore, the results indicated that household size had a positive and significant influence on the level of aflatoxin in food samples. Unlike the study under review that evaluated the factors influencing the levels of aflatoxin contamination, the current study analyses the choice of aflatoxin control practices.

Migwi *et al.* (2020) assessed farmers' willingness to pay (WTP) for Aflasafe KE01 in Kenya. The study used contingent valuation to elicit the farmers' WTP and assessed the factors influencing the WTP using OLS. Access to extension services, credit access, household income, age, and awareness of Aflasafe products positively influenced farmers' WTP, while household size and distance to market negatively influenced the farmers' WTP. However, the current study adopts a poisson regression model to evaluate the number of aflatoxin control practices used in a farming household.

Pretari *et al*. (2019) assessed the impact of postharvest technologies on aflatoxin contamination in the upper Eastern region of Kenya using randomized control trials. The randomized interventions in the study were basic training on health effects and control of aflatoxin, plastic sheets for sun drying of maize and hermetic storage bags. The impact of the interventions was analysed using multivariate regression. The study found that the interventions reduced aflatoxin contamination by over 50 percent, and most of these reductions appeared to be due to training and the use of sun-drying sheets. Unlike the study under review which focused on storage practices alone, the current study analyses both pre and postharvest practices.

Hassan & Nhemachena (2008) evaluated the strategies employed by farmers to adapt to climate change in 11 SSA countries. The study analyzed the determinants of different adaptation strategies using a multinomial logit. The study found that market access, extension service, and farm assets influenced the likelihood of farmers to adapt to climate change.The study under review is relevant for the current study in two ways. Firstly, Hassan & Nhemachena (2008) employed a theoretical approach used by the current study. Secondly, the study analyzed the combination of strategies as the choice response when assessing adaptation strategy at the farm level. Similarly, our study explored the factors influencing the number of aflatoxin control practices adopted at the farm level.

Paxton et *al*. (2011) evaluated factors influencing the number of precision agriculture technologies adopted by cotton farmers. Farmer characteristics such as age and education of the farm operator were associated with the average change in the number of precision technologies used by the farmers. Other factors such as spatial yield variability significantly influenced the intensity use of the precision technologies. Like the current study, Paxton *et al*. (2011) utilized a count data model (negative binomial model).

CHAPTER THREE: METHODOLOGY

3.1. Theoretical Framework

This study is based on random utility theory, where individual *i* is hypothesized to be a rational decision-maker and chooses an alternative that provides the greatest utility relative to the choices available (Greene, 2003). The utility assigned to options available depends on the attributes of the options and the characteristics of the decision-maker (Ben-Akiva & Lerman, 1985). The choice of aflatoxin control practices is modeled using the random utility model (RUM) based on the assumption that farmers in the study area choose aflatoxin control practices that provided maximum utility relative to other available options.

Given the choice of bundle *A* and *B*, farmer i, chooses an outcome that maximizes utility from a set of alternatives of aflatoxin-control practices, j=*1,2…, J.* Each set of alternatives has a certain level of utility U_{ij}. Following Greene (2003), the farmers utility function is specified as;

$U_{ij} = V_{ij} + \varepsilon_{ij}$…………………………………………………………………. **(3.1)**

Where U_{ij} is the latent variable that captures farmers utility gained from adopting a set of aflatoxin control practices, V_{ij} is the deterministic component of the utility function, and ε_{ij} is the random term. The random term represents the unobservable factors since it is impossible to include all the determinants that affect the choice preferences in the model. The deterministic component is represented as a linear combination of the observed characteristics X and the parameters to be estimated β. Equation 3.1 can therefore be specified as;

$U_{ij} = X\beta_{ij} + \varepsilon_{ij}$ ……………………………………………………………………… **(3.2)**

The error term is not observed and the farmer's choice is not fully deterministic, we therefore derived the probability of a particular choice outcome (Greene, 2003).

Following (Greene, 2003) the probability of observing an alternative *j* is specified as shown in equation 3.3

$$P(Y = 1) = \left(U_{ij} > U_{ik} | X_i\right) \ldots\ldots \textbf{(3.3)}$$

Where U_{ij} and U_{ik} are the utilities for option *j* and *k* respectively by farmer *i*.

Discrete choice models are useful in estimating preferences under the random utility theory framework (Train, 2003). The choice of a discrete model depends on the empirical question under study. Traditionally, logit and probit models have been used to model choice. Such models include probit and logit models along with their variants such as multivariate probit, ordered probit, multinomial logit among others. Logit and probit models are used when the dependent variable is binary. The primary difference between probit and logit is that the probit model assumes a normal distribution while the logit model assumes a logistic distribution of the error term.

The extensions of probit and logit models include the multinomial logit model (MNL), multinomial probit (MNP), multivariate probit (MVP), and ordered probit/logit. These models are appropriate in cases where the dependent variable has more than two choice responses (Gujarati, 2007). The multivariate probit model is applicable where a farmer has bundled different technologies and is using the alternative technologies simultaneously, depending on the complementarities between the alternative technologies, (Marenya & Barrett, 2007; Kassie *et al.*, 2013). Whereas multinomial logit is used where technology choices are mutually exclusive as in the case of Derressa *et al.* (2009) and Mwololo *et al.* (2019). Nevertheless, these empirical approaches assume that the adopters are rational and can optimally evaluate choices before making a decision.

Ordered probit/logit allows modeling of the response variables that are discrete, with more than two ordered categories (Greene, 2007). The model is useful in analyses that involve rating and ranking of the options, where each category represents a level of utility and cutoff value in each category (Greene, 2007). The model is not appropriate for the current study because the dependent variable is not ordered nor ranked.

The MNL is appropriate when the response variable is discrete with more than two unordered responses, which are mutually exclusive. The main restriction for the MNL model is the independence of irrelevant alternatives, that is, the probability of choosing one alternative should be independent of the probability of choosing another alternative (Hausman & McFadden, 1984). In this study, most households adopted more than one aflatoxin control practice simultaneously, and therefore the practices were not mutually exclusive. We therefore did not consider MNL model appropriate for this study.

MVP is applicable when the response variable is discrete with more than two unordered categories, but individuals choose two or more interdependent alternatives (Kassie *et al.*, 2013). The farmers in this study utilized more than one practice simultaneously to control aflatoxin. MVP model assumes correlation of error terms between choice alternatives. The assumption did not hold for this study, and therefore we did not consider MVP for our analysis.

The dependent variable for our current study is a count variable, that measures the number of practices a household used to control aflatoxin in maize. Therefore the Poisson regression model (PRM) was found to be the most appropriate since it assumes the dependent variable are counts, with positive integers. The PRM also relaxes the IIA assumption of MNL, and more than one aflatoxin control practice adopted by a household can be modelled using the PRM.

3.2. Empirical Methods

3.2.1. Characterization of aflatoxin control practices in Kilifi County

The study used descriptive statistics to characterize the aflatoxin control practices used by the maize farmers in Kilifi County. The control practices were broadly categorized into preharvest and postharvest practices. The percentages were used to determine the proportion of households using the aflatoxin control practices identified in the study area.

3.2.2 Assessing the factors influencing farmers' choice of aflatoxin control practices

Econometric analysis was used to test the hypothesis that household characteristics, along with other exogenous variables influence the number of aflatoxin control practices used. The Poisson regression model (PRM) was used for this analysis. The dependent variable of the PRM was a count data variable representing the number of practices used by households to control aflatoxin contamination in maize.

The PRM is a regression model where the dependent variable, Y_i , given the a vector of independent variables, X_i , assumes a Poisson distribution. PRM specifies that each observation, Y_i, is drawn from a Poisson distribution with parameter λ_i, which is related to an array of explanatory variables X (Greene, 2008). The specification also accounts for the preponderance of small values of the dependent variables that are discrete in nature. It relaxes linear regression assumption, where the error term is assumed to be normally distributed (Cameron & Trivedi, 2001). The probability density function of Y_i, given X_i is completely determined by a conditional mean as shown in equation 1 and 2

$$\lambda(x) = E(y_i \,|x_i) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \textbf{(3.4)}$$

$$Prob(Y_i = y_i \mid x_i) = \frac{e^{-\lambda}\lambda_i^{y_i}}{y_i!}, y_i = 0,1,2 \dots, n \dots\dots\dots\dots\dots\dots \quad \textbf{(3.5)}$$

Where

λ_i is the Poisson distribution function related to the explanatory variables

y_i is the number of aflatoxin practices used by the farming households

X_i is the a vector of explanatory variables

The PRM assumes the depedent variable has to be non-negetive. The log-linear regression model accounts for the non-negative restriction imposed by Poisson on the dependent variable (Winkelmann & Zimmermann, 1995). The log linear model of the λ_i is presented in as shown in the equation 3.6 (Greene, 2003).

$$ln\lambda_i = x_i' \beta ` \dots\dots\dots\dots\dots\dots \quad \textbf{(3.6)}$$

The PRM therefore introduces a relationship between the mean parameter, λ_i and the explanatory variables, X_i. The log-linear conditional mean function and its equi-dispersion assumptions is is given as;

$$E[y_i \mid x_i] = Var[y_i \mid x_i] = \lambda_i = e^{x'\beta} \dots\dots\dots\dots\dots\dots \quad \textbf{(3.7)}$$

Therefore,

$$\frac{\partial E[y_i|x_i]}{\partial x_i} = \lambda_i \beta \dots\dots\dots\dots\dots\dots \quad \textbf{(3.8)}$$

The PRM was fitted into the data to test the hypothesis that socioeconomic factors do not influence the number of aflatoxin control practices adopted by the farming households in Kilifi County. The exogenous variable included gender, age, household size, extension, a wealth index, distance to the market, group membership, aflatoxin awareness, access to credit and education (Table 3.1).

Table 3.1. Definition of variables used in the empirical model and their measurement

Variable	Variable description	Expected sign
Dependent Variable		
Aflatoxin contamination control practices	Number of aflatoxin contamination control practices adopted by the farmer	
Independent Variables		
Age	Age of the household head (years)	+
Gender	Sex of the household head (1= Male; 0= Female)	+
Education years	Number of years spent in school for the household head (years)	+
Credit	Household head access to credit in the previous season (1= Yes; 0= No)	+
Farmer group	Membership to a farmer group by the household head in the previous season (1= Yes; 0= No)	+
Household size	Number of persons in a household	+
Extension	Access to extension services in the previous season	+
Wealth index	Households Wealth index calculated using principal component analysis	+
Distance to market	Distance to the nearest market (kilometres)	-
Farm size	Maize farm size (acres)	+
Aflatoxin awareness	Household head awareness of aflatoxin (1= Yes; 0= No)	+

i. Age of the household head

The age of the household head was measured in years and was expected to have a positive influence on the choice of aflatoxin control practices. The influence of age on technology adoption in the literature has been found to have mixed outcomes, While some studies found age to negatively influence the choice of technologies (Lapar & Pandely, 1999; Burton *et al.*, 1999), others found it to have no significant influence on farmer's decision to choose an agricultural technology (Bekele & Drake, 2003). Older farmers are more experienced and likely to have accumulated wealth and have access to capital (Lapar & Pandey, 1999). The study expected age to have a positive influence on the choice of aflatoxin control practices given that older farmers were assumed to have more experience in farming and therefore accumulated knowledge on the best farming practices that will improve food availability and food quality in their households.

ii. Gender of the household head

The gender of the household head is a dummy variable with 1 representing male and 0 representing female. We expect gender to have a positive influence on the choice of aflatoxin control practices as men within the household have better access to resources compared to women. Kaliba *et al* (2000) argued that women have less access to critical resources such as land, capital and labour compared to men. Limited access to these critical resources may negatively influence the ability of women to take up aflatoxin control practices.

iii. Education of the household head

The household head's education is a continuous variable measured in years depicting the number of years of education completed by the household head. Education increases the capacity of the farmer to take up innovation technologies in agricultural production. Education of the household head was assumed to have a positive influence on the choice of aflatoxin control practices. More educated farmers are expected to control aflatoxin as they are deemed to have access to information on the new technologies (Marenya & Barrett, 2006) that improves their awareness of the potential benefits of a technology.

iv. Credit access

The households' access to credit is a dummy variable where 1 denotes access to credit for the previous season and 0 otherwise. Access to credit enables adoption of various adaptive agricultural technologies (Deressa *et al.,* 2009). Adoption of improved maize varieties such as drought tolerant maize seed have a positive relationship with access to agricultural credit (Danso-Abbeam *et al*, 2017; Fisher & Carr, 2015). Access to credit was therefore hypothesized to have a positive influence on the choice of aflatoxin control practices as this would facilitate any necessary investment required for aflatoxin control.

v. Group Membership

Membership to a farming or savings group is a dummy variable where 1 denoted membership to a group and 0 denoted non-membership to a group in the previous planting season. According to Danso-Abbeam *et al.* (2017), farmers belonging to a farmer group were more likely to adopt improved maize varieties due to increased access to information through farmer-to-farmer networks. It is therefore assumed that membership to a group increases farmers access to information thus increases their chances of controlling for aflatoxin.

vi. Household Size

Household size is a continuous variable that indicates the number of persons in a given household. A person is considered a household member if they are living in the same household and sharing meals from the same pot in the last one year. The study hypothesized a positive relationship between choice of aflatoxin control practices and household size. Literature has shown that availability of labour enhances adoption of agricultural technologies (Mussei *et al*., 2001). Household size will positively influence the choice of aflatoxin control practices, since households with more members are assumed to have adequate labour needed for implementation of agricultural technologies.

vii. Access to extension service

Extension is a dummy variable, where 1 denotes a household had access to extension service previous season. It is hypothesized that access to extension increases the probability of choosing more aflatoxin control practices. The extension officers play a critical role in the transfer of knowledge and information to farmers, enhancing the uptake of technologies. (Aker, 2011).

viii. Wealth index

A wealth index is a continuous variable that was calculated using Principal Component Analysis (PCA). It aggregates several asset ownership variables into a single dimension the wealth index. It is a measure of wealth and it is assumed that the wealthier farmers have more access to information and also the financial capability to implement aflatoxin control practices. The wealth index therefore was hypothesized to have a positive relationship with aflatoxin control practices.

ix. Distance to the market

Distance to the market is a continuous variable that measures the distance from the farm to the market in kilometers. The variable is a proxy to access to the market. The study hypothesizes that distance to the market has a negative relationship with the probability of adopting the aflatoxin control practices. This means that the closer the farm is to the market, the more likely they are to adopt aflatoxin control practices. Longer distance to the market increase transaction costs, limiting farmers' participation in the input and output markets.

x. Farm size

Maize farm size measures the area under maize production in acres. The size of the farm may influence the ability to take up the aflatoxin control practices. It was hypothesized that the probability of choosing an aflatoxin control practice will be influenced by the size of farm under maize production. Households with larger maize farms are able to take up aflatoxin control practices because household with larger pieces of land are considered wealthier and have greater ability to invest in the aflatoxin control practices.

xi. Awareness of aflatoxin

Aflatoxin awareness is a dummy variable equal to 1 if the farmer is aware of the effects of taking food contaminated with aflatoxin and 0 otherwise. Awareness of risk and the potential benefits of solving the problem may influence the decision to implement innovative agricultural technologies (Hassan & Nhemachena, 2008).

3.3 Data sources

The study used primary data collected from smallholder maize farmers in Kilifi County using semi-structured questionnaires. Prior to the data collection, the enumerators were trained, then the questionnaire was pre-tested to reduce errors associated with the questionnaire design. The household survey was conducted between September and October 2016, targeting the household head or the spouse in maize-growing households in Kilifi County. The enumerators administered the questionnaires through face-to-face interviews in their local language.

3.3.1 Sampling Procedure & Sample Size

A multi-stage sampling technique was used to select smallholder maize farmers in Kilifi County. Kilifi County was purposely selected as one of the aflatoxin hot spots in Kenya (Nyaga, 2010). In stage two, a simple random sampling technique was used to select three out of the 6 sub-counties of Kilifi County. The selected Sub-Counties included Kaloleni, Kilifi South, and Malindi (Kilifi North). In the third stage, two locations in each of the selected sub-counties were selected using a simple random sampling technique. The selected locations included Kaloleni and Mwanamwenga in Kaloleni Sub-County, Chasimba and Junju in Kilifi South Sub-County and Ganda and Gede in Malindi Sub-County. From each location, a sampling frame of smallholder maize farmers was provided by agricultural extension officers.

The 270 households participating in the survey were selected using a simple random sampling technique from the sampling frames, where the number of households in each location was determined using proportion to size technique. To determine the sample size, the following formula by Cochran (1963) was used;

$$n_0 = \frac{Z^2 pq}{e^2} \qquad (3.6)$$

where: n_0 = sample size,

Z = the standard normal deviate at the selected confidence level; the value is 1.96 for commonly used 95percent confidence interval, p = proportion in the target population estimated to have characteristics being measured, $q = (1–p)$ and e = the desired level of precision (5 percent). In this case, p was determined as the proportion of farm families in Kilifi County growing maize and had exposure to aflatoxin contamination control. Seventy five percent of the households in Kilifi County are maize farmers and therefore the study uses p as 0.75.

Thus the computed sample size was

$$n_0 = \frac{(1.96^2)*0.75*0.25}{0.05^2} = 288 \qquad (3.8)$$

A total of 288 households were selected but 270 households were reached during data collection and interviewed because of non-responses from 18 households, hence the sample size used for analysis was 270 households.

3.4 Study Area

Kilifi County is located in the coast region of Kenya. The county borders Kwale County to the South West, Taita Taveta County to the West, Tana River County to the North, Mombasa County to the South and the Indian Ocean to the East. The county covers an area of 12,609.7 km2. According to the Government of Kenya (2010), the population of Kilifi County was projected to be 1.4 million in 2017 with an estimated growth rate of about 3 percent.

The county receives an average annual rainfall ranging from 300mm in the hinterland to 1300 mm in the coastal belt while the annual temperature ranges between 21°C-30°C (GoK, 2018). Agriculture is mainly subsistence, with the major food crops grown in the county being: maize, cassava, green grams, and cowpeas. Cashew nuts, coconuts, and mangoes are the major horticultural crops grown (GoK, 2018). Livestock production, particularly cattle, sheep, goat, and poultry keeping, is also a significant economic and livelihood activity in the county. The other important economic activities in Kilifi include; tourism and fishing (blue economy).

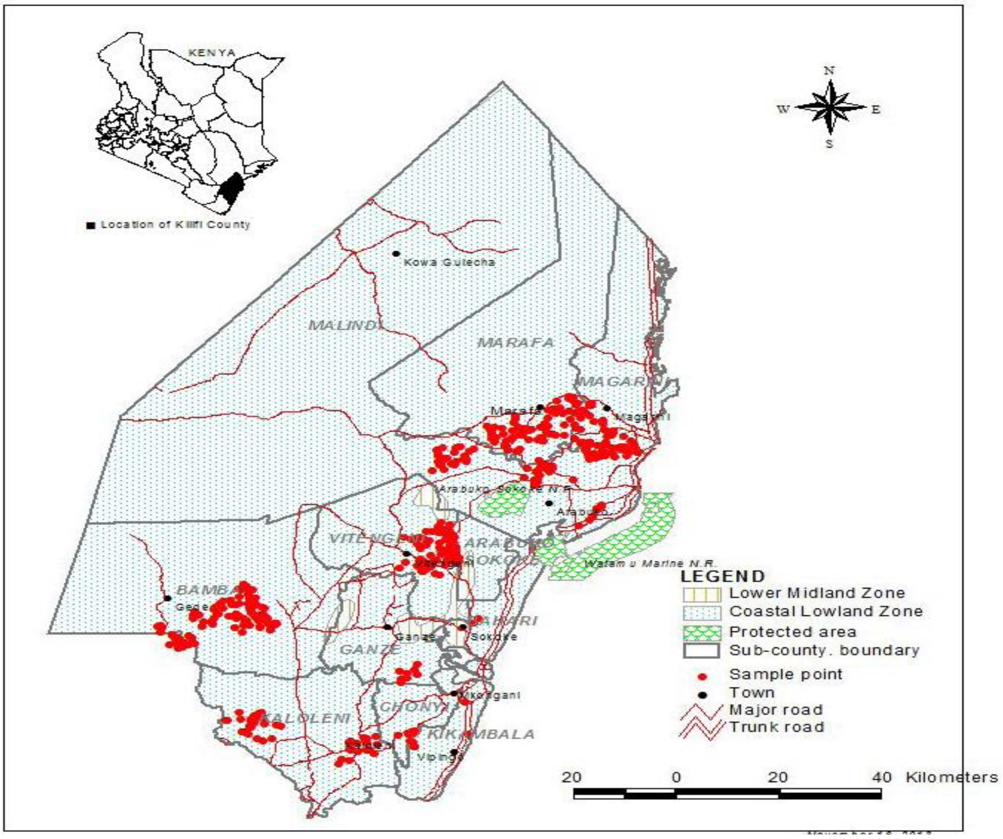

Figure 3.1. Map of Kilifi County
Source: GoK (2010)

3.4 Data analysis

Data were analysed using descriptive and inferential statistics with the help of Stata software version 14. A Poisson Regression Model was subsequently used to assess the factors influencing the choice of the number of aflatoxin control practices adopted by smallholder maize farmers in Kilifi county using Stata version 14.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1. Households Socioeconomic Characteristics

Table 4.1 presents the socioeconomic characteristics of households in Kilifi County. The average age of the head of the household was 55 years. There was no statistical difference in the average age of the farmers across the sub-counties. Though, Malindi had a slightly higher average age of 57.4 years. The overall mean household size was 4.5 but varied by sub-county.

Table 4.1. Farmers socioeconomic characteristics in Kilifi County

	Malindi (n=44)		Kilifi South (n=97)		Kaloleni (n=129)		Overall (n=270)	
Variable	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Age	57.4	12.4	53.6	11.7	54.7	11.7	54.8	11.9
Household size	5.1	1.7	4.7	1.9	4.2	1.8	4.519	1.9
Education years	7.5	4.6	8.8	3.8	8.8	4.1	8.574	4.1
Dist. to market	3.2	4.5	2.9	2.6	3.1	5.4	3.0	4.4
Area under Maize	3.8	1.0	3.9	0.8	4.4	1.1	4.1	1.0
Total land owned								

Malindi had the largest household size, having an average of 5.1 household members compared to Kilifi South (4.6) and Kaloleni (4.2). Overall, the head of the households had spent about 8 years in school. Malindi had the lowest average (7.5) compared to Kilifi South (8.79) and Kaloleni (8.76).

The average distance to the market was about 3 kilometers for all the three sub-counties. Proximity to the market implies that farmers have better access to the input and output markets and are able to better participate in the market at lower transaction costs. The mean farm size under maize production was about 4.1 acres and varied across the three sub-counties. Farmers in Kaloleni have larger maize farms (4.4 acres) than Malindi (3.8 acres) and Kilifi South (3.9 acres). Land under cultivation is a significant physical asset important in determining the choice of appropriate practices to control aflatoxin contamination.

Table 4.2. Distribution of farmer characteristic by sub-county

	Malindi (n=44)	Kilifi South (n=97)	Kaloleni (n=129)	Pooled (n=270)
Variable	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)
Gender				
Male	84.1	86.6	83.7	84.8
Female	15.9	13.4	16.3	15.2
Extension				
Yes	75.0	68.0	63.6	67.0
No	25.0	32.0	36.4	32.0
Farmer group				
Member	59.1	41.2	48.1	47.4
Non-member	40.9	58.8	51.9	52.6
Credit				
Yes	11.4	7.2	8.5	8.5
No	88.6	92.8	91.5	91.5
Aflatoxin awareness				
Yes	79.5	94.8	96.9	93.3
No	20.5	5.15	3.1	6.7

A majority (85 percent) of the households had a male head, while about 47 percent of the household heads belonged to a group, but varied across the county by sub-counties (Table 4.2). Malindi (60 percent) had the highest proportion of household heads who belong to a farmer group followed by Kaloleni (48 percent). Kilifi South (41 percent) had the least proportion of farmers who belong to a group (Table 4.2). Almost half of the household heads belong to a group, which means they have some form of social capital. The benefits of social capital could enhance the adoption of agricultural technology as well as facilitate information exchange within the farmer groups.

Access to credit was low in Kilifi County, where only 8.5 percent of the sampled households reported that they had accessed credit in the preceding year. Malindi had the highest (11 percent) proportion of farmers who had access to credit, followed by Kaloleni (8.5 percent). Kilifi South sub-county had the least proportion of farmers who received credit in the previous 12 months (7.2 percent).

Regarding aflatoxin awareness, an overwhelming majority (93 percent) were aware of aflatoxin control practices and the negative effects of aflatoxin contamiantion. However, the aflatoxin awareness was markedly lower in Malindi (79.5 percent) relative to Kilifi South (94.8 percent) and Kaloleni (96.7 percent).

4.2. Characterization of Aflatoxin Control Practices in Kilifi County

Majority (88.5 percent) of the farmers in Kilifi County used the aflatoxin control practices together, as they complement each other, and therefore the descriptive analyses for these practices were analyzed as multiple response questions. As outlined in Table 4.3 and 4.4, these practices are not mutually exclusive and do not necessarily add up to 100 percent. The study considered four preharvest practices (timely planting, improved variety, pathogen control, and early harvesting).

Table 4.3 presents the preharvest control practices used by maize farmers in Kilifi county. Timely planting helps in preventing drought stress in crops, thereby reducing the susceptibility of the crops to be contaminated by aflatoxin. 67 percent of households practiced timely planting. Over 60 percent of households used improved maize variety. These hybrid maize varieties were tolerant to drought and diseases relative to the local variety, making them less susceptible to aflatoxin contamination. Examples of hybrid maize varieties mentioned by farmers include Pwani PH1 and Pwani PH4 hybrid varieties. These varieties also have good husk cover, which protects them from pest attacks.

Table 4.3. Proportion of Pre-harvest aflatoxin contamination control practices

Preharvest practices	Count	Percent
Timely planting	181	67.0
Improved maize variety	164	60.9

Pest and disease control	127	47.0
Early harvesting	52	18.9

Pest and disease control involved activities that controlled weeds, crop pests, and diseases. The presence of weeds in the maize plots can lead to stress, increasing the aflatoxin contamination. (Bruns, 2003). Similarly, pests contribute to the fungal infection of the maize grain by damaging the maize grain and disseminating the Aspergillus pores (Drepper & Renfro, 1990; Bruns, 2003). Pest control therefore can potentially reduce aflatoxin contamination. 47 percent of the households controlled pests and diseases in their maize farms. Early harvesting entailed harvesting immediately when the maize reaches physiological maturity. Early harvesting significantly reduces fungal infection before harvesting (Rachaputi *et al*., 2002), but the number of households who practiced early harvesting was relatively low (18.9 percent). It is important to note that none of the respondents reported the use of novel control methods such as aflasafe, a biological control method touted as very effective in controlling aflatoxin contamination.

The postharvest control practices complement preharvest practices in controlling. In this study, the postharvest practices reported include proper drying, sorting, and pesticide use. To reduce aflatoxin contamination during storage, 37 percent indicated using proper drying. Sorting before storage by removal of contaminated grains was practiced by 44 percent of the household. Sorting can reduce substantially reduce the toxin level of aflatoxin in maize. About 56.7 percent used pesticides to control pests while the grain is in the store**.**

Table 4.4. Proportion of post-harvest aflatoxin contamination control practices

Aflatoxin-control practices	**Count**	**Percent**
Proper drying	99	36.7
Sorting	120	44.4

Pesticide use	153	56.7

Source: Survey data 2016

4.3.1 Model Diagnostic Tests

Appendix 1–3 presents the results of diagnostic tests for model robustness. The presence of multicollinearity in the data was tested using the tolerance level test, the variance inflation factor (VIF) test and a partial correlation coefficient test. When the pairwise correlation coefficient exceeds 0.6, and the VIF value exceeds 10, then there is a presence of multicollinearity between the explanatory variables (Gujarati, 2004). None of the partial correlation coefficients were greater than 0.35 (Appendix 1), the mean tolerance level test was 0.844 (Appendix 3), and the mean VIF was 1.20 ranging from 1.03-1.39 (Appendix 2). The study therefore concluded that multicollinearity was not a major problem in the data.

The Breusch-pagan/Cook-Weisberg test was used to test for the presence of heteroscedasticity. It tests the null hypothesis that the error term variances are all constant versus the alternative that the variances of the error term are not constant across the observations (Waldman, 1983). The Breusch-pagan test results gave a statistically significant chi-square value of 3.49 (p=0.0619), indicating the presence of heteroscedasticity (Appendix 5). To correct the problem of heteroscedasticity, the robust standard errors were estimated. In Stata, this is done by specifying the robust option in the regression model.

Test for equidispersion

PRM assumes equidispersion in the data, meaning that the variance of the dependent variable is equal to its mean. We tested for over-dispersion/under-dispersion in the data to ensure that the model is fit for analysis. Overdispersion is when the variance is significantly larger than the mean, whereas underdispersion occurs when the variance is significantly lower than the mean (Winkelmann & Zimmermann, 1995). Over or under dispersion may lead to potential bias of the parameter estimates (Wooldridge, 2002).

First we use estat gof command in stata to test the goodness of fit. A significant test statistics from estat gof would indicate that the poisson model is not a suitable model for analysis. The PRM was appropriate given that that the chi square value was insignificant (Table 4.5).

Table 4.5. Test for goodness of fit of the Poisson regression model

Deviance goodness-of-fit	217.49
Prob > chi2(259)	0.97
Pearson goodness of fit	200.04
Prob > chi2(259)	0.997

Then a likelihood ratio test that alpha equals zero was obtained from a negative binomial regression outputs to check for overdispersion. The chi-squared value was not statistically significant *(LR test of alpha=0: chi2(01) = 0.00 Prob >= chi2 = 1.000)*, implying that there was no overdispersion, making poisson an appropriate model for the analysis.

4.3.2 Poisson Regression Model Results

Table 4.6 presents the parameter estimates of the PRM results of the factors influencing the choice of aflatoxin control practices among smallholder maize farmers in Kilifi County. The chi-square test was significant at the 1 percent level, indicating that at least one coefficient in the model is not equal to zero. Overall, gender (p-value 0.019), agricultural extension service (p-value 0.000), the wealth status (p-value 0.035), and farmer aflatoxin awareness (p-value 0.015) significantly influenced the choice of aflatoxin control practices (Table 4.6). The gender of the household head significantly influenced the choice of the aflatoxin control practice at the 5 percent level, which means that households with a male head had more aflatoxin contamination control practices, than households with a female head.

Table 4.6. MLE estimates of the Poisson Regression Model.

Variables	**Coefficient estimate**	**Std. Error**	**P>z**
Gender	0.247**	0.105	0.019
Age	-0.001	0.003	0.795
Household size	-0.002	0.018	0.889
Extension	0.291***	0.068	0.000
Wealth index	0.031**	0.015	0.035
Distance to Market (km)	0.027	0.034	0.416
Group Membership	-0.018	0.070	0.795
Credit	-0.037	0.126	0.768
Aflatoxin awareness	0.289**	0.119	0.015
Education	0.002	0.009	0.798
Constant	0.732	0.254	0.004
Observation = 270			
LR chi2(10) = 47.27			
Prob > chi2 = 0.000			
Log likelihood = -514.792			

***, **, * significance levels at 1, 5 and 10 percent respectively

Gender in developing countries has critical implications in adoption of technologies in agriculture, particularly in rural households. Gender gaps in access to information and resources may influence the adoption decisions at household level. Asfaw & Admassie (2004) showed that male head had better access to new farming technologies, which made households with male head have higher adoption rate.

Access to agricultural extension service significantly increased the choice of aflatoxin control practice at the 1 percent level (Table 4.6). The number of aflatoxin control practices was about 0.3 times higher in households that were visited by an extension officer, highlighting the importance of extension services in disseminating aflatoxin control technologies to farmers.

Agricultural extension services expose farmers to new information, including technologies that are effective in controlling aflatoxin contamination.

Maina *et al*. (2016) found that majority of the farmers received information about aflatoxin contamination from agricultural extension officers in Makueni county, Kenya. This underscores the role of extension service in influencing the uptake of aflatoxin control practices. The results are consistent with Di Falco and Veronesi (2013) and Nhemachena and Hassan (2007). For instance, Nhemachena & Hassan (2007) found extension visits increased the adoption of farming practices that were important in climate change adaption, noting that farmers with access to extension services had a better chance to receive information on climate change and the different adaptive practices.

The wealth index had a positive and significant influence on the choice of aflatoxin control practices at the 5 percent level (Table 4.6). The number of aflatoxin control practices adopted by farmers increased 0.03 times with a unit increase in wealth index. The wealth index is a proxy for the household endowment, computed using variables related to asset ownership. Given that adoption of these practices requires more financial resources, wealthier households may have the advantage of investing in additional aflatoxin control practices, particularly in the rural areas where the credit market is usually imperfect.

This finding corresponds to previous study findings that have shown household wealth has a significant influence on the ability to adopt agricultural technologies, particularly under imperfect credit markets (Holden *et al*., 1998; Swinton & Quiroz, 2003). Comparably, Langyintuo & Mungoma (2008), while testing if the adoption and intensity of use of an improved maize variety differ between the poor and wealthy household, found that household wealth affect how other control variables influence the adoption of agricultural technologies.

Awareness about the health risks associated with consumption of aflatoxin contaminated maize was also an important factor on the number of control practices adopted. Awareness positively influenced the choice of the number of aflatoxin contamination control practices and was significant at the 5 percent level. Farmers who were aware about the health risks of consuming aflatoxin contaminated maize were 2.1 times more likely to use a higher number of aflatoxin contamination control practices as compared to their counterparts who were not aware. Several studies have found that farmer's awareness of the risks and benefits associated with any particular problem positively influenced the choice of technology that solves that problem.

This finding is supported by an earlier study by Jolly *et al.* (2009) who found that action towards reducing aflatoxin contamination in groundnuts was positively associated with an increase in the level of awareness of aflatoxin in Ghana. Bryan *et al*. (2009) also found that farmers were more willing to take up strategies that reduce vulnerability when they were more aware of climate change risks. Moreover, our findings are supported by Chia *et al*. (2020) and Sebatta *et al*. (2018) who reported that prior exposure to information about a particular technology positively contributed to farmers' willingness to use the technology.

CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATION

5.1. Summary

Aflatoxin contamination in crops and livestock is a serious problem in many parts of the world. In Kenya, aflatoxin contamination of agricultural commodities is a recurrent problem. Even though there was a misconception that Eastern Kenya is the only affected region, aflatoxin is widespread in Kenya. Aflatoxin control practices have been disseminated to farmers to minimize the consumption of maize contaminated with aflatoxin. However, the uptake of these practices has been low, varying across different regions and among different socio-economic categories of households. Aflatoxin control practices used by smallholder maize farmers are not well documented and the factors influencing the choice of the aflatoxin control practices are not well understood, particularly in Kilifi County.

The first objective was to characterize the aflatoxin control practices used by maize farmers, while the second objective of the study was to assess the factors influencing the choice of number of aflatoxin control practices used by farmers in Kilifi County. The study employed a poisson regression model on a sample of 270 farmers selected using a multistage sampling procedure. The results of the study revealed that the most widely applied aflatoxin control practices were pre-harvest practices. They include timely planting, use of certified seeds, proper plant nutrition such as fertilizer and manure application, pathogen control, weeding and use of pesticides. Early harvesting and post-harvest practices such as sorting, drying and pesticide use were also identified as methods used to control aflatoxin contamination in maize.

The average household size was 4.5, while the average age of the household head was 55 years. Most household heads had primary education with a mean of 8.5 years of schooling. The access to credit was low, with only 8.5 percent of the respondents having access to credit.

The average distance to the market was about 3km across the sub-counties. The mean area under maize production was 4.1 acres but varied across the sub-counties. The main pre-harvest practices identified include timely planting (67 percent), improved maize variety (60.9 percent), pest and disease control (47 percent), and early harvesting (18.9 percent). The postharvest practices mentioned were proper drying (37 percent), Sorting (44 percent), and pesticide use (56.7 percent). When asked about the novel methods, no household reported using novel biological control practices such as aflasafe despite being available in the market in Kenya. The study show that important socioeconomic variables influence the number of aflatoxin control practices used by farmers. In particular, the poisson regression model show that gender of the household head, access to extension services, wealth status, and aflatoxin awareness play a significant role in determining the choice of practices the smallholder farmers use when controlling aflatoxin contamination in maize.

5.2. Conclusion

Smallholder farmers in Kilifi County control aflatoxin using different farming practices such as use of hybrid maize variety, proper plant nutrition, control of pathogens, timely planting, early harvesting and post-harvest practices (sorting, pesticide, proper drying). The study also revealed that no farmer interviewed reported using novel methods such as use biological control practices (e.g. aflasafe products) to control for aflatoxin. This shows there is no dissemination of the new and effective technologies at the household level despite the county having a significant aflatoxin contamination risks. The study further concludes that socio-economic characteristics including sex of household head, access to extension services, farm size, and aflatoxin awareness significantly influences the choice of aflatoxin control practices in Kilifi County. The number of control practices increased with wealth status, access to extension service and awareness of aflatoxin.

The study also draws conclusion that effective control of aflatoxin requires dissemination of information on aflatoxin risks and technologies/practices to control the aflatoxin contamination from the significant influence of extension service and aflatoxin awareness. Socioeconomic characteristics such as gender of the household and wealth status are predictors of adoption intensity of the aflatoxin control practices.

5.3. Recommendations

Awareness to risk of aflatoxin is significant in adoption of practices that control aflatoxin. To increase awareness, the study recommends policies and strategies that enhance the dissemination of information on the risk of chronic aflatoxin exposure should be persued. Based on the findings, the relevant government agencies and other development partners should promote both existing and novel control practices such as aflasafe to minimize aflatoxin exposure. Given that wealth and gender significantly influence the adoption of control practices, targeting by socioeconomic status should be encouraged during interventions to increase the uptake of these technologies. For instance, interventions should target resource-poor farmers, as well as address gender gaps while promoting technologies that mitigate aflatoxin contamination. A policy option that could enable farmers to adopt these technologies include setting up credits schemes for small holder farmers given that most farmers are poor and may not afford credit from the mainstream financial instutions.

5.4. Suggestions for Further Research

The current study focused on the factors that affect number of practices the farmers adopted without exploring on the effectiveness of these practices in controlling aflatoxin. Extending this study to assess the effectiveness of different combinations of aflatoxin control practices provides a great opportunity for future research.

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APPENDICES

Appendix 1: Pearson correlation matrix for variables used in the model

Variables	Gender	Age	Household size	Education	Extension	Wealth index	Market distance	Group member	Farm size	Credit access	Aflatoxin awareness
Gender	1.00										
Age	-0.14	1.00									
Household Size	-0.05	0.07	1.00								
Education	0.17	-0.33	-0.01	1.00							
Extension	-0.05	0.15	-0.03	0.13	1.00						
Wealth Index	0.07	0.12	-0.06	0.32	0.11	1.00					
Market Distance	0.04	0.05	0.01	-0.11	0.04	0.01	1.00				
Group Member	-0.20	0.21	-0.03	0.04	0.12	0.00	-0.14	1.00			
Farm size	-0.01	0.18	-0.06	0.12	0.24	0.39	0.10	0.03	1.00		
Credit	-0.06	-0.04	-0.04	-0.05	-0.07	-0.09	-0.06	0.22	-0.18	1.00	
Aflatoxin Awareness	0.14	-0.06	0.05	0.11	0.06	0.06	-0.07	-0.01	0.19	-0.02	1.00

Appendix 2: Variance Inflation Factors (VIF) results for testing multicollinearity

Variable	VIF	1/VIF
Education	1.39	0.717064
Age	1.35	0.738503
Farm size	1.35	0.739637
Wealth index	1.35	0.742836
Group member	1.16	0.859635
Extension	1.12	0.892662
Credit	1.10	0.907392
Aflatoxin awareness	1.07	0.936147
Distance to market	1.06	0.945768
Household size	1.03	0.972543
Mean VIF	1.20	

Appendix 3: Tolerance level for Multicollinearity

Variable	Tolerance level
Gender	0.9012
Education	0.7017
Age	0.7382
Farm size	0.7371
Wealth index	0.7428
Group member	0.8337
Extension	0.8901
Credit access	0.9071
Aflatoxin awareness	0.9194
Distance to Market	0.9429
Household size	0.9683
Mean tolerance level	0.8439

Appendix 5: Test for heteroscedasticity

Breusch-Pagan/ Cook-Weisberg test for heteroskedasticity

$\chi^2(1) = 3.49$

Prob > χ^2 = 0.0619

Appendix 6: Household Survey Questionnaire

‘‘ADOPTION OF AFLATOXINS CONTAMINATION CONTROL METHODS BY FARMERS IN KILIFI COUNTY’’

CONFIDENTIALITY

This interview will help us understand the Factors Influencing the Choice of Aflatoxins Contamination Control methods/practises in Kilifi County, Kenya. The information gathered will be used for academic purposes only.

SECTION A: Background information

Questionnaire number: …………… Enumerator’s name: ……………………….

Village: …………………………. Sub-location…………………………

Location: ………………… Division: ………………District: ………………….

SECTION B: Household demography

1.1. Name of household (HH) head: ……………………………………………

1.2. Household’s contacts (*mobile*)……………………………………………

1.3. Respondents name (*if not household head*) ………………………………

1.4. How are you related with the HH *(If respondent is not household head)? /___/ Use Codes (1= spouse, 2= Eldest son, 3 =Eldest daughter, 4= farm worker, 5=Other, Specify ………………………………………………………….)*

1.5. Gender of HH (*1=male, 2 = female*).	1.6. Age of (HH) (*years*).	1.7. Can the household read and write? *(1= Yes 2= No)*

SECTION C: Household composition:

1.8. Number of persons in the household* /_______/ (*please fill in the table below*).

Age	**Male**	**Female**	**Total**
0 year to 14 years			
15 years to 64 years			
More than 64 years			

**These are people who live together (at least for 12 months) and share meal.*

1.9. Education level of the household head.

(0). None /________/

(1). Primary school /______/

(2). Secondary school /_____/

(3). College or Polytechnic /______/

(4). University level /______/ (5). Others (Specify) /___________/.

1.10. What is the total number of years spent in school? /_____/

1.11. How long have you been a maize farmer (experience?) /_____/

1.12. What motivated you to start maize farming?

A) ………………… B) …………………. C) …………… D) ………………

SECTION 1: Labor contribution last season.

1.13. How many household members worked in the family farm full time? /_____/.

1.14. How many household members worked in the family farm part time? /_____/.

1.15. How many household members worked outside the family farm full time? /_____/.

SECTION 2: Maize production, sales and related constraints last season.

2.1 Let us talk about your maize production, home consumption and sales last season.

Which Maize Variety did you grow last season? *(Tick appropriately)*	Total number of maize acreage planted *(last season)*	Total quantity of maize harvested last season. *(green)*		Total quantity of maize harvested last season. *(dry)*		Total quantity of maize consumed at home.				Total quantity of maize sold last season.						Market/ buyer *(Code B).*	
		Qty	Unit *(Code A).*	Qty	Unit *(Code A).*	Qty		Unit (*Code A).*		Qty		Unit *(Code A).*		Price per Unit *(Ksh)*			
						gre	dry	gre	dry	gre	dry	gre	dry	gre	dry	gre	dry

						e n		e n		e n		e n		e n		e n	
1. Mungindo																	
2. Mengawa																	
3.Coast Composite																	
4.Pwani hybrid 1(PH1)																	
5.Pwani hybrid4 (PH4)																	
Other specify………																	

Unit codes (A): 1= pieces (green cobs), 2= pieces (dry cobs); 3= 90kg bags (green cobs), 4 = 90kg bags (dry cobs), 5 = 90kg bags (shelled), 6= Others (specify) ………..................

Market Codes (B): 1= farm gate, 2=village market assemblers, 4= Wholesalers, 5= large scale traders, 6= Dis-Assemblers, 7= Retailers, 8 = Others, specify……………………..

2.2 After you have harvested maize, is it usually sorted/ graded? /_____ / *1=Yes, 2=No*

2.2.1 If yes, who sorts them? /_____/. *Use Codes, (1= seller/farmer, 2= buyer, 3= other, specify…………………………………..)*

2.3 How do you sell your maize? /____ / *Use codes (1= individually, 2 =A group of farmers)***.**

2.4 What is the distance to the nearest market place? /________________/*Km.*

2.5 How would you rate the market you have for your maize produce? *Use Codes*

1= very poor /__/ 2= poor /__/ 3= fair /__/ 4= good /__/ 5= very good /__/

2.6 Was there maize harvested last season that was rejected by buyers? /____/ *Yes =1, No=2.*

2.6.1 If yes to 2.6 above, what were the reasons for rejection? ....

2.6.2 If yes to 2.6 above, indicate the amounts rejected for each variety in the table below.

Variety	Amounts rejected		What did you do with the rejects? *(Use Codes B).*
	Quantity	Units *(Code A).*	

	Green	Dry	Green	Dry	
1. Mungindo					
2. Mengawa					
3.Coast Composite					
4.Pwani hybrid 1(PH1)					
5.Pwani hybrid4 (PH4)					
Other *(specify)*……..					

Unit codes (A): 1= pieces (green cobs), 2= pieces (dry cobs); 3= bags (green cobs 90kg), 4 = bags (dry cobs 90kg), 5 = bags (shelled 90kg), 6=others (specify) ……………………

Codes B: 1=Leave them in the field, 2= consume in the household, 3= Give them away, 4= feed to my animals, 5= store for future use, 6= process /value add 7= other, specify …….

2.7 Do you intercrop maize with other crops in your farm /_____/ *1= yes, 2 = No.*

2.7.1 If yes, to 2.7 please give details of the intercrop(s) last season in the table below.

Crop intercropped with maize.	Acreage (Acres)	Quantity harvested.	Reason for intercropping Code A.

Codes A **(***1=Consumption, 2=. Income, 3= Food diversification, 4. Others specify…………).*

2.8 What were your main constraints to maize production last season? (*Please rank them in order of importance).*

Constraint	**1=yes 2=No**	**Rank** *(See code)*
Land preparation		
Sowing operations		
Fertilizer application		
Inter-cultivation and weed control		
Pests and disease control		
Harvesting and field drying		
Threshing		
Storage		
Marketing		
Other (specify)…………….		

Rank: 1= Most serious, 2=fairly serious, 3=least serious

2.7 Which pests and / or diseases damaged your maize last season? *(Please show the pictorials below to respondent if unable to mention any).*

…………………………………………………………………………………………………

Others (specify) ……………………………………………………………………………

SECTION 3: I will ask you about your maize production practices.

3.1 Do you keep maize production records? /___ / *1=Yes, 2= No.*

3.1.1. If yes to 3.1, Which ones? (Circle all that apply). *(1=Labor wage records, 2= pesticide application records, 3= fertilizer/manure records, 4=sales records, 5= yield records. 6= other, specify……………)*

3.2 Did you weed your maize crop last season? /_____/ 1=*Yes, 2=No*.

3.2.1 If yes, how many times per production cycle? /____/ (year).

3.3 Did you apply fertilizer to your maize crop last season? /_____/ 1=*Yes, 2=No*.

3.3.1 If yes, how many times per production cycle? /____/ (year).

3.2.2. How often did you spray your maize crop against pests and/or diseases? /___ / *(1=once, 2=twice, 3=when I see signs of disease or pest, 4= seasonal, 5=Never).*

SECTION 4: Awareness of aflatoxin contamination and its control methods.

4.1 Are you aware of aflatoxins contamination? /____/ *Yes =1, No=2.*

4.1.1 If yes to 4.1, how did it manifest in your farm? *(Please show the pictorials below to respondent if unable to indicate any manifestation).*

Others (specify) ………………………………………………………………………

4.1.2 If yes to 4.1, where did you learn about it? *(1=Government extension officers, 2=Radio, 3=Newspapers, 4=Agro-vets/farm input suppliers, 5=Farmer organizations, 6=Neighbors, 7=NGOs e.g. PCCS/AKF, 8= others specify…………………....)*

4.1.3 If yes to 4.1, which aflatoxins contamination control method/s are you aware of? *(Record all components mentioned by the respondent first the probe further using the choices)* (Codes 1= Pre-harvest 2=Traditional (post-harvest) 3=Novel methods)

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………….

4.1.4 If aware of any in 4.3.1, which one do you prefer most? ……………………………..

4.2. Did you participate in any aflatoxins contamination control demonstrations/trials/seminar introduced by the government and/or NGOs? /____/ *Yes=1, No=2.*

4.2.1. If yes to 4.2 which year did you participate? /_______/

4.2.2. If yes to 4.2 who conducted the demonstrations/trials/seminar? *(1=Government extension officers, 2= Agro-vets/input suppliers, 3=Farmer organizations, 4=Neighbors, 5=NGOs e.g. PCCS/AKF, 6= Others specify…………….)*

4.2.3. If no to 4.2 above, what is the distance in (KMs) between your farm and the nearest site where aflatoxin contamination control demonstrations/trials/seminars were held? /_______/.

4.3. When did you experience the last outbreak of aflatoxin contamination? *(1=One year, 2=two years, 3=never experienced, 4=always experience, 5=others specify…………….)*

4.4. What effect did you experience due to aflatoxin contamination? (*1= human health/death 2= quantity of maize lost 3= number of livestock affected 4= others specify……………)*

SECTION 5: Aflatoxin contamination control practices and adoption of aflatoxin contamination control strategies.

5.1. I will ask you about aflatoxin contamination control practices in your maize farm. *(Let the respondent mention the practices used then record them in the table below.)*

Do you know any of the following Aflatoxin contamination control practices?	Yes = 1, No =2.	If yes, give year first used	Main source of technology/practice. *(Code A.)*	Which technology/practise are you using on your farm?	Have you been using this technology continuously? Yes=1, No=2.	Does the technology work? Yes = 1, No = 2.	Amount spent on the technology last season. (Ksh).
1. Pre harvest management strategies							
Timely planting							
Optimal plant densities							
Proper plant nutrition							
Avoiding drought stress							
Controlling plant pathogens weeds and insect pests							
Proper harvesting							
Others, specify……………							
2. Traditional management strategies							
De-hulling							
Roasting							
Baking							
Frying							
X-radiation, extrusion cooking, nixtamalization.							
Seed cleaning and sorting,							
Insecticides and fumigants							
3. Novel management strategies							
Use of natural extracts and essential oils							
Use of Resistant varieties							
Biological control							
4. Do nothing.							

CODE A (1= Research centers (KARI etc), 2= Demonstration/trial sites, 3= Neighbors, 4=Bought from local agro vet dealers, 5= provided by government extensionist, 6= provided free by NGOs, 7= other specify……………………………………………………………………)

SECTION 6: Let us talk about your perception of aflatoxin contamination control methods.

6.1 Is aflatoxin contamination a problem in this area? /_____/ *Yes=1, No=2.*

6.2 Do farmers in this area see the benefits of aflatoxin control? /____/ *Yes=1, No=2.*

6.3 Has aflatoxin contamination control reduced the prevalence of aflatoxicosis and related ailments in this area? /_____/ *Yes=1, No=2.*

6.4 Are aflatoxin contamination control services affordable? /____/ *Yes=1, No=2.*

6.5 Should aflatoxin contamination control services be offered by the government for free? /_____/ *Yes=1, No=2.*

6.6 If you adopted any aflatoxin contamination control method what would you say in relation to the following aflatoxin contamination control methods attributes? *(Record all components mentioned by the respondent)*

6.6 Aflatoxin contamination control method	Attribute					Rating *(use codes)*
	6.6.1 low in labour costs	6.6.2 low in pesticide use	6.6.3 low in income expenditure	6.6.4 Increase in yields	6.6.5 Better maize quality and price	

Rating: 1=ineffective; 2=less effective; 3=effective; 4=very effective

6.7 What is your perception of aflatoxin effects on livestock? (Record all components mentioned by the respondent first then probe further using the choices).

………………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……..

1= Low productivity 2= Can cause disease to people 3= Can cause disease to animals 4=rejection of animal byproducts 5= They have no effect

6.7 Among the three categories of methods, which one do you prefer most and why? Kindly rank and name the method/s (Codes: 1= Early harvesting, 2= Proper plant nutrition 3= Control of plant pathogens 4=Traditional methods 5=Timely planting)

Listing	Preferred due to cost element	Preferred due to availability	Preferred due to effectiveness
Pre-harvest			

<u>SECTION 7: Access to credit and information on Aflatoxin contamination control methods.</u>

7.1 Did you or your spouse receive any form of credit/loan last season for the purpose of maize production? /____/ *1=yes, No=2.*

7.1.1 If yes, please fill the table below.

Source of credit. *(Use code A*).	Amount received in (*Ksh.)*	Form of credit. *(Use Code B).*	Purpose of credit. *(Use Code C).*

(Code A. Source: 1= Farmer group, 2= other self-help group, 3= Friends/Relative, 4= Bank, 5=Microfinance, 6=merry go-rounds, 7= other, specify……………………………)

Code B. Form: 1= in kind e.g. inputs, 2=money, 3=other (specify……………………………….)

Code C. Purpose: 1= to purchase seeds, 2= to purchase fertilizer, 3= to purchase pesticides, 5= to rent additional land, 6= to expand crop area, 7= other (specify……………………….).

<u>7.2 Access to Aflatoxin contamination control methods information.</u>

7.2 Have you been receiving information on Aflatoxin contamination control? /___/ *Yes=1, No=2.*

7.3 Have you been receiving new information Aflatoxin contamination control? /___/. *Yes=1, No=2.*

7.4 If yes to 7.2 and 7.3 above, fill the table below ranking the sources of information on Aflatoxin contamination control in order of importance. *(Let the respondent mention them first).*

Source of information.	**Ranking for maize production practices**	**Ranking for Aflatoxin contamination control methods**
Government extension officers		
Radio, TVs		
Newspaper , Bulletins, magazines		
Agro vet store/ inputs dealers		
Farmer organizations		
Neighboring maize farmers.		
NGOs e.g. churches, PCCS, AKF, Mosques		
Research institutions (e.g. KARI, ICIPE, University)		
Demonstration plots/sites		
Mobile phone updates, internet		
Field days		
Others (specify…………………………)		

7.5 How often do you receive Aflatoxin contamination control information from the main source? /_____ / *(Often=1, rarely =2, never = 3).*

7.5.1 If often or rarely, when was the last time you received Aflatoxin contamination control information? /_______ / (*give month and year).*

7.6 How many times were you visited by an agricultural extension officer last season? /___/

7.7 How many times did you visit/consult agricultural extension officer last season? /___/

7.8 Did you attend a farmer field day/ seminar/demonstration on maize production last season? /___/ *1=Yes, 2= No.*

7.8.1 If yes, how many times did you attend the demonstrations/field days/seminars last season? /______/ .

7.8.2. State the topics covered during the training. (*Let the respondent mention then Circle all the codes that apply). (1= Land preparation and Sowing operations 2= Fertilizer application, Inter-cultivation and weed control 3= Pests and disease control 4= Harvesting and drying 5= Threshing and Storage 6= Seed production and selection, 7= Source of high quality seeds, 8= Maize marketing, 9= Others, specify…………………………………………….)*

<u>8.0: Household occupation, household income(s) and group membership.</u>

8.1 What is your main occupation? *Occupation codes (farming =1, other=2), if other, specify…………………………………..*

8.2. Apart from sale of farm produce, rank your other sources of income in the table below.

Rank	Income source.	Number of days worked per month/ number of units sold.	Actual Daily /weekly / monthly pay rate for labor and unit price for products sold (Ksh).	Earnings per month/season (Ksh).
1				
2				
3				
4				

8.3 Group membership of the household head and the spouse(s). (social network).

8.3.1 Is the household head or spouse(s) a member(s) of a group? /_____ / *Yes=1, No =2.*

8.3.2 If yes, please fill the table below.

Household Member Name	Relationship of member with the household head. (*Use Codes A).*	Type of group the household member is registered: *(Codes B).*	Year joined	Current role in the group *(Codes C).*
1.				
2.				
3.				

Code A (1= Household Head, 2= spouse 3= other specify…………….).

Codes B (1= Input supply/farmer coops/union, 2= Crops/seed producer and marketing group/coops, 3= Farmers' Association, 4=Women's Association, 5 =Youth Association, 6= *Church/mosque association, 7 = saving and credit group, 8= Others, Specify…………………)*

Codes C (1 =Chairman, 2=Vice chairman, 3= Secretary, 4 = Treasurer, 5= Member, 6 = Ex-official, 7= others, specify …………………………….)

SECTION 9: Land tenure system, land use and asset ownership.

9.1 What is the total size of your land? /________/ acres.

9.2 How many crop enterprises did you have last season? /__________/.

9.2.1 Please record all the crop enterprises undertaken last season in the table below.

Plot Number	Crops planted *(start with maize)*	Ownership status of plot *(use Codes A)*	Acreage *(Acres)*
1			
2			
3			
4			

Code A (1= own with title deed, 2= own without title deed, 3=family land, 4= communal, 5=rented in, 6=others (specify……………………….…)

9.3 If the land is rented in 9.2.1, what is the rental rate per season? /_____/ (Ksh. / Acre.)

9.4 How many livestock enterprises do you have? /______/.

9.4.1 Please record all the livestock in the table below. *(Let the respondent mention)*

Livestock	Number	Current price per head	Livestock	Number	Current price per head
Adult cows			Rabbits		
Adult bulls			Pigs		

Heifers			Chicken/poultry		
Calves.			Donkeys		
Young bulls			Ducks		
Young heifers			Sheep		
Goats			Other, specify…………		

9.5 Let me ask you about the assets you own.

Assets	Total Number	Resale price/unit at current state in KES	Assets	Total Number	Resale price/unit at current state in KES
Fork Jembe			Hose pipe		
Hoe			Car		
Mobile phone			Radio		
Generator			Bicycles		
Knapsack sprayer			Sprinklers		
Ox plough			Water pumps (fuel/electric)		
Panga/Slasher			Hand pump		
Television			lorry		
Ox cart			Pickup		
wheelbarrow			Other (specify..........)		

Thank you very much for your time**.**