ASSESSMENT OF FARMERS' PERCEPTIONS OF AND WILLINGNESS TO PAY FOR AFLASAFE KE01, A BIOLOGICAL CONTROL FOR AFLATOXINS IN KENYA

BERNARD GITHINJI MIGWI

A56/81599/2012

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURAL AND APPLIED ECONOMICS, UNIVERSITY OF NAIROBI

July 2016

DECLARATION

This thesis is my original work and has not been submitted for a degree course in any other academic institution.

Bernard Githinji Migwi

Signature ……………………. Date …………………….

Approval by Supervisors

This thesis has been submitted for examination with our approval as supervisors:

1. Dr. John Mburu

   Department of Agricultural Economics,

   University of Nairobi

   Signature ……………………. Date…………………….

2. Dr. Maina Wagacha

   School of Biological Sciences,

   University of Nairobi

   Signature ……………………. Date …………………….

3. Dr. Charity Mutegi

   International Institute of Tropical Agriculture (IITA)

   Signature…………………………… Date……………………….

DEDICATION

This work is dedicated to my parents Mr. and Mrs. Migwi and to Judy for their love and persistent encouragement that has always inspired my life.

ACKNOWLEDGEMENT

With a heart full of gratitude, I hereby thank all the people who made the entire process of undertaking this research and writing this manuscript successful. I am particularly indebted to my supervisors Dr. John Mburu, Dr. Maina Wagacha and Dr. Charity Mutegi for their invaluable advice, constructive criticisms and interest in my study.

The African Economic Research Consortium (AERC), World Bank and the International Institute of Tropical Agriculture (IITA) are acknowledged for funding this study; and the Kenya Agricultural and Livestock Research Organization (KALRO) for logistical support during the field survey.

My heartfelt appreciation also goes to the University of Nairobi for offering me a scholarship to pursue my coursework and the staff from Ministry of Agriculture, Livestock and Fisheries (MoALF) for their valuable ideas, material and moral support. The enumerators involved in data collection deserve exceptional thanks for their committed efforts to collect reliable data during fieldwork, under sunny and rainy conditions and long journeys traveled.

I would also like to appreciate all the farmers and extension agents who took part in the survey for willingly volunteering important information for this research. I cannot forget the valuable contribution of my classmates for their continued encouragement and help all through the development of this work.

Finally, my sincere appreciation goes to everyone who contributed to this work through prayers, encouragement, and moral support. All your efforts helped me hold on throughout the study. All these efforts bore fruit through God's abundant love, grace, and mercy.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS AND ACRONYMS

CVM	Contingent Valuation Method
G.O.K	Government of Kenya
IARC	International Agency for Research on Cancer
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
KALRO	Kenya Agricultural and Livestock Research Organization
KEBS	Kenya Bureau of Standards
KSTCIE	Kenya Standing Technical Committee for Imports and Export
PACA	Partnership for Aflatoxin Control in Africa
PCPB	Pest Control Products Board
PCA	Principal component analysis
MoALF	Ministry of Agriculture, Livestock and Fisheries
NIB	National Irrigation Board
NTP	National Toxicology Program
RESET	Regression Equation Specification Error Test
SPSS	Statistical Package for Social Scientists
USDA-ARS	United States Department of Agriculture-Agricultural Research Service
WTP	Willingness to pay

ABSTRACT

Aflatoxin contamination of key staples compromises quality of food products, trade and health of consumers whereas acute exposure can be fatal. Aflasafe KE01 is a promising biological control product in the management of aflatoxin contamination of key staples reducing levels of the toxin by up to 80 per cent in a single application. The biological product is made up of four natural indigenous strains of *Aspergillus flavus* that are atoxigenic. Being a novel biological pesticide, farmers' perceptions and willingness to pay (WTP) need to be understood to facilitate commercialization. The objective of this study was to assess the farmers' perceptions of and willingness to pay for Aflasafe KE01 as a biological control product in the management of aflatoxin contamination of key staples in Kenya. Further, the study assessed the potential influence of different factors on the WTP estimates. A sample of 480 households from four Counties identified as aflatoxin hotspots was randomly selected and interviewed through household survey questionnaires. Principal component analysis was used to reduce the farmers' perceptions to more simplified components. The contingent valuation method (CVM) was employed to estimate the amount of money farmers were willing to pay while the influence of different factors on farmers' WTP were assessed using the ordinary least squares regression method. Results show that famers' perceptions can be grouped into a number of principal components namely; education and promotion need, effectiveness of the bio-pesticide, fear of unknown, maize disease a serious problem, bio-pesticide acceptability, aflatoxin is a serious problem and environmental safety. For effective adoption to occur, farmer will have to be sensitized fully to boost their confidence on the use of Aflasafe KE01. Using CVM the mean WTP value per kilogram of Aflasafe KE01 was Kshs 113 (US$1.33) for farmers in Tana River County, Kshs 152 (US$1.79) for Lower Eastern trial farmers and Kshs 147 (US$1.73) for Lower Eastern non-trial farmers (US$ ≡ Kshs 85)[1]. The amounts the households were willing

[1] The conversion rate used at the time of data collection was one dollar to Ksh 85.

to pay were higher than the Kshs 130, the price of a similar product in Nigeria except for households in Tana River County. This clearly shows that households in Kenya are willing to pay more for Aflasafe KE01 to control aflatoxin contamination in maize. From the econometric findings, the factors that were found to positively influence farmers' WTP were utilization of crop extension services, credit utilization, awareness of bio-pesticide, contract agreement, household income, gender, age, being from Bura sub-county and initial bid amount. Those that were found to negatively influence WTP were household size, distance to market, perceptions of product effectiveness, and years of practice of the main livelihood activity. Based on the findings, there is need for increased extension services to educate and promote Aflasafe use. The results also shows that if farmers could access credit from the lending organizations either in the form of liquid cash or farm inputs, it would help increase their adoption rate for the bio-pesticide and also of other agricultural innovations. As distance to market was found to influence negatively the WTP, the stakeholders should thus target developing distribution networks that favor accessibility by end users situated away from urban centers.

CHAPTER ONE: INTRODUCTION

1.1 Background Information

The government of Kenya's policy objective on food safety, standards, and quality is to ensure safe and high-quality food. This is through the creation of public awareness on relevant issues, and by setting, promoting and enforcing appropriate guidelines, standards and a regulatory framework (G.O.K, 2011). Access and availability of safe food free from disease causing organisms is a measure of the status of food security of an individual or of a country; its compromise thus contributes negatively to the food security status.

Aflatoxin is a major impediment to the advancement of the health and well-being of vast populations in the African continent. The rural poor particularly in sub-Saharan Africa are chronically exposed to unsafe levels of aflatoxins. Cereals and legumes consumed are usually produced, stored, prepared and marketed by households without much awareness of the risks posed by aflatoxin contamination (IITA, 2012).

Aflatoxin is a secondary metabolite produced mainly by the fungi *Aspergillus flavus* and *A. parasiticus*. The fungi infect various crops (maize and groundnuts included) in the fields and stores making food and feed unsafe for human and animal consumption respectively (Cotty *et al.*, 2010). The fungi occur ubiquitously and produce aflatoxin that is carcinogenic and teratogenic for both humans and animals (Wild, 2007). Extensive aflatoxin contamination in food and production systems in sub-Saharan Africa has resulted in significant social and economic losses with respect to impaired health and productivity of people and animals, increased food spoilage, and inability to market agricultural products internationally (Munasib and Roy, 2012). A total of 317 cases of aflatoxicosis were reported in 2004 which marked the most severe episodes of an outbreak in Kenya. This was as a result of ingestion of aflatoxin contaminated maize. The reported fatality rate was thirty-nine percent (Azziz-Baumgartner *et al*., 2005; Lewis *et al*., 2005; Nyikal *et al*., 2004).

International trade is affected by aflatoxins which act as a non-tariff barrier to agricultural products that have more than the permissible levels of contamination e.g. for EU/Nestle aflatoxin (≤4 ng/g), World Food Program procurement limit (<10 ppb), and the US (<20 ng/g). Locally, maximum allowable levels of 10ppb aflatoxin contamination are allowed by Kenya Bureau of Standards (KEBS, 2007). Therefore, food quality and safety issues resulting from aflatoxin contamination have presented a significant obstacle to programs designed to improve nutrition and agricultural production while linking small farmers to markets.

Maize, which is one of the most important staple foods in sub-Saharan Africa, including Kenya, is one of the most susceptible crops to aflatoxin contamination (McCann, 2005). Toxigenic fungi can attack maize prior to harvest and further decay the crop during post-harvest stages hence mycotoxins may form both during crop development and post-harvest stages (Atehnkeng, *et al*., 2008).

To counter this, various strategies for controlling aflatoxin contamination from field to consumption have been employed. These include good agricultural practices such as selection of stress and aflatoxin tolerant cultivars for planting. Good pre-harvest practices are also employed to prevent the predisposing factors that increase the chance of *Aspergillus* colonization and aflatoxin contamination. These factors include irrigation and water conservation practices, management of insect pests, timely harvesting of crops and avoiding direct contact of grains with soil since it increases chances of colonization (Munkvold, 2003). Post-harvest practices such as rapid grain drying to appropriate moisture levels for minimizing fungal colonization, sorting of the infected grains and ensuring storage of the crop in moisture and insect proof zone help reduce contamination (IITA, 2012). Certain dietary practices have been recommended but are not practical at smallholder level since some of the fungal infection stages cannot be observed with the unaided eye and require complex techniques to detect them (IITA, 2012).

Biological control is a practical and effective method of reducing aflatoxin in the field and during storage (Atehnkeng *et al*., 2008). The innovative bio-control solution was developed by USDA-ARS (United States Department of Agriculture-Agricultural Research Service) and is being widely used in the USA, reducing aflatoxins during both crop development and post-harvest storage, and throughout the value chain (IITA, 2012). Atoxigenic[2] strain based biological control is a natural, non-toxic technology that uses the ability of native atoxigenic strains of *Aspergillus flavus* (the fungus that produces aflatoxin), to naturally out-compete their aflatoxin producing cousins (Atehnkeng *et al*., 2008). The Atoxigenic isolate-based biological control seeks to competitively exclude aflatoxin producers from the crop environment to achieve both single-season influences on the aflatoxin content of the crop and long-term reductions in the average aflatoxin-producing potential of fungal communities resident in target areas. On application, the atoxigenic strains in Aflasafe produce a large number of spores on sorghum grains, and competitively displace toxic strains of *A.* flavus (Atehnkeng *et al*., 2008). The treatment causes significant reduction of more than 70% in maize and groundnut of aflatoxin concentration in crops harvested from the treated fields (IITA, 2012).

International Institute of Tropical Agriculture (IITA), in partnership with USDA-ARS, has successfully adapted Aflasafe™ [3] (bio-pesticide in use in Nigeria) technology in Nigeria using native microflora. Field testing of Aflasafe™ in Nigeria over the past 4 years has produced extremely positive results: aflatoxin contamination of maize and groundnut was consistently reduced by 80–90%, and even as high as 99% (IITA, 2012). Native atoxigenic strains have

---

[2] Atoxigenic strains do not produce aflatoxin
[3] Aflasafe™ is the name of the bio-pesticide used in Nigeria

been isolated from Kenyan soil and maize grains and used to develop a country-specific product that have gone through field trials in collaborative effort with the Kenya Agricultural and Livestock Research Organization (KALRO) and International Institute of Tropical Agriculture (IITA) (IITA, 2012). In Kenya, both on-station and on-farm trials for Aflasafe KE01 have been concluded and full registration provided for the product (IITA, 2012). Continuous efficacy trials, however are still carried out to sustain a continuous regime of strengthening existing data. Such trials are currently going on in Lower Eastern Kenya (Makueni, Machakos and Kitui Counties) and in the coastal areas (Bura and Hola irrigation schemes), as well as in the Galana irrigation scheme that stretches across the counties of Tana River and Kilifi. Based on the concluded field efficacy trials carried out so far, Aflasafe KE01 has resulted in over 90% reduction in aflatoxin levels (KSTCIE, 2012; PCPB Report, 2015).

Adopting and applying Aflasafe KE01[4] to address aflatoxin contamination in Kenya can dramatically improve the health and income of millions of families while reducing commodity losses. To link smallholder farmers to markets, and to improve the quality of food produced, there is a need to manage aflatoxin levels in crops and livestock effectively. This is because agricultural development efforts to achieve greater food security and reduce food- borne diseases will be compromised, particularly in sub-Saharan Africa where contamination is widespread and chronic. Reduction of aflatoxin content in crops can improve farmer access to markets which enhances farmers' income. Distribution of aflatoxin-free maize along the value chain ensures that the consumers are not exposed to the poisonous toxins. However, several downstream commercialization efforts must be addressed before the large-scale adoption of biocontrol by smallholder farmers becomes a reality.

[4] Aflasafe KE01 is the name given to the biopesticide in Kenya

1.2 Background of Aflasafe KE01

Aflasafe KE01 is a bio-competitive product made up of four natural, indigenous strains of *A. flavus* that are atoxigenic and native to Kenya. Small amounts of the atoxigenic mixture is coated onto sterilized sorghum grains and allowed to internally 'colonize' them for a short period and then dried after which it is ready for use in the field. On application, the atoxigenic strains in Aflasafe KE01 produce a large number of spores on sorghum grains, which act as a food source, and competitively displaces toxic strains of *A. flavus*.

Inoculation of the field with Aflasafe KE01 inoculum is best done when the soil is wet. Adequate moisture in the soil allows the atoxigenic strains to grow rapidly on the sorghum grains which are used to transport the active agent (fungi). Hand broadcasting of the inoculum is done along the rows while ensuring an even spread of the product across the field; this is done 2 to 3 weeks before flowering. After the spores have formed on the surface of the sorghum grain, they are carried by insects and wind on to the maize where they competitively exclude toxigenic strains (KSTCIE, 2012). This leads to a substantial decrease of aflatoxin concentration in harvests from the treated fields. Currently only farms that were used to test the efficacy have been treated with Aflasafe KE01 in Makueni, Machakos and Kitui. However area wide application has occurred in Hola, Bura and Galana through a collaborative effort of the National Irrigation Board, the MoALF and IITA.

1.3 Problem Statement

Different strategies to control *A. flavus* infection and aflatoxin contamination have been used while some are under research. These include the use of stress and resistant varieties, good pre-harvest and post-harvest practices of handling maize. Despite the use of existing methods to control aflatoxin, contamination of maize still remains high (IFPRI, 2010).

Based on its high efficacy (over 80% reduction reported with a single application of the product in the field (Cotty, 2006; IITA, 2012), its use alongside other management strategies can dramatically reduce aflatoxin contamination in food systems. Farmers, who are end users of the product, would therefore be expected to adopt it in the farming systems. Adesina and Baidu-Forson (1995) however found that subjective perceptions of farmers on new agricultural technologies affect their adoption.

Studies done previously like the one by Walker and Davies (2013) shows farmers willingness to pay for drying machine or services that improve post harvest handling of maize but none is on bio-products. Although the product is effective in the trial areas, little information if any is available on the farmers' awareness and perceptions of Aflasafe KE01 in Kenya. It is also not known whether smallholder farmers will be willing to adopt or buy[5] Aflasafe KE01 after being availed to them through registration and commercialization. In addition, it is not known whether farmers in areas where no trials have been conducted will be willing to pay for the bio-product. In Nigeria, the product costs US$ 1.5 per kg (approximately Ksh 128/kg) with a recommended application rate of 5-10kg per hectare (IITA, 2012). However in Kenya it is not yet known how much the smallholder farmers would be willing to pay for the product. Similarly, there exists a knowledge gap on the kind of factors that would affect farmers' willingness to pay for Aflasafe KE01.

1.4 Purpose and Objectives

The purpose of the study was to assess the farmers' perceptions of and willingness to pay for Aflasafe KE01 as a biological control product for aflatoxin management in Kenya.

---

[5] As expected, it is assumed that any farmer who is willing to buy Aflasafe is an adopter of the same.

1.5 Specific objectives

i. To assess farmers' awareness and perceptions of Aflasafe KE01 in managing aflatoxin contamination

ii. To assess the willingness of farmers to pay for Aflasafe KE01 in managing aflatoxin contamination

iii. To assess factors affecting farmers' willingness to pay for Aflasafe KE01

1.6 Hypotheses

i. Farmers have positive perceptions towards Aflasafe KE01

ii. Farmers in Kenya are willing to pay for Aflasafe KE01 as much as those in Nigeria

iii. Farmers' demographic, socio-economic and market-access characteristics, as well as their linkages to public agricultural services, do not affect their willingness to pay for Aflasafe KE01

1.7 Justification of the study

As demonstrated by Walker and Davies (2013), farmers have shown willingness to pay (WTP) for services that reduce their exposure to aflatoxins. Consumers are also willing to pay premiums for contaminated-free foods that do not put their families at health risks although mechanisms that exist to guarantee aflatoxin free food have not been entirely successful especially in Kenya.

The information generated by this study on the willingness to pay for Aflasafe KE01 will be necessary for commercialization of the bio-pesticide. If the farmers' WTP for the bio-control product is positive, out scaling, upscaling and commercial viability of the product will be justified. The study findings will also help in establishing pricing mechanisms.

Willingness to pay estimates from the study will help policy makers and marketers to make more informed decisions on maize farmers' response and demand for Aflasafe KE01. The policy makers and marketers will use the estimates of the premiums that the maize producers are willing to offer for Aflasafe KE01 attributes to guide promotion investment decisions and efficient fund allocation if need be. This will enable them to have more informed investment strategies.

Results on farmers' perceptions and factors influencing WTP will be an insight to both product formulators and private sector that is expected to be involved in commercialization efforts, to understand the characteristics of the target group of the technology, including their willingness to adopt the technology and their demand for the product. Factors that were found to influence WTP would be used by researchers and policy makers for proper targeting purposes. The information on the perceptions and awareness will be most useful in determining priority areas with respect to the diffusion of information to help in adoption of the technology. The willingness to pay estimates elicited by this study will help the project partners in approximating the ability of the small-holder farmers to meet the cost of Aflasafe KE01. This will also help to inform if there is a need for government intervention, for example, through subsidy.

Results of the demographic and socio-economic factors influencing WTP will be important for targeting and provision purposes. Factors that influence WTP such as age, if found to influence WTP, will give insights on areas and groups that need more targeting. Factors influencing WTP that require government intervention such as extension services will require government provision if not available. The government or the research organizations may be required to provide the supporting services such as education to facilitate adoption.

Strategies that reduce aflatoxin contamination are required to control the toxins and improve health, income and livelihoods of farmers and consumers. Contamination of maize which is a staple food for many Kenyan families can directly reduce availability of food. Producers of the affected maize may also earn less because of product rejection, reduced market value, or inability to gain access to the higher-value international trade market. Consumption of aflatoxin-contaminated crops by humans causes aflatoxicosis and increases liver cancer risk. Use of Aflasafe KE01 that reduces exposure to aflatoxin will therefore promote food security, enhance trade and promote the health of both maize producers and consumers.

CHAPTER TWO: LITERATURE REVIEW

2.1 Theoretical background of economic valuation of new agricultural technologies

Estimates of the value of novel products/new agricultural technologies have become crucial tools to agribusinesses in guiding decision making. The estimates are useful in an era coupled with a shift towards a more consumer/producer demand driven marketplace as demonstrated by Lusk and Hudson (2004). This has led to a number of studies being done to estimate the willingness to pay (WTP) values of the novel products such as foods and technologies with the aim of helping agribusiness in product adoption decisions. The estimates of WTP values have different use when considered for agribusiness use versus environmental policy as demonstrated by Lusk and Hudson (2004). In environmental policy use, the primary objective is to estimate the mean WTP and also aggregate changes in the welfare of the affected parties. This is different to agribusiness which is interested in WTP estimates that can be used to derive compensated market demand curves for the new products. The agribusiness may be interested with the position on the demand curve that maximizes profit that in most cases is not necessarily the mean value. Zapata and Carpio (2014) demonstrated that the maximum amount of money that a producer is WTP for a new production factor is equal to the perceived difference between the ex-post and ex-ante firm's profit levels. They also attested that WTP of the producer is a function of output and input prices and input ex-ante and ex-post qualities. Using comparative statics, producers' WTP was shown to be a decreasing function of upgraded input price, its initial quality level and as an increasing function of output price and final quality level.

Given the importance of WTP estimates in market research, surveys on purchasing intentions are therefore important to agribusiness. This is because it can help to derive the deviation from the intended and actual purchases. Currently, contingent valuation (CV) use is increasing in many countries to measure both use and non- use values for many purposes involving market and non-market goods. CV was generally a method used to estimate the value of non-market goods such as water but currently have been advanced to be used for market goods, where prices are currently unavailable such as a novel product (Wattage, 2001). Willingness to pay (WTP) or willingness to accept (WTA) functions have been generated for many sets of market goods and used for policy contexts using CV methodology (Kaneko and Chern, 2005). This method aims to construct a hypothetical market for a novel product as realistic as possible in a survey setting to elicit the WTP of the consumer of the product. The method provides for the respondents to express their willingness to pay for the product without actually making a payment during the survey.

2.2 Review of methods for analysis of household perceptions

The aim of perception analysis is to discover which variables in the set form coherent subsets that are relatively independent of one another (Harman, 1976; Kim and Mueller, 1978; Tabachnick and Fidell, 2007). Factor analysis aims to summarize a multitude of measurements with a smaller number of factors without changing the information. The observed variables can, therefore, be combined to form a more authentic measure of that factor (Widaman, 1993). Some studies have used principal component analysis (PCA) to condense variables into smaller components. Negatu and Parikh (1999) for example used PCA to reduce eight perceptions on adoption of wheat to two components. Since the variables showed strong collinearity among the eight measures, the authors attempted to draw the best possible linear combination by reducing them into two components to include in the regression. Principal component analysis has also been used in education field for example by Delnero and Weeks (2000) to group the varying perceptions secondary agricultural teachers' viewed important regarding their job responsibilities. Using varimax rotation (Kaiser Normalization) method, three theoretical factor arrays were generated.

Barreiro-Hurle, Colombo, and Cantos-Villar, 2008 used PCA to summarise red wine consumer preferences. The 15 variables were reduced into four parameters accounting for sixty six percent of the variance enabling them to be included in their choice experiment model. Lwayo and Obi (2012) also used PCA to condence 20 sources of risks into seven principal components that explained more than sixty percent of the variation. The author used the Kaiser-Guttman rule to determine the optimal number of the components to be extracted. Owino, Jillo, and Kenana (2012) used PCA with Kaiser Normalization to analyse opinions related to wildlife and Park conservation. The authors used principal components wih Eigen values more than one to extract three parameters. Cumming and Wooff (2007) have argued PCA is the preferred data reduction method without changing the original information.

The assumption of the use of PCA is on interval data that is multivariate and normally distributed. Kim and Mueller (1987) however justified the use of ordinal data such as Likert scale in the condition that PCA is used to find general clustering of variables for exploratory purpose (Brown, 2009) and also if the variable correlations are believed to be less than 0.6. The current study also used PCA with Kaiser Normalization to reduce the perception variables to fewer parameters that were unrelated. Principal components with Eigen values greater than one were selected for analysis (Owino, Jillo, and Kenana, 2012).

2.3 Aflatoxin contamiantion and household health

Aflatoxin was first listed as a human carcinogen in the first annual report on Carcinogens in 1980 by the National Toxicology Program of the Department of Health and Human Services (NTP, 1980). Aflatoxin B1, which is the most common is the only mycotoxin classified as a Group 1A human carcinogen by International Agency for Research on Cancer (IARC, 2002). Intake of low daily doses of aflatoxins over long periods result in chronic aflatoxicosis that manifest through impaired food conversion, stunting in children, immune suppression, cancer and reduced life expectancy (Egal *et al*., 2005). High concentrations of aflatoxin ingested result in rapid development of acute aflatoxicosis that leads to liver damage causing jaundice, hepatitis and death under severe cases (Egal *et al*., 2005).

Outbreaks of acute aflatoxicosis has hardly been reported in developed countries. The outbreaks have nevertheless occurred in several developing countries in which case only India and Kenya have cases of repeated reports of acute aflatoxicosis (Cotty *et al*., 2010).

Between the year 2004 and 2006, about 200 Kenyans died after consuming maize contaminated with high levels of aflatoxins (Nyikal *et al*., 2004). In the year 2010 over two million bags of maize in eastern and central provinces were found to be highly contaminated and could not be traded (Azziz-Baumgartner *et al*., 2005; Nyikal *et al*., 2004). Globally, about US$1.2 billion in commerce is lost annually due to aflatoxin contamination related cases (IITA, 2012). In Africa, about US$450 million each year is lost due to aflatoxin-related trade barriers (IITA, 2012).

2.4 Use of biological methods to control pests and diseases in agriculture

Biological control is the use of organisms to reduce the effect of another organism. In the case of biocontrol of aflatoxins, it is the use of organisms intended to reduce aflatoxin contamination in crops. One of the most used technology utilizes atoxigenic strains of *Aspergilli* that have the ability to competitively exclude toxigenic strains from colonizing crops. The biocontrol methods have been used to control aflatoxins in maize, groundnuts and cottonseed in some countries as documented by Cotty *et al.* (2007) and Atehnkeng *et al.* (2008).

Given the promising ability of biocontrol methods to reduce adverse effect if properly targeted, Simberloff and Stiling (1996) found that introductions of certain biological products ended up adversely affecting non-target native species doing more harm than good. These unintended effects called for regulations of the officially sanctioned releases as well as of those released by the private citizens. They found that regulation of such biological control methods were lacking exposing native species to risks of extintion (Simberloff and Stiling, 1996). Governments are tasked to enact laws that would allow biological control while at the same time lowering the risk that might result from the use of the biochemical.

Assessment of adoption gaps by Kumar and Popat (2008) in the management of aflatoxin contamination of groundnut, found that the majority of farmers were in high adoption gap category. Farmers have not adopted pre-harvest and post-harvest management practices that reduce aflatoxin contamination. The adoption gap has been shown to be influenced by farmers' knowledge, market orientation, and innovativeness hence need for strategies to increase the knowledge of farmers through various extension approaches as pointed out by Kumar and Popat (2008). Kolli and Hall (2013) found that there was no difference in prices for contaminated groundnuts or market restrictions that would have acted as an incentive to producers to produce aflatoxin-free groundnuts. Farmers' socio-economic factors condition their production and post-harvest methods according to Kolli and Hall (2013). This is contributed by pressure to clear their high-cost credits at the earliest and labor or machine availability. Market differentiation of contaminated and aflatoxin-free groundnuts can therefore be crucial in the reduction of adoption gap as Kolli and Hall observed.

The Partnership for Aflatoxin Control in Africa (PACA) consultative workshop concluded that comprehensive multi-sectoral approaches are required to control aflatoxin and improve the wellbeing of African farmers, farm households and consumers (PACA, 2013). There is need for campaigns to raise consumer demand for safe and high-quality food. Consumers are responsive to aflatoxin contaminated maize or products especially if likely to be consumed as food (Hoffmann *et al.,* 2013). There exist information asymmetry that hinders buyers from having maize quality attributes before buying. Hoffmann *et al.* (2013) also showed that farmers tend to channel infected products into other uses such as production of alcoholic beverages or livestock feed yet these toxins are likely to get into their bodies even without direct consumption of infected maize. Farmers are not aware of the health risks involved in consumption of aflatoxin-contaminated products (Hoffmann *et al.,* 2013; Kolli and Hall, 2013). Farmers are not aware of aflatoxin and do not consider its contamination as a problem in their groundnut production systems (Kolli and Hall, 2013). There is therefore need for efforts to ensure distribution and adoption of improved inputs and improved quality of production. The strategies will require effective policies, an establishment of standards and regulations to aid in the reduction of aflatoxin prevalence and exposure in Africa.

2.5 Review of farmers' perceptions and adoption of new agricultural technologies

Farmers subjective perceptions of new technologies have been evinced to affect their adoption of new technologies using Tobit (Adesina and Baidu-Forson, 1995). There is, therefore, need to incorporate farmers' perceptions in the study to compliment the socio-economic, demographic and institutional factors so as to yield unbiased estimates. The capture of perceptions would also help the developer of the technology to yield more targeting technologies.

Young and more educated farm operators are more likely to use new technology. Farmers with smaller operations but more profit per unit of land than average are likely to adopt new technology more easily (Abdulai and Huffman, 2005; Koundouri *et al*., 2006). Adoption has also been shown to be influenced by access to credit, contact to extension agents and proximity of a farmer to other operators (Abdulai and Huffman, 2005). The geographical condition of the area such as the occurrence of drought has also been shown to influence the adoption of the technology (Koundouri *et al*., 2006).

Membership to an agricultural group have been shown to influence positively adoption of technologies. Agricultural groups are avenues of exchange of knowledge among the farmers hence the influence. Nkamleu (2007) found that involvement in group activities exposes farmers to a wide range of ideas and information that may positively change their attitude towards new agricultural technologies. Abdulai and Huffman (2005) found that the proximity of a farmer to other operators was important in influencing their adoption decisions. The findings concur with what Ajayi (2006) and Singh *et al*. (2008) found. Ajayi (2006) found that members who were in agricultural groups were willing to pay more for extension services as compared to their counterparts while Singh *et al*. (2008) found that membership in an agricultural self-help group was significant in the adoption of new farming practices.

2.6 Review of factors likely to influence farmers' willingness to pay

The literature on economic estimation is comprised of numerous studies that have been done to determine factors influencing the WTP. Some studies such as the one done by Hudson and Hite (2003) and Qaim and Janvry (2003) found that the producers' WTP was significantly lower than current technology prices. The results showed that it would have required government subsidy to induce adoption (Hudson and Hite, 2003) or lowering of the price by companies producing the techology (Qaim and Janvry, 2003). The factors that were found to affect WTP were soil characteristic variability, soil quality, how well the technology integrates into current farming practices and equipment. Some studies have however shown willingness to pay a premium for reduced risk of food borne illness through the estimation of WTP for insurance (Nayga *et al*., 2006; Baniasadi *et al*., 2013). The findings show that willingness to pay for individuals in the effort to reduce the risk of foodborne illness is influenced by the information shared and possessed of the nature of food irradiation.

Geographical location and risk exposure have been shown to play a great role in affecting adoption decision (McCorkle, 2007). Marketing efforts have also been shown to focus on large, high-income operations that are perceived to make high profits ignoring the small scale farmers who contribute the highest share of food consumed (McCorkle, 2007).

The WTP for low toxicity pesticides was found to be influenced by farmers' experience with poisoning, income variables, and current exposure to pesticides (Garming and Waibel, 2009). Using contingent valuation method to elicit farmers WTP for low toxicity pesticides, it was revealed that farmers were ready to spend an additional amount of their current pesticide expenditure in order to avoid health risks. Gender has also been found to affect WTP (Steur *et al*., 2012) where the female Shanxi rice consumers were willing to pay a premium for Genetically Modified (GM) rice.

Willingness to pay has been shown to be influenced by consumer income positively and by consumer age negatively (Walker and Davies, 2013; Muhammad *et al.,* 2015). Wealthier households are capable of purchasing products that will help them stay healthier, (Muhammad *et al.,* 2015). Walker and Davies (2013) demonstrated that farmers have shown willingness to pay for services that reduce their exposure to aflatoxins. Consumers are also willing to pay premiums for contaminated-free foods that do not put their families at health risks.

Respondents' age and household size have been shown to influence consumers to pay higher prices for healthier products such as organic food (Koundouri *et al*., 2006; Muhammad *et al*., 2015). Muhammad *et al*. (2015) found that the larger the household is in size, the more they were willing to pay for organic foods. This was as a result of more resources that those household have as compared to others with small household size. The findings may however not always hold especially in the African context where large households are not necessarily more endowed in terms of resources as compared to small households. Some of the factors found to influence WTP were used to develop the study questionnaire.

2.7 Review of willingness to pay elicitation methods

The main objective of valuation of novel goods is to estimate the maximum amount the the market good is worth to the respondent. The estimates are also important to agribusiness in product adoption decisions. The most widely stated prefernce technigue used is contingent valuation method (CVM) and choice experiment (CE) methods. CVM estimates the maximum amount the market good is worth to the respondent. Various CVM elicitation method such as open-ended CV format, bidding game, the payment card, the discrete choice (take-it-or-leave-it) and the dichotomous question with follow up have been used in studies to value both public and private goods. Ajayi (2006) for example estimated the farmers willlingness to pay (WTP) for extension services using CVM to derive the lower bound mean (LBM) amount they are ready to offer for the service. However presenting set of money values from which respondents are to choose from does not present a market like situation and is likely to create anchoring biases.

Some studies have used open-ended elicitation format to elicit willingness to pay (Abdinasir, 2005; Budak *et al.*, 2010; Ogunniyi *et al.*, 2011; Kwadz *et al.,* 2013). Competition Commission (2010) found out this elicitation method to be straightforward, no anchoring bias and hence does not provide respondents with cues about what the value of the change might be, it is very informative since maximum WTP can be identified by each respondent and requires relatively straightforward statistical techniques Though the method is easy to formalate the questions, Desvousges *et al*. (1983) and Arrow *et al*. (1993) asserts that respondents often find it difficult to assign a monetary value or give their true maximum WTP for a change or a good they are unfamiliar with and have never thought valuing before without some form of assistance. It is also evident that most market transactions do not involve stating maximum WTP values rather than decisions on whether to buy a good or not. As a result, many open-ended CV formats typically produce an intolerably large number of non-responses or protest zero responses to the WTP questions and outliers who typically give unrealistically large bids leading to unreliable responses. De Groote *et al*. (2011) compared consumer willingness to pay for yellow and fortified maize using experimental auctions to establish the most prefered between them. The use of this method was limited in this study since there was no available substitutes for the biocontrol product.

The use of dichotomous choice contingent valuation to reveal WTP have been used such as by Hubbell *et al*. (2000) and Qaim and Janvry (2003). The elicitation method have been shown to provide respondents with more market-like structure than the simple open-ended format (Hubbell *et al*., 2000). The elicitation method also has the ability to provide less cognitive burden to the respondents who only have to state "Yes" or "No" to a given price which mimics the way a respondent would decide whether or not to buy a good at a certain price hence minimizes non-response and avoids outliers (Competition Commission, 2010). Its limitations include some degree of "yea-saying" (Competition Commission, 2010). Its WTP values are significantly larger than those resulting from comparable open-ended questions and also suffer from starting point bias. The method formats are relatively inefficient in that less information is available from each respondent where the analyst only knows whether WTP is above or below a certain amount.

To elicit WTP, various studies have also used double-bounded dichotomous choice model (Kalashami, Heidari, and Kazerani, 2012; Kimenju and De Groote, 2008; Gebremariam and Edriss, 2012; Baniasadi *et al*., 2013). Although Kimenju and De Groote (2008) used double-bounded dichotomous choice model to estimate the consumer willingness to pay for genetically modified food, the method cannot reveal the actual maximum WTP amount. The use of dichotomous choice (DC) with follow up aims to overcome some of the biases likely to arise (Dare, 2014). Wattage (2001) asserted that though this method leads to more efficiency, the inherent problems of discrete choice methods still exist. The Competition Commission (2010) noted that the choice method is more efficient than single-bounded dichotomous choice as more information is elicited about each respondent's WTP. However, in addition to problem of anchoring and "yea-saying" the method may lead to loss of incentive compatibility (truth telling) due to the fact that the subsequent dichotomous questions that seek to provide the double-bound may not be viewed by respondents as being exogenous to the choice situation. Carpio and Isengildina-Masaa (2009) used a contingent valuation framework to evaluate consumer willingness to pay for premiums. The method is limited in use in the current study since it can only be used to value and compare a good already in the market hence could to be used.in these study.

Revealed preference have also been used to elicit willingness to pay for market goods (Muhammad *et al.,* 2015). However to elicit WTP using this method it involves observing the actual expenditure made in the market place to purchase the good hence cannot be used for a novel product such as Aflasafe KE01.

The use of payment card elicitation format as a CVM to elicit willingness to pay have also been used (Bliem and Getzner, 2008; Gunduz and Bayramoglu, 2011; Alhassan *et al*., 2013;). The payment card provides a context to the bids hence tries to avoid starting point bias and reduces the number of outliers as compared to open-ended and iterative bidding methods. The elicitation method is however vulnerable to biases relating to the range of the numbers used in the card and the location of the benchmarks and cannot be used in telephone interviews (Competition Commission, 2010). Arrow *et al*. (1993) also notes that presenting respondents with a set of money values from which they make their choice is likely to create anchoring biases.

Bidding game to elicit WTP have also been used for example by Dror *et al.* (2007); Garming and Waibel (2009) and Sathya and Sekar (2012). Although the method encourages respondents to consider their preference carefully before stating the amount they are willing to pay it is prone to anchoring bias where a respondent may be influenced by the starting values, and succeeding bids used (Willis, 2002). It also leads to a large numbers of "yea-saying" bids and outliers. The method requires face to face interactions between the interviewer and respondent hence not suitable for mail surveys (Competition Commission, 2010).

The current study used iterative bidding games. Although Boyle *et al.* (1988) asserts there exists no superiority between iterative bidding, payment cards and dichotomous cards (DC) each elicitation method has its strengths and weakness. Cummings *et al*. (1986) asserts that the bidding process is likely to capture the highest price respondents are willing to pay hence it measures the full consumer surplus. The technique uses relatively easy to answer questions that are difficult to free ride on to give a continuous measure of WTP. This provides respondents with their usual market transaction experience where consumers do not face a "take it or leave it" situation when buying but rather a negotiation or a bargaining situation. The procedure is well adapted to personal interview surveys and shown to capture the respondents' highest price they are willing to pay as argued by Wattage (2002). Venkatachalam (2004) also resolves that bidding game has been proved to work comfortably in developing countries since it offers comparatively better outcomes by providing "market-like" situation to respondents by allowing them research their preferences of the product in question. The respondents are allowed more time by the iteration procedure in order to him/her. The monotonous increment of the small regular amounts gives the respondent more opportunities to reject the bid amount, compared to a double-bound dichotomous choice format where the bid amounts are doubled or halved (Venkatachalam, 2004). Studies carried out to compare the elicitation format have also shown the bidding game being more reliable than the dichotomous choice methods (Dong *et al*., 2003).

CHAPTER THREE: METHODOLOGY

3.1 Conceptual framework

Willingness to pay can be perceived as the amount of money people are willing to give up in order to get an improved product that meet their desired outcomes. The various factors that influence an individual WTP are those linked to their social and economic characteristics and those related to the attributes of Aflasafe KE01. The farmer/producer will have a zero WTP if the utility he/she perceives to get is less than the amount of money they forego; hence farmers will not be interested in the good. The WTP of Aflasafe KE01 using CVM (contingent valuation method) provides information on the factors influencing it.

It was hypothesized that the product advertisement that includes the extension of knowledge to the farmers, packaging and labeling of Aflasafe KE01 would impact on farmers' knowledge (Singh *et al.*, 2008). The Aflasafe attributes which include its efficacy and residue effect to survive in the fields for long will influence farmers' willingness to pay for Aflasafe KE01 as Radjabi *et al.* (2014) found. The socio-economic characteristics of farmers such as age and income will influence their adoption and use of Aflasafe KE01 which will thus affect their willingness to pay for the biopesticide (Niyaki *et al.*, 2010; Radjabi *et al.*, 2014). The perceived increase in food quality and reduced health risks, increased productivity as a result of minimized contamination and increased maize marketability will influence farmers' willingness to pay for the bio-pesticide. The farmers' perceptions and attitude towards Aflasafe KE01 will also affect the farmer's willingness to pay for new agricultural technologies (Adesina and Baidu-Forson, 1995). Adoption of Aflasafe KE01 will lead to reduced aflatoxin contamination in maize hence production of clean produce (Cotty *et al.*, 2010). Production of clean produce will promote food security, improved health of the consumers and enhance maize marketability that has been hindered by the presence of large amounts of aflatoxins (ASARECA, 2015).

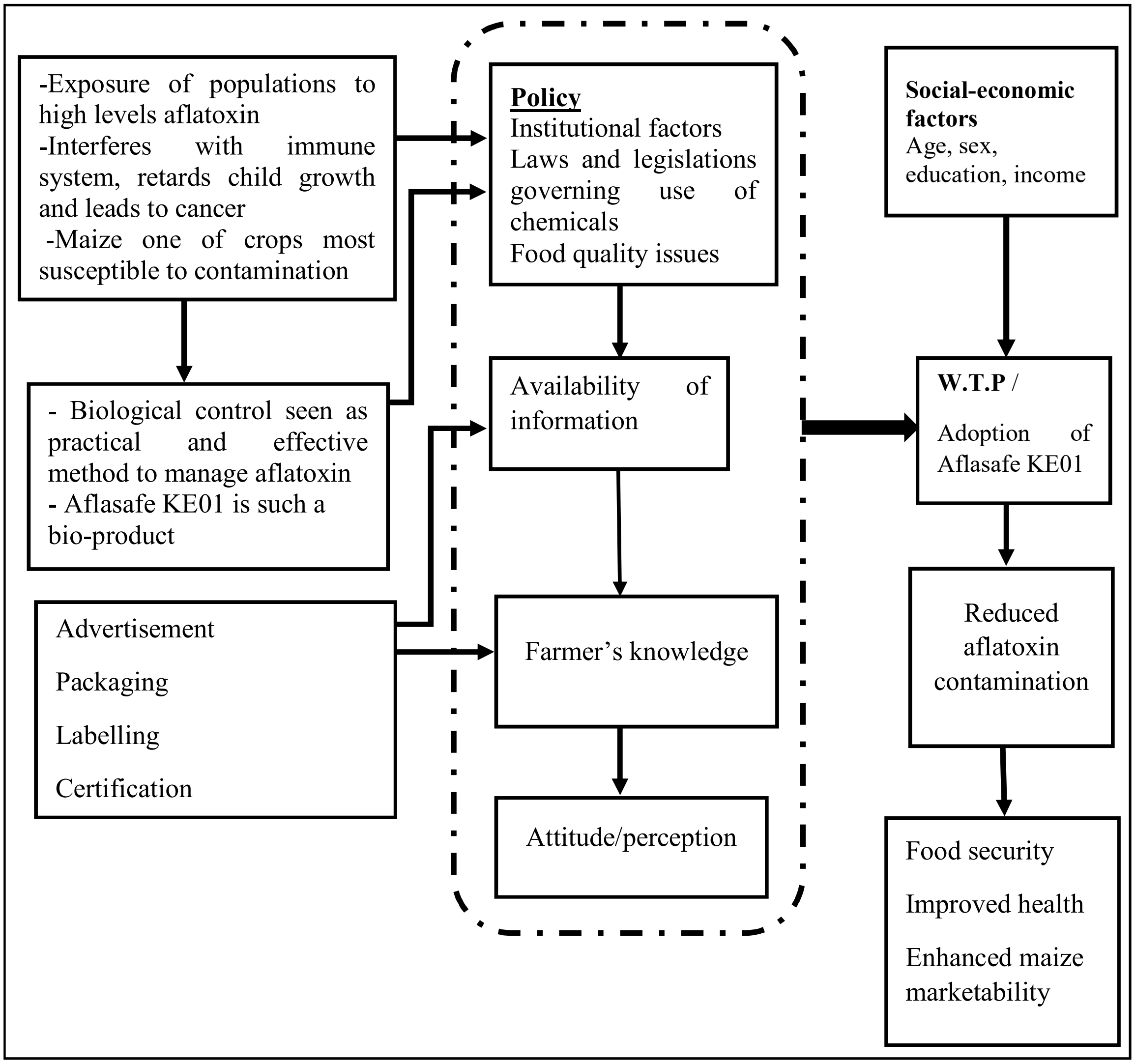

Figure 1: Conceptual framework showing interaction between farmers' perceptions and WTP for Aflasafe KE01

Source: Own conceptualization

3.2 Description of the study area

The study was carried out in four counties. Makueni, Machakos, Kitui Counties (in Lower Eastern[6] Kenya) and Tana River in the coastal region of Kenya. The four counties were chosen because they are aflatoxin hotspots where aflatoxicosis has been reported and are among the Counties whose maize has recently been condemned for trade for being highly contaminated (Nyikal *et al*., 2004, Villers, 2014). The counties also represent some of the areas where there have been field trials on the efficacy of aflasafe KE01.

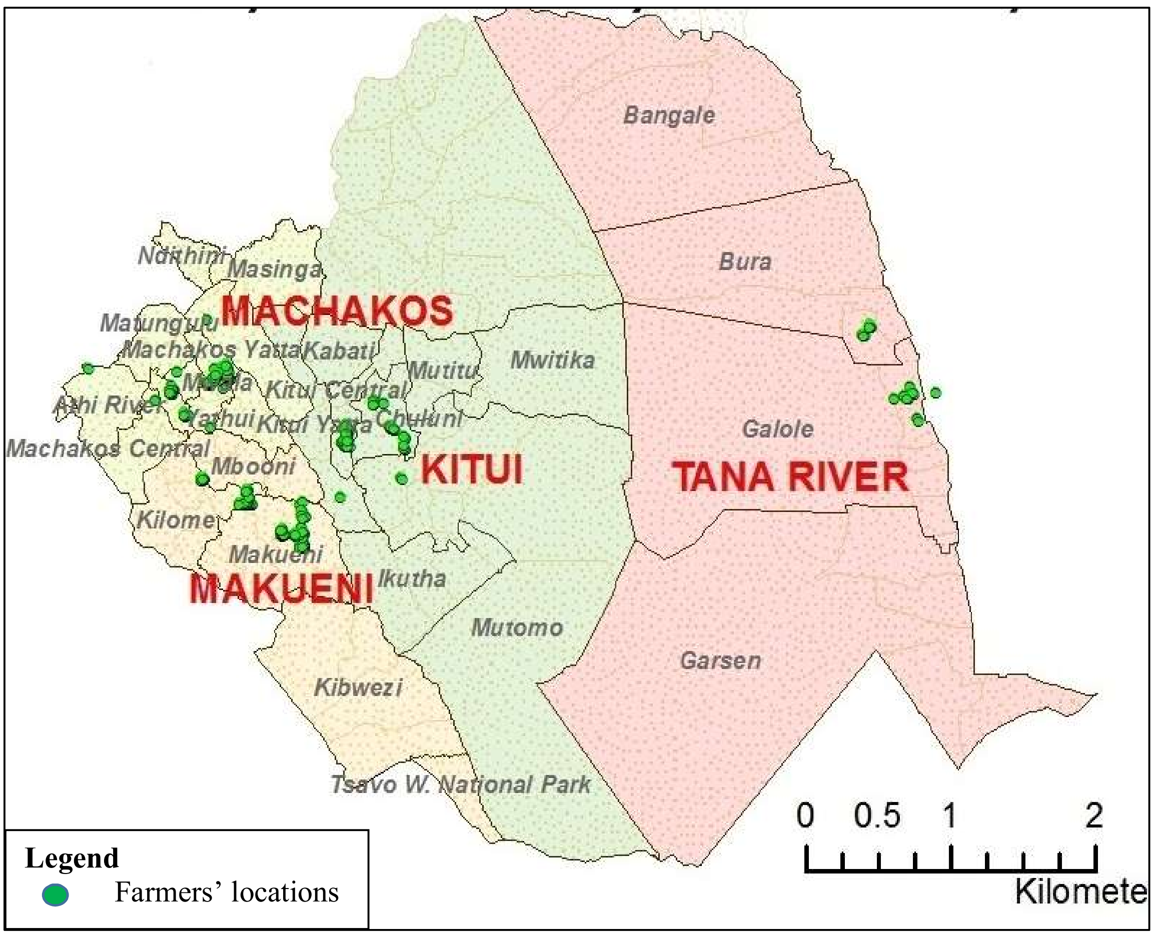

Figure 2: Map of the study area

Source: Author 2014

[6] Lower Eastern Kenya represent Machakos County, Makueni County and Kitui County in this study

3.2.1. Machakos County

Machakos County borders Nairobi and Kiambu Counties to the West, Embu to the North, Kitui to the East, Makueni to the South, Kajiado to the South West, and Murang'a and Kirinyaga to the North West. The County has an altitude of 1000 - 1600 meters above sea level.

The local climate is semi-arid, conditions that create stress to crops hence predisposing maize to aflatoxin contamination. The Counties' hilly terrain covers most parts of the County. The beautiful mountainous scenery is perfect for tourist related activities such as camping, hiking safaris, ecotourism, and cultural tourism, dance and music festivals. The County is well endowed with natural capital including livestock (Chipeta *et al.*, 2015), minerals, wild game, and tourists' attraction sites such as rangeland, and space.

The County practices subsistence agriculture with maize and drought-resistant crops such as sorghum and millet being grown. A large amount of produce is traded through well-organized open air markets. The produce traded includes fruits, vegetables and other foodstuffs like maize and beans (Republic of Kenya, 2012; Chipeta *et al.*, 2015). Two sub-counties were selected in the County, namely Kathiani and Mwala. Kathiani being a trial area while Mwala was a non-trial area.

3.2.2. Makueni County

Makueni County geographically borders Kajiado County to the West, Taita Taveta County to the South, Kitui County to the East and Machakos County to the North. Wote town is the administrative capital of the County.

The County lies in the arid and semi-arid zones of the Eastern region of the Country, creating favorable conditions for fungal infection. Annual temperatures range from 20.2°C to a maximum of 35.8°C (Chipeta *et al.*, 2015). Annual rainfall ranges from 150mm-650mm

(Jaetzold *et al.*, 2006). The main ecological zones include lower midlands (LM), Lower highlands (LH) and Upper midlands (UM) (Chipeta *et al*., 2015).

The County practice both commercial and subsistence agriculture. Cotton and fruit farming is done for commercial purpose in the lower part of the County. Subsistence farming of maize, beans, peas and drought-resistant crops such as sorghum, sweet potatoes, cassava, and millet is also practiced. Horticultural production is through community water management projects which include dams, irrigation schemes, and boreholes (Chipeta *et al*., 2015).

The County has some tourist attraction sites such as the Volcanic Chyulu hills (that forms Chyulu Hills National Park) in Kibwezi West Constituency, Mbooni Hills in Mbooni sub-County and Kilungu hills in Kilungu sub-County (Chipeta *et al*., 2015).Wote and Kaiti were the trial areas while Kathonzweni was a non-trial area.

3.2.3. Kitui County

Kitui County borders Machakos to the west. The County lies between 400m and 1800m above sea level. The central part of the County is characterized by hilly ridges separated by wide low-lying ones (Chipeta *et al*., 2015). The low lying ridges are separated by extensive low-lying areas with a slightly lower elevation of between 600-900 meters above the sea level. Kitui Central, Mutitu Hills and Yatta plateau are the highest areas in the County. Their altitudes enable them receive more rainfall than other areas and consequently are the most productive areas. Some of the tourist attraction sites include the Yatta Plateau which stretches from the north to the south of the County and lies between rivers Athi and Tiva.

The County is in semi-arid and arid agro-ecological zones. They can further be divided into the semi-arid farming zone, semi-arid ranching zone, arid-agro-pastoral area and arid pastoral zone. This makes it food insecure with food poverty rate reported at 55.5% (Chipeta *et al*., 2015). Agricultural development is practiced in the semi-arid farming zone. The semi-arid ranching areas are less fertile and are used for drought resistant crops and livestock keeping. The Arid-agro-pastoral zone and Arid-pastoral zones are suitable for rearing livestock (Chipeta *et al*., 2015).

The County's climatic conditions vary in terms of rainfall and temperatures. The annual rainfall ranges from 500mm to 1050 mm. The County experiences a bimodal pattern of rainfall with long rains falling in the months of March to May. They are usually very erratic and unreliable for agriculture. The reliable rains are usually the short rains that form the second rainy season falling between October and December. High temperatures are experienced throughout the year ranging from 14°C to 34°C.with a maximum mean annual temperature ranges between 26°C - 34°C.

Agriculture is the primary economic activity especially subsistence farming and lowland cattle-grazing (Republic of Kenya, 2012). River Athi is the only perennial river flowing along the border with Machakos County. The County has built several dams to supplement the needed water. The County has a cotton growing industry with much of it is done at subsistence level and not fully exploited. The former Nzambani division represented the trial area in the County while Katulani represented the non-trial area.

3.2.4. Tana River County

Tana River is a County in the former Coast Province. The County borders Kitui County to the west, Garissa County to the Northeast, Isiolo County to the North, Lamu County to the South East and Kilifi County to the South. It is situated in a semi- arid area with annual relief rainfall varying between 400mm and 750mm with a mean annual temperature ranging between 30°C and 33°C (Chipeta *et al*., 2015).

Hola is its administrative headquarter. It is also a historic town since it was the site of detention camp during the British colonial rule The tourist attraction physical features include the undulating plain that is interrupted in a few places by low hills at Bilbil (around 200 meters above the sea level) around Madogo and Bura divisions. The altitude of the land in this County ranges from 20 meters to 200 meters. The County is also characterized by several seasonal rivers commonly known as lagas flowing from the west-east direction from Kitui and Makueni Counties and drain into River Tana (Republic of Kenya, 2013).

The river beds support livestock and wildlife during the dry season as they can retain water. They also provide sites for shallow wells, sub-surface dams and earth pans (Republic of Kenya, 2013). The County is characterized by settlement patterns that are random but concentrated close to the river.

Pokomo, Orma, and Wardey are the dominant ethnic groups. Pokomo are mostly crop farmers while Orma and Wardey are predominantly nomadic. Other inhabitants of the County include Bajuni, Malakote, the Waata and Boni.

The County has been earmarked for Galana/Kulalu Ranch Project by the National Government targeting to put 1.2 million acres of land under irrigation. Out of the total targeted land, 0.5 million acres is to be put under maize production according to the Ministry of Agriculture, Livestock, and Fisheries development. Hola (Galole) and Bura sub-counties were selected for the study. The maize farmers targeted in the area are in irrigation schemes using water from Tana River to produce their crops.

3.3 Methods and procedure

3.3.1 Research Design

The research was quantitative and executed through household surveys using a semi-structured questionnaire. Face to face interviews were conducted between the trained enumerators and the household decision maker/spouse. The questionnaire included a prefatory segment, an elabolated description of Aflasafe KE01 as the bio-pesticide to be valued, the current status with regard to field trials of the bio-pesticide, and the payment mode through which the product will be provided and made available for use. The questionnaire also provided a means to elicit farmer's perceptions on the use of a bio-pesticide in the control of aflatoxins and their WTP. It also enabled the collection of the respondent's socio-demographic characteristics.

3.3 2 Sampling Procedure

Households in the four counties were divided into two categories depending on whether they participated in the Aflasafe KE01 trials or not. Households that took part in the field efficacy tests between the year 2012 and 2013 were referred to as trial farmers while those who did not participate were referred to as non-trial farmers. Trial farmers were also divided into two; treatment and control farmers. Treatment farmers were those whose fields were treated with the bio-pesticide while the control farmers were those whose fields acted as the control for the treated farms. Trial farmers were perceived to be aware and to have information regarding the bio-pesticide since their farms had been selected through participatory engagements with the IITA and KALRO personnel who sensitized them on the technology before the trials were conducted. The trial farmers were also involved in the application of the bio-pesticide in the field.

Non-trial farmers were those who hailed from sub-counties where no Aflasafe KE01 efficacy tests had taken place. These groups of farmers were perceived not to have any information related to Aflasafe KE01. To elicit WTP for this category of farmers, a hypothetical scenario was created to help them understand the bio-pesticide.

The four counties were grouped into three study group categories. Tana River households, both treatment and control farmers were categorized as one group referred to us Tana River in this study. The trial farmers from Machakos, Makueni and Kitui Countries were referred as Lower

Eastern trial farmers while the non-trial farmers were referred as Lower Eastern non-trial farmers.

Systematic random sampling was used to select households that participated in Aflasafe KE01 treatment and control project in Makueni, Machakos and Kitui Counties. Out of 143 treatment households a total of 77 households were selected for interview. The total number of control households was 138 hence 57 household head were selected for interview.

In Tana River, a total of thirty-two households that participated either as treatment or control farmers were randomly selected and interviewed. The Thirty-two farmers were among the Seventy-two who participated in efficacy trials from the two distinctive irrigation schemes namely Bura and Hola.

An extra 314 households in Makueni, Machakos and Kitui Counties were selected. This group comprised the non-trial households in this study. The selected non-trial sub-counties were Kathonzweni in Makueni County where 109 farmers were interviewed, Mwala in Machakos County where 110 farmers were interviewed and Katulani in Kitui County where 95 farmers were interviewed. The sub-counties were selected based on expert opinion and also since they are some of the areas that have ever experienced aflatoxin contamination problems. Proportionate to size criteria was used to get the number of farmers to be interviewed from each of the three sub-counties namely Kathonzweni, Mwala and Katulani. Multistage sampling was used to select Locations, sub-locations and the villages from which farmers were selected. Systematic random sampling was used to select farmers to be interviewed in each of the selected sub-counties.

3.4. Data types

The study used primary data from the field survey and interviews. Key informant interviews with Research Officers from each of the selected Ministry of agriculture, livestock and fisheries

County offices were carried out. The interview was to capture the current situation of the aflatoxin contamination problem of maize and also on the readiness of farmers to adopt the Aflasafe technology. The availability of supporting infrastructure to support adoption of Aflasafe technology was also discussed. Household interviews were conducted and information gathered on the amount of money farmers were willing to pay for the bio-pesticide and the factors likely to influence their WTP.

3.5 Data collection

The study used a questionnaire to obtain the primary data. The instrument was considered reliable and capable of obtaining detailed information on the topic of study. The effectiveness of the questionnaire that was used was assessed through the execution of a pre-test. The questionnaire was revised based on the feedback from the pre-test to create the hypothetical market as concrete as possible. Trained enumerators conducted the face to face interviews with the household respondents. A total of 480 questionnaires were administered to the respondents in the four Counties.

3.6 Data analysis

The field survey data collected on the farmer's perceptions, WTP amounts for Aflasafe KE01 and factors likely to influence the WTP were analysed using econometric software. The statistical package for social scientists (SPSS) version 20 was used to generate descriptive statistics such as mean and percentages. Descriptive statistics was employed to analyse the general characteristics of the respondents and also to analyse the respondent's perceptions of the use of Aflasafe KE01. Principal Components Analysis (PCM) model using SPSS was used to condense and classify the farmers' perceptions. Statistical Package for Social Scientists was also used to estimate farmer WTP amounts. The Ordinary Least Square (OLS) model using

STATA version 12 was used to assess the relative significance of the major hypothesized variables likely to influence the household WTP.

3.6.1 Assessment of farmers awareness and perceptions of Aflasafe KE01

Factor analysis is a method that attempts to represent a set of observed variables say Y_1, $Y_2 \ldots Y_n$ in terms of common factors. The common factors formed are unique to each observed variable (Harman, 1976; Kim and Mueller, 1978; Tabachnick and Fidell, 2007). Factor analysis aims to summarize a multitude of measurements with a smaller number of factors without changing the information. It also enable us establish that most sets of questionnaire items measure the same fundamental factor with varying reliability. The observed variables can therefore be combined to form a more authentic measure of that factor (Widaman, 1993). Factor analysis covers both the principal component analysis (PCA) and principal factor analysis (Rao, 1964). The PCA is an approximation to principal factor analysis especially if the components are rotated. The distinguishing characteristic of the two methods is that PCA assumes that all variability in a variable need to be used in the analysis while in principal factor analysis, the variability used is the one in the variable that is common with the other variables (Lwayo and Obi, 2012). The two methods yield similar results in most cases although PCA is the preferred data reduction method (Cumming and Wooff, 2007) while principal factor analysis is preferred for detecting the structure (Rao, 1964; Tabachnick and Fidell, 2007).

PCA have been used to transform large number of variables in a data set into a smaller and more coherent set of orthogonal (uncorrelated) factors which are called principal components (Rao, 1964). The principal components explain much of the variance among the set of the original variables. Each principal component is usually a linear weighted combination of the initial variables, with coefficients equal to the eigenvectors of the correlation or covariance matrices (Rao, 1964; Lwayo and Obi, 2012).

The principal components are ordered in such a way that the first component normally accounts for the largest possible amount of variation in the original variables. The second component account for the maximum that is not accounted by the first and is completely uncorrelated with the first principal component (Rao, 1964). The third component accounts for the maximum that the first and the second did not account for and so forth. Rao (1964) asserts that PCA is the most successful method of conducting factor analysis. The first principal component can implicitly be computed as follows;

$PC_n = f(a_{ni}X_i, \ldots\ldots\ldots\ldots\ldots a_{1k}X_k)$ ……………………………………………………………i

If the number of principal components is greater than 1, say n numbers, then each principal component will be a continuous variable or quantity related to the products of the values of the constituent variables and their respective weightings or component loading (a). The relationship is an additive one hence the value of the principal component can be obtained by addition of the products as shown in the equation;

$PC_n = f(a_{11}X_1 + a_{12}X_2 + \ldots\ldots\ldots\ldots\ldots a_{1k}X_k)$ …………………………………………………ii

Where PC1 is the first principal component, a_{1k} is the regression coefficient for the *k*th variable that is the eigenvector of the covariance matrix between the variables, and X_k is the value of the *k*th variable.

The assumption of the use of PCA is on interval data that is multivariate and normally distributed. Kim and Mueller (1987) justify use of ordinal data such as Likert scale data in the condition that PCA is used to find general clustering of variables for exploratory purpose and also if the variable correlations are believed to be less than 0.6. The current study used PCA to reduce the perception variables.

Farmers' perceptions of Aflasafe KE01 were assessed on those who had information of the bio-pesticide (Trial farmers). These were farmers who had already used the product during the field trials (treatment farmers) and those who participated as control farmers.

Farmers who had not used the bio-pesticide were expected to reveal their awareness of a bio-product to control aflatoxin contamination (Aflasafe KE01) and their willingness to pay. Their demographic, socio-economic and market-access characteristics, as well as their linkages to public agricultural services that are likely to affect their willingness to pay for Aflasafe KE01, were examined.

Trial Farmers gave their perceptions on some of the attributes regarding the use of Aflasafe KE01 on the Likert scale of one to five (where 1 = strongly disagree, 2 = disagree, 3 = unsure/neutral, 4 = agree and 5 = strongly agree). The variables tested included basic product design, delivery mode, ease of usage, efficacy attributes, sustainability issues of the product, external support services related to the product and socio-cultural compatibility. The 17 items were; "maize disease is a serious farming problem", "Aflatoxin is a serious challenge to maize production", "Current aflatoxin control methods are sufficient", "Bio-pesticide is safe", "Bio-pesticide can reduce aflatoxin contamination", "Bio-pesticide is a GMO", "Sorghum (carrier material) can be a weed", "Bio-pesticide may be non-selective", "Aflasafe KE01 will offer solution to aflatoxin", "Distribution should be through the private sector", "Farmers should be educated on problems of aflatoxins", "Bio-pesticide use is not difficult", "Promotion and awareness of bio-product crucial", "Possibility of counterfeiting Aflasafe KE01", "Bio-pesticide use is socially acceptable", and "Aflasafe use is environmental friendly.

Principal component analysis (PCA) using statistical package for social sciences (SPSS) was used to reduce the number of the variables but still reflect a large proportion of the information contained in the original dataset. Data was screened to ensure no outliers. The minimum amount of data for factor analysis was satisfied for each group with a sample size of 32 for the

Tana River County farmers, 77 for Lower Eastern treatment farmers and 57 for Lower Eastern Control farmers.

Some items were eliminated because they did not contribute to a simple factor structure and failed to meet a minimum criteria of having a primary factor loading of 0.5 or above. Components that did not have at least three items loading on them were also eliminated as justified by Everitt and Hothorn (2011). The remaining variables that were analyzed were those that satisfied several well-recognized criteria for factorability of correlation. The Kaiser-Meyer-Olkin measure of sampling adequacy considered was that above the threshold of 0.5. Any value below 0.5 is considered miserable according to Everitt and Hothorn (2011). The Bartlett's test of sphericity was significant for all the three groups at 1% significant level. Since there was no relationship between the components, varimax rotation, which is a form of orthogonal rotation strategy was used.

3.6.2 Contingent valuation method to estimate the willingness to pay

Contingent Valuation Method (CVM) is a stated preference (SP) method used to determine the values of environmental goods and services. The method can also be used with market goods where prices are presently not available (in this case Aflasafe KE01). Contingent valuation method (CVM) was used to elicit how much the farmers were willing to pay for Aflasafe KE01, which is a new and a hypothetical bio-pesticide currently not available in the market. Iterative bidding games were used to elicit the maximum amount the farmers were willing to pay.

3.6.3 Theoretical Framework

The study was based on random utility model (RUM) theory. According to Hanemann (1991), a consumer utility maximization problem subject to budget constraint can be evinced where the level of good's quality (q) is fixed exogenously. For agribusiness computation, q is most relevant as a measurement of a good's quality. A rational consumer or producer will choose the level of the market product, say x_m that maximizes his/her utility to produce the traditional

Marshallian demand curve, $x_m(p,y,q)$; (p is the market price of the good and y is the consumer/producer income). The indirect utility function that results is given as v(p,y,q). An improvement in the quality of the existing product from q_0 to q_1 can lead to a measurement of the value the consumer/producer places on it. This can be deduced by determining the magnitude of WTP such that this equation holds: $v(p,y\text{-}WTP,q_1) = v(p,y.q_0)$.

The econometric basis of the approach rests on the behavioral framework of random utility theory in which case the discrete choices in a utility maximizing framework are described (McFadden, 1974; Ben-Akiva and Lerman, 1985). The consumer cannot choose a good above his/her budget since his/ her demand for the product will be constrained.

Assume the farmer/producer is faced with an option of producing clean maize that is free from contamination, say from q_0 to q_1, where q_1 is superior to q_0, $q_1>q_0$, and the initial indirect utility is $V\ (q_o\, y, z, \varepsilon)$, where y is income, z is vector of market commodities, prices and characteristics of the individual and ε is unobservable stochastic component. If the farmer perceives that the change is a betterment, then $V\ (q_1, y, z, \varepsilon), \geq\ V\ (q_o, y, z, \varepsilon)$; and if the change will cost the farmer $A, a utility maximizer farmer will only pay $A (yes) if $V\ (q_1, y - A, z, \varepsilon), \geq\ V\ (q_o, y, z, \varepsilon)$ and "no" otherwise. The compensating variation measure C is the value that solves $\Delta V(C, q_1, q_o, y, z, \varepsilon)\ =\ V\ (q_1, y - C, z, \varepsilon), - V\ (q_o, y, z, \varepsilon)\ =\ 0$ and the solution gives $C\ =\ C(q_1, q_o, y, z, \varepsilon)$ which is the maximum WTP for the change from q_0 to q_1.

Adoption of a novel input can also be viewed as the intention of the farmer to improve the quality of the existing maize from q_o to q_1. The WTP or the shadow price for the change can be given by:

$$WTP\ =\ \pi(p, w, qi)\ –\ \pi(p, w, qo),$$

(Where **w** = vector of input prices, and **p** = vector of output prices to yield an indirect restricted profit function $\pi(\boldsymbol{p}, \boldsymbol{w}, g)$. The WTP is thus the amount of profit the producer would be willing to forgo to obtain q_1 rather than q_o. A producer will therefore use the novel input if the perceived gain in utility is higher than the current level.

3.6.4 Willingness to pay elicitation format

Elicitation of the amounts farmers were WTP took two different form depending on whether the farmer was a trial or non-trial farmer. Since the trial farmers were aware of the bio-pesticide, a hypothetical scenario was therefore not necessary.

Non-trial farmers were perceived not to have any information related to Aflasafe KE01. To elicit WTP for this category of farmers, a hypothetical scenario was created to help them understand the bio-pesticide. "The hypothetical scenario was as follows "*Maize production supports the livelihood of your household in various ways. However, frequent occurrence of aflatoxins in maize causes significant losses in maize yield and income. It also causes health problems such as cancer, stunted growth in children and even death under severe cases as witnessed in 2004 in which 317 people died. Use of the biocontrol product will reduce aflatoxin related health issues and fatalities, increase productivity, quality and marketability of maize. The biocontrol product is in use in USA and Nigeria and has been tested in Kenya with positive results. The biocontrol product is developed by scientists, and it reduces contamination of maize with aflatoxin by about 90% giving both single-season crop and long-term influences on the average aflatoxin-producing potential of fungal communities resident in target areas. Suppose this product was to be introduced in the market and you were to purchase it using your cash or through credit by agro-dealers but expected to pay later after harvest, would you purchase it if it was offered at Ksh 130/kg*?"

The initial amount of Ksh 130 per kilogram of Aflasafe KE01 was based on the cost for a similar product in use in Nigeria charged at $1.5/kg. In elicitation of the maximum WTP, the protest bids were identified. Ahead of the valuation question, the trial households were asked whether they were willing to use the biopesticide in future and if not, what the reasons were.

After being asked their willingness to use the biopesticide in future, the respondent was asked his/her willingness to pay (WTP) for the biopesticide.

3.6.5 Bidding process

The study used iterative bidding with the view of encouraging respondents to consider their preferences carefully through the provision of rounds of discrete bids. The bidding game helped to elicit farmers' maximum WTP amounts.

The respondents were asked whether they would pay each of a series of amounts that ascend or descend from a specified starting point (Ksh 130/kg). The iterative process eventually arrives at the respondent's maximum WTP (Wattage, 2002).

The farmers were led through the iterative bidding game process to elicit the maximum amount they would be willing to pay for the bio-product after product and mode of payment description. The product was described clearly and its efficacy quality explained before bidding started. The farmers were informed they would use their cash or buy through credit from agro-dealers and repay after crop sale. They were also informed of the recommended application rate of 10kg per Hectare (equivalent to four kilograms per Acre) so as to ensure incentive compatibility.

A bid of ± Ksh 20 was used to elicit the maximum amount that a farmer would be willing to pay. If a farmer response was a YES to the initial bid amount, an increment of Ksh 20 was offered until the maximum amount the farmer would be willing to pay was attained. If the farmer response was a NO to the initial bid, equal decrements of Ksh 20 was used until the amount the farmer would be willing to pay was revealed. This would be the maximum amount the farmer would be willing to pay. Protest answers were judged by first asking the respondent/ farmer if they were willing to pay for the product and if no, the reasons why they were not willing to pay any amount. The average amount the farmers were willing to pay for the bio-pesticide were estimated from the values recorded.

3.6.6 Addressing biases in contingent valuation method

Although CVM have been found to be flexible in use to value novel products, it suffers from a variety of theoretical and practical difficulties. Samuelson (1954) however asserts that CVM is likely not to suffer from the strategic behavior when used with a private good as it is the case in public goods. Since strategic behavior in CVM is a function of the respondents' perceived payment obligation and the respondents' expectations about provision of a public good, respondents' tend to give a WTP amount that differs from their true willingness to pay. The behavior is geared towards an attempt to influence the provision of the public good. Provision is however not a concern for private goods that consumers need to pay for.

The important biases you would face when using CVM are hypothetical, starting point (anchoring), sample-related and the vehicle biases. The hypothetical bias arises when an individual responds differently when responding to a hypothetical question than when confronted with a real payment situation. This occurs in situations where the payment scenarios are not incentive compatible. It creates a situation where the respondents' allege that they will purchase a good but when placed in a corresponding purchase decision in real life they will either pay less or fail to buy (Karen *et al.*, 2008; Sabah and Wilner, 2011). To correct for the hypothetical bias, follow-up certainty questions are important as advised by Karen *et al*. (2008), but since the bio-pesticide is a market good, decision to buy or not is entirery anchored on the perceived benefits after use and also on the price of available substitutes hence no follow up questions were necessary.

Starting-point (anchoring) bias occurs because the value selected has an appreciable impact on the observed bids. Karen *et al*. (2008) asserts that the starting value conveys information to the respondent about expected or reasonable bids hence influencing the final bid amount. If the starting point is far away from the true value, the procedure terminates before the true bid is reached hence a well selected starting point is important. This study used the cost for a similar product in use in Nigeria hence ensuring that real market situation was created. Since the product is the same, it is perceived that the farmers in the two Countries behave almost the same.

The payment vehicle bias arises when the payment vehicle is either misperceived or is itself valued in a way unintended by the researcher. It is revealed when respondents WTP is different depending on the payment method used. The vehicles used in CVM are utility bills, entrance fees, taxes, user fees and higher prices. Since the bio-pesticide is not a public good, the product price was the best payment vehicle for this study since it is incentive compatible. The payment method made it clear to the respondents that they would have to pay the bid amount to use the bio-pesticide.

Sample selection bias have been shown by Edwards and Anderson (1987) to be low for field surveys and interviews. The bias occurs when the probability of obtaining a valid WTP response among sample elements is related to the respondent's value for the good. In field interviews, there is less potential for non-respondents to be consciously self-selected hence free from sample selection bias. For the current study, an attempt was made to reduce bias problems to a low minimum level at the design stage of the survey questionnaire. The questionnaire was modified significantly as a result of the pre-test. The enumerators were also well trained to carry out in-person interviews.

3.6.7 Empirical model to assess factors influencing the WTP

From literature review, the factors that were found to influence WTP as outlined in Section 2.6 were used. The independent variables that were used to assess the factors that affect willingness to pay for Aflasafe KE01 and their direction of influence is as outlined in Table 1. The dependent variable was the Maximum WTP (Max WTP) which was the amount of money a household would be willing to relinquish to acquire the bio-pesticide.

Table 1: Description of hypothesized independent variables

Variable	Symbol	Description	Expected sign
Access to crop extension	Extcon	1 = access within last one year, 0 = No access	+
Credit use	CreditAcc	1 = access credit within last one year, 0 = no access	+
Awareness of bio-pesticide	AwareBio	1= aware, 0 = not aware	+
Experienced Aflatoxin contamination	AflaConta.	1= Yes, 0 = No	+
Experienced maize loss to diseases	Disease	1= Yes, 0 = No	+
Household size	Hhsiz	Number of the household members	+
Contract agreement of sale	CntrtAgrmt	Contract arrangement to sell maize 1 = Have a contract agreement 0 = No contract agreement	+
Years of main livelihood activity (experience)	Experience	Number of years of practicing main livelihood activity (experience)	+
Income	Hhinc	Natural log of household income	+
Agricultural group membership	MbrAgric	Whether a farmer belongs to an agricultural related group 1= Yes, 0 = No	+
Maize production	Prodn	The quantity of maize harvested in 90 kg bags	+
Age (Years)	Age	Age of the household head/ decision-maker	+
Area under cultivation	AreaCult	Acres under cultivation	+

Land tenure	Tenure	Type of land tenure of the household 1 = Formal ownership of land, 0 = Otherwise	+
Distance to market	DistMkt	Distance to the local market	-
Education	HEDUC	Number of years of schooling completed	+
Initial bid amount	Initamt	1= if the household said yes to the initial amount; 0 = Otherwise	-
Gender	Gender	Gender of the household head 1 = Male, 0 = Otherwise	±
Perception of product effectiveness	PercEffective	Whether a farmer perceives the product to be effective 1 = Yes, 0 = Otherwise	-
Main occupation of the household head	Occup	1 = On- farm activities 0 = Off-farm activities	+
Bura	Bura	The respondent residence 1 = Bura, 0 = Otherwise(Hola)	±

According to Niyaki *et al.* (2010) adoption of a biological control method is affected by education level, family size, experience of the farmer in production and the rate of participation in educational and extension services, hence the need to incorporate them in this study. As education level increases, adoption is expected to increase as shown in the literature review. Therefore adoption of a new technology increases with increase in education hence a hypothesized positive sign. Literature shows a positive relationship between WTP and household size. Horna *et al.* (2005) found that large households with many members were likely to adopt new technologies fast. Large households provide the required labour force that is essential in adoption of technologies that are labour intensive hence the positive relationship. Experience and extension services have been shown to increase WTP/adoption in literature hence the positive relationship. Access to extension services help to equip the farmers with the important skills and knowledge that help them in the adoption of new technologies. Access to credit positively influence WTP as well since it enables the farmer to purchase the input when required.

Awareness created for a technology through formal means positively affect the adoption of the technology by the farmers (Daberkow and McBride, 2003; Singh *et al.*, 2008). Study by Radjabi *et al*. (2014) on the socio-economic factors on adoption of biological control in Iran found that age, activity experience, distance between field and home, social corporation amount, average yield and behavior of extension agents in biological product promotion affected adoption. As the average yield increases, the farmer is motivated to use technologies that ensure the large quantities produced are not destroyed since the cost that would be incured is massive. Distance on the other hand negatively influence WTP. As distance increases, so the transaction costs are likely to increase. Some of transaction costs that would be incured would be the lost time in search of the market information. Increase in distance is therefore likely to affect adoption negatively.

The variable initial bid amount was theorized to influence negatively the magnitude of WTP according to Wattage and Simon (2008). From an economic theory, demand decreases with increase in commodity price. Since CVM assumes an actual market setting, an increase in the bid of a good should results in the decrease of its demand.

The factors whether a farmer had previously experienced maize disease and if the farmer had lost maize due to aflatoxin contamination were also hypothesized to positively affect WTP. These factors are likely to affect the farmer subjective perceptions as shown by Adesina and Baidu-Forson (1995).

The socio-economic factors likely to affect the respondents' WTP were estimated using a model that allowed their introduction as independent variables into the WTP function. The available choices were censored Tobit method and OLS (Ordinary Least Square).

The maize farmer willingness-to-pay function for Aflasafe KE01 can be assumed to be:

$$WTP \quad = f\,(Yi, Ei, Ai, Mi \ldots)$$

Where: WTP = Willingness to pay; Y = Income; E = Education; A = Age and E = Membership of Agricultural groups.

The estimated model can therefore be written as:

$$WTPi \; = \; Xi\beta i \; + \; \mu$$

Where X is a vector of explanatory variables, β is a vector of coefficients and μ is a random variable accounting for unobservable characteristics. Ordinary least square (OLS) was used to estimate the explanatory variables that influenced the farmers' willingness to pay after being superior to Tobit model. The iterative bidding game yields WTP amounts that form a continuous dependent variable that accepts zero values. The values are also point estimators for the sample. The transformed error term was homoscedastic and linear in parameters. The variables did not show signs of multicollinearity hence the choice of OLS regression model. The respondents' socio-economic characteristics likely to shape the WTP were evaluated using an OLS regression model that allowed their insertion into the model. These factors included the farmers' farming experience, income, principal occupation and education grade of the household decision maker. Other factors that were included are family size among others.

CHAPTER FOUR: RESULTS AND DISCUSSION

This chapter provides a discussion of the socio-economic characteristics of sample households for Tana River County, and Lower Eastern Kenya. It also includes information on household's perceptions towards the use of the biopesticide (Aflasafe KE01), the estimated mean WTP and the factors that influenced their WTP.

4.1 Socio-economic profile of the households in the research area

The summary of the descriptive statistics of the variables used in the study are given in Table 2. The means of the dummies in the Table gives the percentages. Considering the variable "access to crop extension" given as "Extcon", the mean 0.50 shows that 50 percent of the Tana River County households covered by this study accessed extension services within the last one year.

The average household size was six for Tana River and five for both Tana River trial and non-trial areas. The average size of the household in Lower Eastern of five persons per household is in agreement with findings of Jaetzold *et al.* (2006) of 4.9 persons/household.

The average household head age was 44, 51 and 52 years for Tana River County, Lower Eastern Trial, and Lower Eastern non-trial households respectively as shown in Table 2. This concur with the national population findings where 57.2% of household heads are aged 40 years and above (G.O.K KIHBS Basic Report, 2006).

The percentage of male headed households was 56% for Tana River, 37% for Lower Eastern Trial households and 40% for Lower Eastern non –trial households. The average household size was six persons for Tana River and five for both trial and non-trial households in Lower Eastern Kenya. The findings are in accordance with those of Jaetzold *et al.* (2006) of 4.9 persons for households in Lower Eastern Kenya.

The average number of years of schooling was six for Tana River households and ten and nine for trial and non-trial families in lower Eastern Kenya respectively. The findings for Lower Eastern concurred with the National status report that showed majority of Kenyans (51%) had attained primary school education (G.O.K., 2010).

Tana River County had the highest number of households in agricultural groups at 66% while non-trial Lower Eastern households had the least at 24%. Most households in Tana River County had joined an agricultural group to access irrigation water contrary to those in Lower Eastern. The need for irrigation water would be the likely reason for having high numbers of the households being in Agricultural groups in Tana River County.

Majority (>85%) of the households practiced agriculture as their primary occupation. KARI (2012) asserted that over 80% of rural population derive their sustenance mainly from agricultural related activities. This includes activities such as crop farming inclusive of food and cash crops; feed and fodder; gardening/vegetable and fruit production; livestock keeping inclusive of camel, cattle, sheep and goat; mixed farming; farm worker on household farm and domestic work in own home. Off-farm occupation included those with formal salaried employment such as private sector employee and civil servants and those running self-employed businesses.

Table 2: Descriptive statistics of explanatory variables

Variables	Tana River County n = 32			Lower Eastern (Trial) n = 134			Lower Eastern (Non-Trial) n = 314		
	Min	Max	Mean (SD)	Min	Max	Mean (SD)	Min	Max	Mean (SD)
Extcon	0	1	0.50 (0.51)	0	1	0.65 (0.48)	0	1	0.40 (0.49)
CreditAcc	0	1	0.69 (0.47)	0	1	0.10 (0.30)	0	1	0.05 (0.21)
Hhsiz	1	18	6 (3.81)	1	15	5 (2.41)	1	17	5.11 (2.30)
AwareBio	0	1	0.97 (0.18)	0	1	0.87 (0.34)	0	1	0.06 (0.23)
CntrtAgrmt	0	1	0.97 (0.18)	0	1	0.08 (0.28)	0	1	0.04 (0.19)
Aflaconta	0	1	0.41 (0.50)	0	1	0.93 (0.26)	0	1	0.28 (0.45)
DistMkt	1	4	1.1 (1.15)	1	15	2.21 (2.65)	1	15	3.17 (1.84)
PercEffective	1.3	3.4	0(1)						
MbrAgric	0	1	0.66 (0.48)	0	1	0.49 (0.50)	0	1	0.24 (0.43)
Hhinc(ln)	9.21	11.61	9.70 (0.72)	9.21	11.74	9.88 (0.82)	9.21	11.73	9.73 (0.734)
Prodn				2	140	17.55 (18.68)	0.5	75	11.01 (11.38)
HEDUC	1	18	6.44 (4.33)	1	19	9.9 (4.22)	1	19	9.18 (4.14)
Disease	0	1	0.56 (0.50)	0	1	0.31 (0.46)	0	1	0.36 (0.48)
Gender	0	1	0.56 (0.50)	0	1	0.37 (0.48)	0	1	0.40 (0.49)
Age	23	74	44.1 (15.29)	24	87	51.4 (14.15)	23	92	52.03 (15.78)
Experience	2	40	10 (10.79)	4	54	22 (12.10)	1	72	21 (14.68)
Occup	0	1	0.88 (0.34)	0	1	0.84 (0.36)	0	1	0.85 (0.36)
Bura	0	1	0.59 (0.50)						
AreaCult	1.5	6	2.95 (0.97)	1	40	4.57 (4.34)	0.38	20	3.95 (3.31)
Tenure				0	1	0.41 (0.49)	0	1	0.35 (0.48)
Initamt	0	1	0.41 (0.50)	0	1	0.55 (0.50)	0	1	0.55 (0.50)

Source: survey data, 2014; SD- Standard deviation

4.2 Households' awareness of use of bio-pesticide in control of aflatoxin

The three figures shows households' awareness of bio-pesticide use. The trial households as expected had the highest percentage of their members' aware of biological pesticide use. Almost 97% of the households in Tana River were aware of the bio-pesticide use. In Lower Eastern trial households, 92.5% were aware of biological pesticide use to control aflatoxin. This shows that information dissemination during the trials was effective and was able to reach a large number of households.

Lower Eastern non-trial households that were aware of bio-pesticide use to control aflatoxins was 5.7% as shown in Figure five. Although no trials had been conducted in this areas, this group have acquired information. The group claimed to have received the information from the Ministry of agriculture, livestock and fisheries, media and from other farmers. This shows the importance the different agricultural information transfer methods plays.

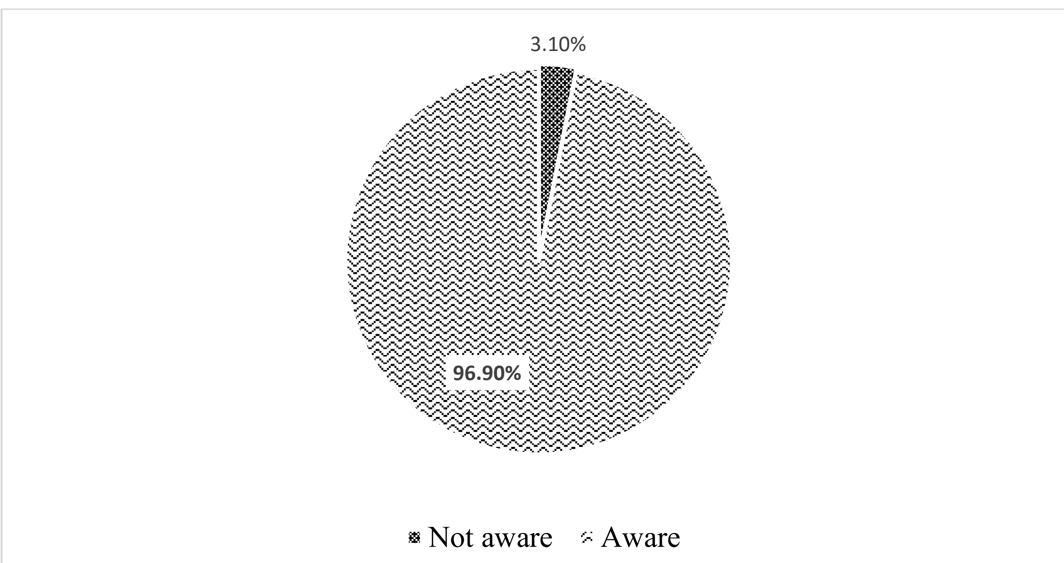

Figure 3: Tana River households' awareness of bio-pesticide use to control aflatoxin

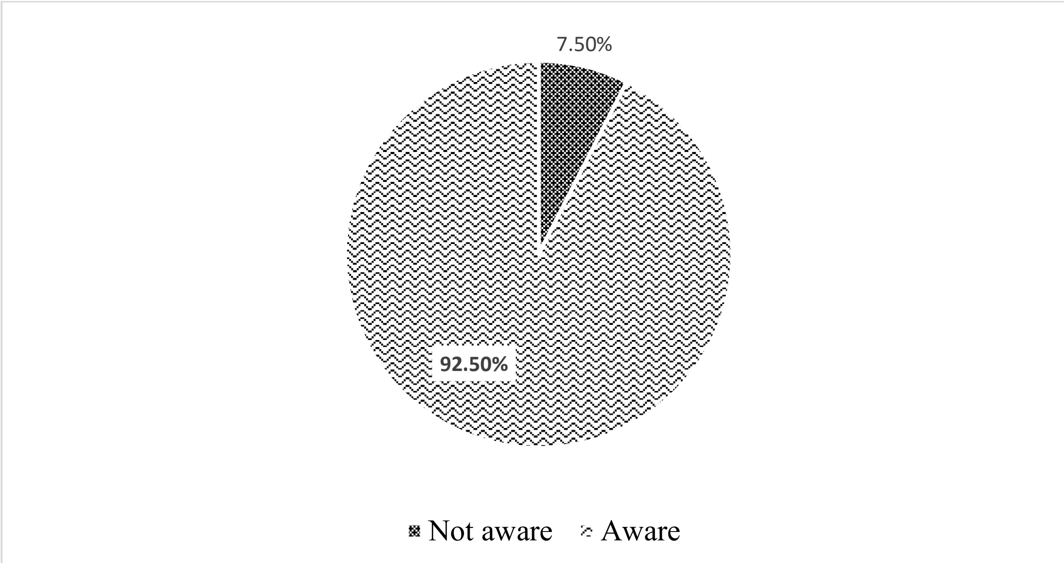

Figure 4: Lower Eastern trial households' awareness of bio-pesticide use

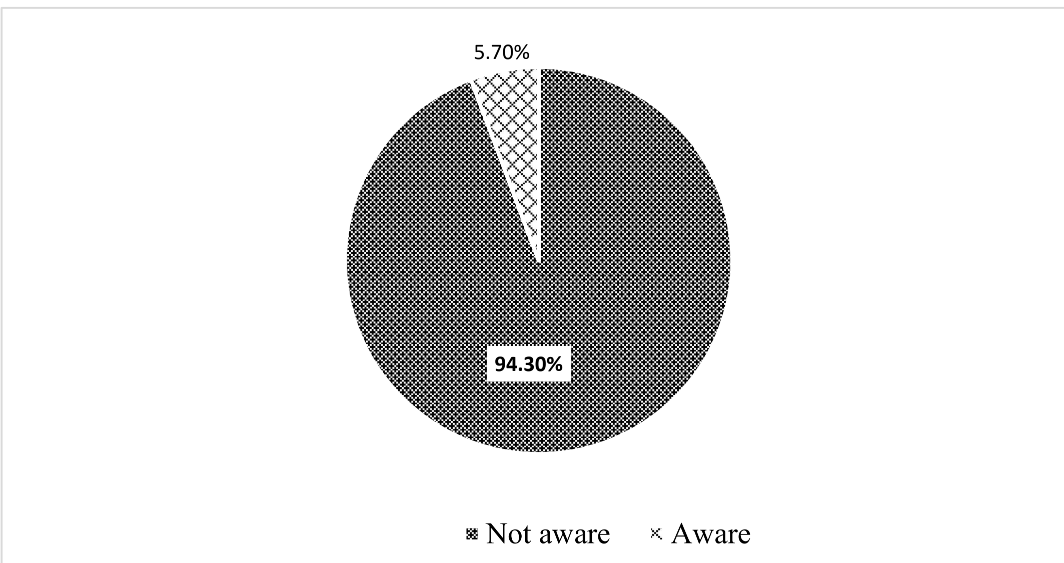

Figure 5: Lower Eastern non-trial households' awareness of bio-pesticide

4.3 Farmers' perceptions on use of Aflasafe KE01 on the trial households

The three tables show the principal components extracted from the two household groups namely; Tana River households and Lower Eastern trial (treatment and control) households.

4.3.1 Perceptions of households in Tana River on use of Aflasafe KE01

The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy for this group of households was 0.563 and satisfied the threshold of above 0.5 for factor analysis (Everitt and Hothorn, 2011). The Bartlett's test of sphericity was significant (χ^2 (78) = 168.92, $p < .01$) at 1% as shown in Table 3. Since there was no relationship between the components, varimax rotation, which is a form of orthogonal rotation strategy was used.

Three principal components were extracted from the households in Tana River and they contributed about 60% of the variance. The perceptions were labeled as education and promotion, effectiveness and fear of the unknown. A total of four items were eliminated because they did not contribute to a simple factor structure and failed to meet a minimum criteria of having a primary factor loading of 0.5 or above.

The proportion of variance accounted by the component education and promotion was 23%. Households believed strongly that promotion and awareness creation of the bio-product was crucial to facilitate adoption. They also considered aflatoxin contamination to be a serious challenge to maize production as evident in the literature. The households believed that it is important to educate farmers problems related to aflatoxins since most are not aware about the long term effects. The households however, perceived the bio-pesticide not to be safe, a perception that need to be changed for effective adoption.

The proportion of variance accounted by the component effectiveness was 20%. The households believed that the bio-pesticide can reduce aflatoxin contamination and offer solution to the recurrent problem of aflatoxicosis. This perception is a positive one since it is likely to enhance adoption. Although they have a positive perception regarding the effectiveness of the bio-pesticide, they believed that the sorghum used as a carrier material may end up germinating in their field and become unwanted weed. This was as a result of few sorghum crops being spotted in the treated fields.

The component fear of unknown accounted for 19% of the variance. Households strongly feared that the bio-pesticide might be non-selective and might end up killing unintended micro-organisms in the soil. They also believed that the current methods of aflatoxin control are sufficient a perception that might hinder adoption. Although the households believed that the bio-pesticide is not a genetically modified organism (GMO), they perceived it as a foreign material in their maize product. Households are apprehensive of distribution of counterfeited bio-pesticides hence the need for the government to ensure regulations and standards are enhanced to prevent losses that can result from use of adulterated inputs.

.

Table 3: Factor loadings and communalities for Tana River County households

	Education and promotion	Effectiveness	Fear of unknown	Communality
Promotion and awareness of bio-product crucial	**0.799**	0.178	0.129	0.69
Aflatoxin a serious challenge to maize production	**0.793**	0.011	-0.180	0.66
Farmers should be educated problems of aflatoxin	**0.724**	0.246	-0.398	0.74
Bio-pesticide is safe	**-0.722**	0.200	-0.113	0.57
Maize diseases are a serious farming problem	**0.610**	0.117	0.046	0.39
Bio-pesticide can reduce aflatoxin contamination	0.203	**0.868**	-0.130	0.81
Aflasafe will offer solution to aflatoxin	0.266	**0.782**	-0.178	0.71
Sorghum (carrier material) can be a weed	-0.208	**0.672**	0.175	0.52
Bio-pesticide may be non-selective	0.063	0.549	**0.732**	0.84
Current aflatoxin control methods sufficient	-0.275	0.046	**0.675**	0.53
Bio-pesticide is a GMO	0.003	0.134	**-0.632**	0.42
Bio-pesticide is a foreign material	0.165	0.427	**0.621**	0.60
Possibility of counterfeiting Aflasafe KE01	0.070	-0.296	**0.590**	0.43
Proportion of variance	0.227	0.196	0.185	0.60
Kaiser-Meyer-Olkin Measure of Sampling Adequacy (MSA)				0.563
Bartlett's Test of Sphericity	Approximate Chi-Square (df)			168.92(78)
	Sig.			0.01

PCA results with varimax rotation. Source: survey data, 2014

4.3.2 Perceptions of treatment households in Lower Eastern on use of Aflasafe KE01

The KMO measure of sampling adequacy for this group of households was 0.579 and satisfied the threshold of above 0.5 for factor analysis as outlined by Everitt and Hothorn (2011). The Bartlett's test of sphericity was significant (χ^2 (91) = 295.78, p < .01) at 1% as shown in Table 4. Having meant the minimum criteria, factor analysis was carried out.

Four principal components were extracted from the responses of treatment households in Lower Eastern. The four components accounted for 58% of total proportion of variance. The components were labelled as fear of unknown, maize diseases a serious problem, bio-pesticide acceptability and bio-pesticide effectiveness. The component fear of unknown accounted for 16% of the variance while the rest accounted for 14% each. Three variables were eliminated because they did not contribute to a simple factor structure and failed to meet the minimum criteria of primary factor loading.

Households strongly feared that the sorghum used as a carrier material would geminate and turn out to be weed in their farms. They also believed that the biopesticide is a foreign material that need not to be introduced into their crops. Although the households have reservations for the product, they believed that it is environmentally friendly. They are however apprehensive that the product might end up killing unintended organisms causing imbalance in the ecology.

The households believed maize disease particularly aflatoxin contamination to be a serious farming constraint especially after numerous rejection of their produce in the market. They also believed that bio-pesticide use is difficult given that proper application timing is required to ensure effectiveness. Maize is supposed to be treated at the flowering stage and when the soil is moist to achieve better results.

Under the category bio-pesticide acceptability, the households asserted that bio-pesticide use was socially acceptable and did not in any way go against their culture. They however agreed that for adoption to be achieved, households need to be educated on the problems associated to aflatoxin contamination. The households also believed that promotion and awareness creation of the bio-pesticide was all important if the intended adoption was to be achieved.

The category bio-pesticide effectiveness had three items that loaded heavily. Households is this group believed that Aflasafe would reduce and completely bring solution to the perennial problem of aflatoxin contamination that have been experienced. This group however do not think counterfeiting Aflasafe KE01 is an issue as witnessed with those in Tana River. This shows that the households are confident with the current private sector model of farm inputs distribution. .

Table 4: Factor loadings and communalities for Lower Eastern treatment households

Variables	Fear of unknown	Maize disease a serious problem	Bio-pesticide acceptability	Bio-pesticide effectiveness	Communality
Sorghum (carrier material) can be a weed	**0.804**	-0.009	0.093	0.269	0.73
Bio-pesticide is a foreign material	**0.686**	-0.002	0.179	0.109	0.52
Aflasafe use cant cause environmental pollution	**0.663**	0.028	0.418	-0.112	0.63
Bio-pesticide may be non-selective	**0.626**	0.131	-0.240	-0.361	0.60
Maize diseases are a serious farming problem	0.015	**0.777**	0.121	0.117	0.63
Aflatoxin a serious challenge to maize production	-0.063	**0.707**	0.250	0.253	0.63
Bio-pesticide use is difficult	-0.280	**-0.632**	0.099	0.362	0.62
Bio-pesticide use is socially acceptable	0.135	-0.020	**0.686**	-0.014	0.49
Farmers should be educated problems of aflatoxin	0.009	0.427	**0.685**	0.202	0.69
Promotion and awareness of bio-product crucial	0.032	0.344	**0.661**	0.007	0.57
Current aflatoxin control methods sufficient	0.277	-0.319	0.450	0.009	0.38
Aflasafe will offer solution to aflatoxin	0.065	-0.061	0.082	**0.743**	0.57
Bio-pesticide can reduce aflatoxin contamination	0.364	0.158	-0.010	**0.728**	0.69
Possibility of counterfeiting Aflasafe KE01	0.130	-0.128	0.024	**-0.601**	0.40
Proportion of variance	0.163	0.141	0.139	0.137	0.58
Kaiser-Meyer-Olkin Measure of Sampling Adequacy (MSA)					0.579
Bartlett's Test of Sphericity — Approximate Chi-Square (df)					295.78(91)
Sig.					0.01

PCA with varimax rotation; Source: survey data, 2014

4.3.3 Perceptions of control households in Lower Eastern on use of Aflasafe KE01

The KMO measure of sampling adequacy for this group of households was 0.733. The Bartlett's test of sphericity was significant (χ^2 (78) = 291.85, $p < .01$) at 1% as shown in Table 5. Since both the tests meant the minimum criteria, factor analysis was carried out.

Principal component analysis extracted three categories of perception in this group. The three components accounted for 61% of total proportion of variance. The components were labelled as fear of unknown, aflatoxin is a serious problem and environmental safety each accounting for 25%, 19% and 17% of the variance respectively. The items that were eliminated for not contributing to a simple factor structure and failing to meet the minimum criteria of primary factor loading were four.

Sorghum can be a weed loaded heavily on the component fear of unknown. The fear of sorghum germinating was evident in this group of households also. Although the sorghum is pre-cooked and only acting as a carrier material, the households feared it might germinate as well. They also feared that Aflasafe KE01 is a foreign material that should not be used. Regardless of the fear they have, they believed that the bio-pesticide can reduce and offer long lasting solution to the repeated problem of aflatoxin contamination. This is important since it is likely to affect their adoption decisions.

They asserted that aflatoxin contamination is a serious challenge to maize production. They also agreed that maize diseases in general are serious farming problem just like their counterparts. This group seemed not to fear counterfeiting of the bio-pesticide just like the treatment households in Lower Eastern. They however concurred with the rest of the households that promotion and awareness creation of the bio-pesticide is of essence for adoption to take place.

The perception that bio-pesticide is environmental friendly loaded heavily on this third category. Households are not worried about any environmental effect that would result from the use of the bio-pesticide. They also concurred with the treatment households that use of the bio-pesticide is socially acceptable and does not contradict their culture. These assertions are important for adoption process. They however perceived the current aflatoxin control methods to be sufficient although contamination is still evident. This could be as a result that most households are not aware of the risks that arise from consumption of aflatoxin contaminated food stuffs. Some of the fungal infection stages cannot also be observed with unaided eye hence households may be unknowingly ingesting small doses of aflatoxins that can result to chronic aflatoxicosis.

Table 5: Factor loadings and communalities for Lower Eastern control households

Variables	Fear of unknown	Aflatoxin is a serious problem	Environmental safety	Communality
Sorghum (carrier material) can be a weed	**0.849**	0.125	-0.054	0.74
Bio-pesticide is a foreign material	**0.775**	-0.069	0.043	0.61
Aflasafe will offer solution to aflatoxin	**0.766**	0.125	0.138	0.62
Bio-pesticide can reduce aflatoxin contamination	**0.650**	0.090	0.347	0.55
Distribution should be through the private sector	-0.509	-0.208	-0.411	0.47
Aflatoxin a serious challenge to maize production	0.176	**0.830**	-0.027	0.72
Maize diseases are a serious farming problem	-0.180	**0.810**	0.167	0.72
Possibility of counterfeiting Aflasafe KE01	-0.101	**-0.622**	0.199	0.44
Promotion and awareness of bio-product crucial	0.546	**0.602**	0.248	0.72
Farmers should be educated problems of aflatoxin	0.429	0.522	0.441	0.65
Aflasafe use can't cause environmental pollution	0.122	-0.082	**0.796**	0.65
Current aflatoxin control methods sufficient	-0.044	0.078	**0.722**	0.53
Bio-pesticide use is socially acceptable	0.309	-0.026	**0.677**	0.55
Proportion of variance	0.250	0.189	0.173	0.61
Kaiser-Meyer-Olkin Measure of Sampling Adequacy (MSA)				0.733
Bartlett's Test of Sphericity		Approximate Chi-Square (df)		291.85(78)
		Sig.		0.01

PCA with varimax rotation: Source: survey data, 2014

4.4 Households' willingness to pay for the Aflasafe KE01 as a biopesticide

Among the trial households in Tana River, 93.6% agreed that they would be willing to use the bio-pesticide in future. The remaining 6.3% were not willing to use the biopesticide in future citing that they were not sure whether the problem was seasonal, or the fungi are always present in the soil. The households mentioned that some of the carrier material (sorghum) germinated on their farms and turned to be a weed in their maize fields.

Among the trial households in Lower Eastern, 99.3% were willing to use the bio-pesticide in future. The remaining 0.7% claimed that they wound not use the bio-product since they had not received the results of the soil samples taken previously from their farms for analysis. All the three responses were treated as protest bids since they resulted into a situation where the household's WTP is zero, not because the bio-pesticide is ineffective but because they objected to some aspects of the way the process of reporting the findings was carried out.

For the Lower Eastern non- trial households 99.7% were willing to pay a positive amount for the bio-pesticide. The rest expressed no need for use of the product since the households had not experienced the problem before. This was also treated as a protest bid.

4.4.1 Estimation of Mean WTP

From the sample, the mean maximum WTP was estimated (Table 6). The minimum amount of money that the households were willing to pay for the three categories was Ksh 30 but the maximum amount was Kshs 250, 490 and 510 for Tana River County, Lower Eastern non-trial, and Lower Eastern trial households respectively. The low amount for the trial Tana River households as compared to the Lower Eastern households can be explained by the fact that parcels of land are not permanently allocated to them but on rotational basis. This decreases motivation for long term investments. Households in Lower Eastern, in contrast own the parcels of land hence they have incentives to invest on their land since Aflasafe KE have a long term effect.

The mean WTP was Kshs 113 (US$1.33) for households in Tana River County, Kshs 152 (US$1.79) for Lower Eastern trial households and Kshs 147 (US$1.73) for Lower Eastern non-trial per one kilogram of the Aflasafe KE01, (US$ ≡ Kshs 85). There was no statistical difference on the mean value of the trial and non-trial farmers in the lower Eastern. The high amounts households were willing to pay in the Lower Eastern Kenya can be explained by the household perception of maize diseases and aflatoxin contamination being a serious problem in agricultural production. The previous aflatoxicosis outbreaks witnessed in the area causing deaths and rejection of maize could also have led to the WTP amounts observed. Although there have been condemnation of maize in Tana River County, the plausible explanation for their low WTP could be the fact that parcels of land are not permanently allocated to them hence no incentives for long term investments. The mode in all the three groups was Ksh 90 as shown in Table 6. This shows that households in Lower Eastern were willing to pay more contrary to those in Tana River County who were willing to pay less for one Kilogram of the product as compared to Nigeria where Aflasafe is already in use.

Table 6: Summary of households' maximum WTP per one Kg of Aflasafe KE01

	Household Category	**Valid n**	**Mean**	**Std. dev.**	**Min**	**Max**	**Mode**
Max WTP (Kshs) / Kg Aflasafe KE 01	Tana River	30	113.3	52.0	30	250	90
	Lower Eastern-Trial area	133	151.8	101.7	30	510	90
	Lower Eastern-Non Trial area	313	147.1	93.4	30	490	90

Source: Survey data, 2014

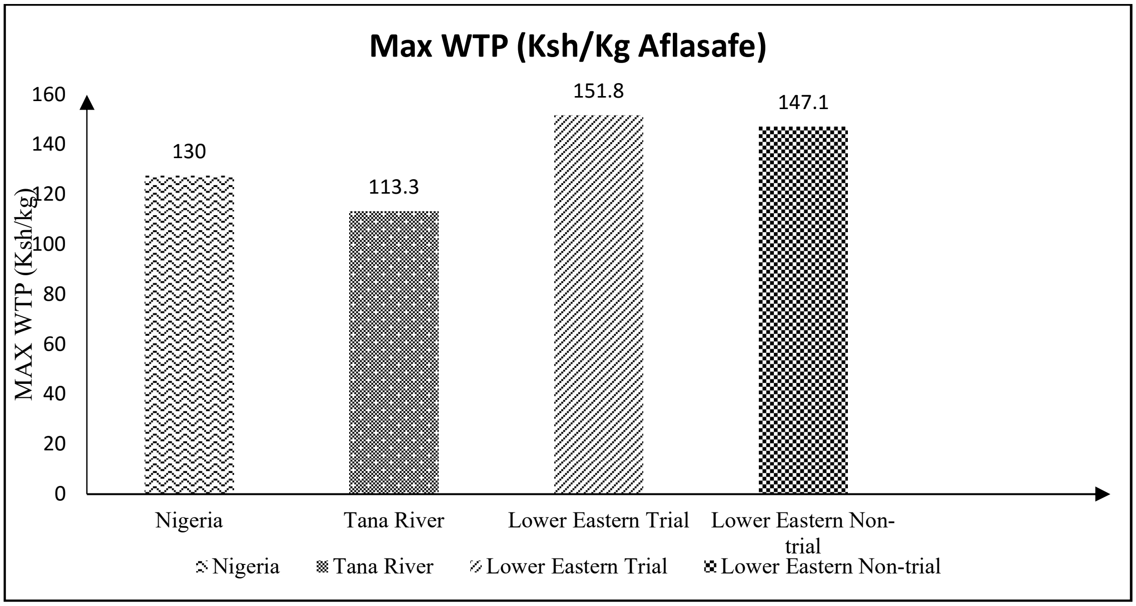

Figure 6: Comparison of Nigeria's price and Kenyan farmers WTP for Aflasafe KE01

4.5 Factors influencing households WTP for Aflasafe KE01

The households' maximum WTP values from the iterative bidding elicitation method form a continuous dependent variable that has zero values. The factors that are likely to influence WTP were assessed using OLS regression model. All the zero WTP amount for this study were treated as protest bids and were not included in the OLS regression model.

The description of the independent variables theorized to influence the maximum WTP, and their expected relationship with the dependent variable was done in Chapter three. The explanatory variables were screened for the existence of multicollinearity, heteroskedasticity and omitted variable/misspecification errors before the model was run. The linear correlation coefficient (r) established that the independent variables were weakly collinear with each other. Variance Inflation Factor (VIF) was employed to quantify the severity of multicollinearity since it measures how much the variance of the estimated regression coefficient is increased because of collinearity shown by results in the appendices (Annex 3). As stated by Greene (2002) VIF greater than five shows high multicollinearity while Gujarati (2004) asserts that as a rule of thumb, VIF that exceeds 10 shows the variable is highly collinear. The variables that were selected and incorporated in the final model were founded on the hypotheses and those whose VIF values were less than 5 showing a non-existence of multicollinearity.

The model was also tested for heteroskedasticity using the Breusch-pagan/Cook-Weisberg test and misspecification errors using Ramsey's RESET test. The tests satisfied the OLS assumption of homoscedasticity and of no omitted variable as shown in the appendices (Annex 3). The explanatory variables took both qualitative and quantitative form. The qualitative variables were presented by dummy variables where 1 indicates their presence while 0 showed otherwise as was shown in Table 2.

The null hypothesis that the independent variables had no effect on the maximum WTP was examined using the significance levels of each variable. According to Gujarati (2004), the p-values being the lowest significance level at which a null hypothesis can be rejected were used in determining whether to reject the null hypothesis or not. The levels of significance were of 1%, 5%, and 10%. If at 1% level ($p\text{-value}<0.01$), it indicated that the variable is highly significant. At 5% level of significance ($0.01<p\text{-value}<0.05$), and at 10% level (p-value between 0.05 and 0.1) indicated that the variable was moderately significant and weakly significant respectively.

The OLS model estimates for the factors that influenced the WTP for the bio-pesticide are presented in Table 7. The F-statistic values were all significant at 5% level of confidence an indication that the composition of the variables considered in this study significantly contributed to the changes in the households' WTP for the bio-pesticide. The adjusted R^2 values that explained the variation in the dependent variable (WTP) caused by variation in the independent variables (Gujarati, 2004) were 0.8369, 0.6623 and 0.6831 for Tana River County, Lower Eastern (Trial area) and Lower Eastern (Non-trial area), respectively. These results indicated that the variables considered could explain 83.7%, 66.2% and 69.9% of the variation notable in the households WTP respectively. All the values passed the reliability test as described by Mitchell and Carson (1989) where a CV study with the value of R-squared being less than 15% is questionable.

The factors that were found to positively influence households' WTP were utilization of crop extension services, credit utilization, awareness of bio-pesticide, contract agreement, household income, gender, age, being from Bura sub-county and initial bid amount. Those that were found to negatively influence WTP were household size, distance to market, perceptions of product effectiveness and years of practice of the main livelihood activity.

Initial bid amount positively influenced the WTP for the bio-pesticide at one percent for all the three categories of households. This shows that if the initial bid amount was increased, the household mean WTP would have also increased. This was contrary to what was hypothesized as the initial bid was to influence the magnitude of WTP negatively. From an economic theory, when a bid of a good increases, considering a real market situation such as the one presented by iterative bidding, the demand of that product decreases (Wattage and Simon, 2008). This shows that the households believed that the initial bid amount presented to them could be the right amount to pay for the bio-pesticide hence based their valuation on that amount. This shows a likelihood of occurrence of starting point bias and explains the high influence of initial bid amount on the WTP amounts.

Access to extension services positively influenced WTP of households in Tana River County at 10%. Access to extension services was likely to increase households WTP. This was consistent with expectations considering that extension services are a kind of education to local households, and educated people are more aware of effects associated with aflatoxin contamination hence they are more willing to pay to prevent contamination. Kumar and Popat

(2008) and Niyaki *et al.* (2010) found that extension services that created awareness are vital to the adoption of biological control methods.

Credit utilization was found to influence positively WTP for all the three groups of households. The influence was at five percent for Tana River and Lower Eastern non-trial households while for Lower Eastern trial households was at ten percent. The findings conform to those of Assa *et al.* (2013) who found that access to credit is essential in enabling households to access and purchase farm inputs. The households that obtained and used credit within the last one year showed an increased willingness to pay for the bio-pesticide. Access and utilization of credit was likely to increase households' WTP. Utilization of credit was an indication of ability to access the bio-pesticide even if the household did not have liquid cash at the moment when the bio-pesticide is needed hence the influence.

Household size was found to influence negatively the amount the household was willing to pay for Tana River and the Lower Eastern non-trial households. The influence was significant at ten percent for Tana River and one percent for Lower Eastern non-trial households. An increase in one unit of the household size would reduce the WTP by about three shillings for Tana River households and three cents for Lower Eastern non trial area. Household size was expected to affect WTP positively especially where the size is attributed to human capital. The result is contrary to literature as shown by Horna *et al.* (2005) in their discussion paper. The authors found that households with more human capital were likely to take up new technologies that are labor intensive. The negative relationship in the results can be due to the fact that increase in family size increases the budget allocations of the household on essential goods such as food and clothing reducing the amount of money available to be used for purchase of the bio-pesticide as supported by Muhammad *et al.* (2015).

Awareness of the biological control and biopesticide was found to have a positive influence on willingness to pay for the bio-product in Lower Eastern non-trial households. The influence was significant at 5% for Lower Eastern non-trial households. This shows that the trials were effective in disseminating information that had a spill-over effect in the neighboring counties. The results are consistent with the findings of Singh *et al.* (2008) and Aryal *et al*. (2009). Households that are aware of a new product are more receptive to paying for the product (bio-pesticide) compared to those who do not have an idea.

Having a contract agreement with the maize buyers positively influenced WTP for the Lower Eastern non-trial households at 5%. Households with strong contract agreements with the maize buyers showed high WTP for Aflasafe KE01. Contract arrangement assures households of availability of a ready market for their maize, which acts as a motivation for WTP. On the other hand, the contract maintains high standards of quality that farmers must meet to sell their products. Qaim and Janvry (2003) found that there are requirements that need to be observed when a household is in a contract with another party hence the influence.

Distance to market was found to negatively influence WTP for non-trial households in the Lower Eastern at 10%. As distance increased, the WTP for the households decreased by almost two percent. This is attributed to transaction costs that a household may incur in the process of searching for information about the bio-pesticide. Nelson and Temu (2005) also found that remoteness of the product markets was significant in influencing input intensity of the Tanzanian coffee growers. Long distances in search of iputs are seen to discourage the use (Nelson and Temu, 2005).

The variable perception of effectiveness negatively influenced WTP at ten percent for Tana River households. Households' perception of the ability of Aflasafe KE01 to reduce aflatoxin contamination and to be selective was seen to be vital in deciding how much one would be willing to pay. This however is in agreement with the findings of Steur *et al*. (2010) who found that consumer perceptions influenced WTP for the Genetically Modified (GM) rice. Households that have a negative attitude about the bio-pesticide are therefore likely to pay less for the bio-product.

The explanatory variable household income positively influenced WTP for Lower Eastern trial and non-trial households at ten percent. An increase of one unit of income is likely to increase the amount a household is WTP by about five to eight percent. This shows that more wealthy households are more likely to be willing to pay for the bio-pesticide. This is consistent with literature that shows wealthier households to be more risk averse and are likely to pay for healthier foods. Household income is also a proxy for ability to purchase inputs by the farmer. This means as income increases, the household is likely to be more concerned of what they are consuming hence the high willingness to pay to produce foods free from aflatoxin contamination.

The explanatory variable gender (being a male) was only found to influence positively WTP for Lower Eastern non-trial households at ten percent. Being a male increased the willingness to pay for the bio-pesticide. The motivation could be the fact that contamination of staples such as maize can directly reduce availability of food. Women tend to be more risk averse as compared to men hence they are less likely to adopt new technologies such as Aflasafe KE01 that are perceived to be risky (Boucher *et al.*, 2008; Fletschner *et al.,* 2010). As findings by Odendo *et al*. (2009) revealed, male headed households have higher access to resources and information that enables them to be more likely adopters of novel technologies.

The variable experience given by the number of years a household has participated in maize production was found to negatively influence WTP for both Tana River and Lower Eastern trial households at ten percent. An increase in one year of experience is likely to reduce the amount a household is willing to pay by one shilling for Tana River households. The results are contrary to what was hypothesized. Kumar and Popat (2008) found the adoption gap to be influenced by farmers' knowledge, market orientation, and innovativeness hence the need for strategies to increase the knowledge of households through various extension approaches. A plausible explanation can be the fact that as the farming experience increases, the households become aware of the best maize handling practices that help to curb or reduce aflatoxin contamination. These practices include timely planting and harvesting, proper drying and storage in aerated and moisture free granaries. This helps the households to maintain their maize quality hence the negative influence on WTP.

The age of the household head positively influenced WTP for the trial households in Lower Eastern at 5%. This is consistent with the hypothesis. Older farmers have more experience and therefore are in position to better assess the characteristics of a novel technology as compared to the younger ones.

Being a farmer from Bura positively influenced WTP at ten percent for the group from Tana River County. A plausible explanation would be that Bura households are not as risk averse as their counterparts in Hola and are willing to try new agricultural technologies.

Table 7: Factors influencing WTP for Aflasafe KE 01 for the three farmers' categories

OLS Regression model estimates						
Dependent variable: Max WTP						
	Tana River County		**Lower Eastern (Trial area)**		**Lower Eastern (Non-trial area)**	
Variables	**Coeff.**	**P-value**	**Coeff.**	**P-value**	**Coeff.**	**P-value**
Constant	107.77	0.217	3.27	0.000***	4.02	0.000***
Extcon	30.51	0.053*	0.06	0.395	0.01	0.851
CreditAcc	36.94	0.013**	0.21	0.064*	0.21	0.020**
AwareBio			0.11	0.363	0.19	0.023**
Hhsiz	-3.10	0.100*	-0.02	0.235	-0.03	0.001***
CntrtAgrm			0.16	0.156	0.26	0.018**
Aflaconta	-2.36	0.924				
DistMkt	3.32	0.585	-0.003	0.792	-0.02	0.071*
PercEffect	-15.56	0.064*				
MbrAgric	-8.67	0.545	0.10	0.179	0.02	0.698
Hhinc	-1.25	0.881	0.08	0.061*	0.05	0.067*
Prodn			0.002	0.363	0.0003	0.868
HEDUC	-0.05	0.974	-0.004	0.643	-0.005	0.316
Disease	8.96	0.515				
Gender	-9.50	0.408	-0.10	0.183	0.07	0.089*
Experienc	-0.89	0.097*	-0.01	0.060*	-0.002	0.181
Age			0.01	0.028**		
Occup	-0.52	0.977	-0.004.	0.959	0.061	0.260
Bura	20.98	0.086*				
AreaCult	-2.43	0.688	0.01	0.211	0.0003	0.983
Tenure			-0.06	0.435	0.023	0.576
Initamt	79.31	0.001***	0.973	0.001***	0.898	0.001***
Number of obs.		30		129		313
F(16,13)		10.30	F(17,111)	15.77	F(16,296)	43.03
Prob.>F		0.0001		0.000		0.000
Adjusted R-squared		0.8369		0.6623		0.6831
Root MSE		21.01		0.34886		0.3231

Note: *, ** and *** implies statistically significant at 10%, 5% and 1% respectively

Source: Survey data, 2014

CHAPTER FIVE: CONCLUSION AND POLICY RECOMMENDATIONS

5.1. Conclusions

The study objective was to assess household perceptions of and willingness to pay for Aflasafe KE01 as a biological pesticide to control aflatoxins in maize in Kenya. Household perceptions were classified into; education and promotion need, effectiveness of the bio-pesticide, fear of unknown, maize disease a serious problem, bio-pesticide acceptability, aflatoxin is a serious problem and environmental safety. For effective adoption to occur, farmer will have to be sensitized fully to boost their confidence on the use of Aflasafe KE01. The fact that households do not have reservations that the product can cause environmental pollution or is not socially acceptable is a positive attribute towards adoption. The results support the first hypothesis that claimed a positive perception towards Aflasafe KE01. We therefore failed to reject the first hypothesis and claimed that farmers have positive perceptions towards some of the attributes of use of Aflasafe KE01.

From the study, it was shown that the households were willing to pay for the bio-pesticide to produce maize that is free from aflatoxin contamination. Although the WTP amounts from this study were hypothetical, the values are higher than the amount charged for a similar product in Nigeria save for Tana River. This shows a positive willingness to pay for the bio-fungicide by the households. This provides a basis for pricing considerations by relevant stakeholders. The findings supported the second hypothesis that claimed that Kenyan farmers are willing to pay for Aflasafe KE01 as much as those in Nigeria. We therefore fail to reject the hypothesis.

The factors that were significant in affecting household WTP for Aflasafe KE01 for the trial and non-trial areas were also assessed. Some factors were found to be significant for certain category of households and not others. In general, the factors that were found to positively influence farmers' WTP were utilization of crop extension services, credit utilization, awareness of bio-pesticide, contract agreement, household income, gender, age, being from Bura sub-county and initial bid amount. Those that were found to negatively influence WTP were household size, distance to market, perceptions of product effectiveness, and years of practice of the main livelihood activity. The explanatory variable credit use was found to be significant in all the three categories of households. All the variables satisfied the hypothesized direction of influence except for initial bid amount and experience measured by the number of years a farmer has been in maize production.

The results show that some factors were significant in influencing the magnitude of WTP hence rejection of the null hypothesis and acceptance of the alternative one. The null hypothesis claimed that farmers' demographic, socio-economic and market-access characteristics, as well as their linkages to public agricultural services, do not affect their willingness to pay for Aflasafe KE01.

5.2. Policy recommendation

The study showed a positive willingness to pay for the bio-pesticide. This provides a basis for pricing considerations by product formulators such as IITA and the government through the Ministry of Agriculture, Livestock and Fisheries. The pricing should reflect the households' income since it was found to influence the WTP of the bio-pesticide.

From the study, it was found that farmer's perceptions to Aflasafe KE01 use fall under; education and promotion need, effectiveness of the bio-pesticide, fear of unknown, maize disease a serious problem, bio-pesticide acceptability, aflatoxin contamination is a serious problem and environmental safety. This shows that for the product to be adopted fully and for households to be willing to pay for it, the stakeholders need to target these aspects. There is need to increase provision of extension services and education on the effectiveness, mechanism and mode of action, and timing of application of Aflasafe KE01. There is also the need for promotion of the product to ensure farmers are fully aware of it by the MoALF. The relevant government and non–governmental organizations should be at the forefront in educating farmers and diffusing information related to aflatoxin contamination. Given the importance shown by farmers on the perception of education and promotion, it is important to ensure households are educated. Education and promotion leads to awareness creation that has shown to positively affect farmers' willingness to pay for Aflasafe KE01.

Farmers are apprehensive of the distribution of fake or counterfeited farm inputs, a concern that bends their preference towards a public sector driven distribution model for the bio-pesticide. Farmers also fear that the private sector may inflate the cost of the product. This underscores the need by stakeholders such as Kenya Bureau of Standards to ensure proper mechanisms that shield farmers from such concerns; for example, developing stringent quality control measures such as barcoding for the packaged product.

Credit use was found to influence significantly WTP. It is, therefore, important for the Government through the Ministry of Finance to facilitate access to credit from the lending organizations by ensuring affordable rates of borrowing. The study showed that if households could access credit from the lending organizations either in the form of liquid cash or farm inputs, it would help increase their adoption rate for the bio-pesticide and also of other agricultural innovations.

Awareness of the bio-pesticide was found to influence positively WTP hence need to step up awareness initiatives through the MoALF field days, farmer field schools, and sensitization efforts through extension workers. Awareness creation will also help to create a market for the bio-pesticide once it is commercialized.

Households that were in contract farming agreements showed a higher willingness to pay hence this group of farmers would be a promising target for enhancing product uptake. However, small and large sized rural households that are characteristically food insecure have been shown to be worst affected by aflatoxin contamination, and would therefore also need to be targeted. This category may not afford Aflasafe KE01 even when all considerations are made to ensure reasonable pricing. The need for both private and public sector driven models for product uptake is vital.

Distance to market was found to influence negatively the WTP. The stakeholders should thus target developing distribution networks that favor accessibility by end users situated away from urban centers. The use of National Irrigation Board and National Cereals and Produce Board stores can ensure the bio-product is readily accessible. This would reduce transaction costs that farmers incur when accessing agricultural inputs, as transportation costs contribute to the cost of the inputs. Farmers also demonstrated their wealth in indigenous knowledge, which comprised of practices that helped them maintain the integrity of their maize. Such knowledge needs to be upheld even as modern mitigation methods are developed. The farming experience was shown to influence negatively the magnitude of WTP. There is need to carry out aflatoxin testing of maize samples from both treated and non-treated farmers' fields, to demonstrate the effectiveness of Aflasafe KE01 and subsequently enhance farmer confidence on its effectiveness. Field demonstrations can also be used to show improved efficacy as a result of complementing the technology with other aflatoxin management practices that the farmers are using.

5.3 Suggestion for further study

This study assessed the amount of money farmers are willing to pay for Aflasafe KE01 using CVM. Future studies could focus on determining the cost of production and distribution of the bio-pesticide to the farmer. The information generated will help the stakeholders in setting the bio-pesticide price that reflects the production and distribution costs.

REFERENCES

Abdinasir, A. (2005). Willingness to pay for improved rural domestic water services: a contingent valuation study of Sericho division, Isiolo district. Nairobi, Kenya: Department of Economics, University of Nairobi. Retrieved from http://erepository.uonbi.ac.ke:8080/xmlui/handle/123456789/20966

Abdulai, A., and Huffman, W. E. (2005). The Diffusion of New Agricultural Technologies: The case of Crossbred-Cow Technology in Tanzania. American Journal of Agricultural Economics, 87(3), 645-659.

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

Ajayi, A. O. (2006). An assessment of Farmers' Willingness to Pay for Extension Services using the Contingent Valuation Method (CVM): The case of Oyo State, Nigeria. *The Journal of Agricultural Education and Extension, 12*(2), 97-108.

Alhassan, M., Loomis, J., Frasier, M., Davies, S., and Andales, A. (2013). Estimating farmers' willingness to pay for improved irrigation: An economic study of the Bontanga irrigation Scheme in Northern Ghana. *Journal of Agricultural Science, 5*(4), 31-42.

Arrow, K., Solow, R., Portney, P., Learner, E., Radner , R., and Schuman, H. (1993). Report of NOAA Panel on Contingent valuation. *Federal Register, 58*(10), 4601-4614.

Aryal, K. P., Chaudhary, P., Pandit, S., and Sharma, G. (2009). Consumers' willingness to pay for organic products: A case from Kathmandu Valley. *The Journal of Agriculture and Environment, 10*, 15-26.

ASARECA. (2015). ASARECA Policy Newsletter; Aflatoxin impacts and potential solutions in Agriculture, Trade, and Health. *18(9)*. ASARECA.

Assa, M. M., Edriss, A.K., and Matchaya, G. C. (2013). Cost efficiency, Morishima, Allen-Uzawa and Cross-Price elasticities among Irish potato farmers in Dedza district, Malawi. *International Journal of Economic Sciences and Applied Research, 6*(1), 59-73.

Atehnkeng, J., Ojiambo , P., Ikotun, T., Sikora , R., Cotty, P., and Bandyopadhyay, R. (2008). Evaluation of atoxigenic isolates of *Aspergillus flavus* as potential biocontrol agents for aflatoxin in maize. *Food additives and Contaminants, 25*, 1266-1273.

Atehnkeng, J., Ojiambo, P. S., Donner, M., Ikotun, T., Sikora, R. A., Cotty, P. J., and Bandyopadhyay, R. (2008). Distribution and toxigenicity of *Aspergillus* species isolated from maize kernels from three agro-ecological zones in Nigeria. *International Journal of Food Microbiology, 122*(1), 74-84. doi:10.1016/j.ijfoodmicro.2007.11.062

Azziz-Baumgartner, E., Lindblade, K., Gieseker, K., Schurz, R. H., Kieszak, S., Njapau, H., Schleicher, R., and Mccoy, L. F. (2005). Case-control study of an acute aflatoxicosis outbreak -Kenya 2004. *Environmental Health Perspectives, 113*, 1779-1783.

Baniasadi, M., Yazdani, S., and Salami, H. (2013). Investigation of the potential market and estimation of WTP for insurance of Pistachio tree truck (case study Rafsanjan-Iran). *International Journal of Agricultural Management and Development, 03*(4), 259-267.

Barreiro-Hurle, J., Colombo, S., and Cantos-Villar, E. (2008). Is there a market for functional wines? Consumer preferences and willingness to pay for resveratrol-enriched red wine. *Food Quality and Preference, 19*, 360-371.

Ben-Akiva, M., and Lerman, S. (1985). Discrete choice analysis, theory and application to travel demand. *Cambridge, MA: MIT Press*.

Bliem, M., and Getzner, M. (2008). *Valuation of ecological restoration benefits in the Danube River basin using stated preference methods – Report on the Austrian case study* *results*. Klagenfurt, Austria: Institute for Advanced Studies Carinthia / Department of Economics, Klagenfurt University.

Bonti-Ankomah, S., and Yiridoe, E. K. (2006). *Organic and conventional food: A literature review of the economics of consumers' perceptions and preferences. Final Report.* Nova Scotia Agricultural College, truro, Nova Scotia, Canada: Organic Agriculture Centre of Canada.

Boucher, S., Carter, M., and Guirkinger, C. (2008). Risk rationing and wealth effects in credit markets: theory and implication for agricultural development. *American Journal of Agricultural Economics, 90*(2), 409-423.

Boyle, K., Michael, P. W., and Bishop, R. (1988). Validation of empirical measures of welfare change. *Land Economics, 64*(1), 94-98.

Breustedt, G., Muller-scheeBel, J., and Latacz-Lohmann, U. (2008). Forecasting the Adoption of GM Oilseed Rape: Evidence from a discrete choice experiment in Germany. *Journal of Agricultural Economics, 59*(2), 237-256.

Brown, J. D. (2009). Principal components analysis and exploratory factor analysis-Definitions, differences, and choices. *Shiken: JALT Testing and Evaluation SIG Newsletter*, 26-30.

Budak, D. B., Budak, F., and Kaçira, Ö. Ö. (2010). Livestock producers' needs and willingness to pay for extension services in Adana province of Turkey. *African Journal of Agricultural Research, 5*(11), 1187-1190. doi:10.5897/AJAR09.567

Carpio, C. E., and Isengildina-Masaa, O. (2009). Consumer willingness to pay for locally grown products:the case of South Carolina. *Agribusiness, 25*, 412-426. doi:10.1002/agr.20210

Chipeta, S., Henriksen, J., Wairimu, W., Muriuki, H., and Marani, M. (2015). *Agricultural Sector Development Support Programme (ASDSP) mid term review.* Nairobi, Kenya: Citat.

Competition Commision. (2010). *Review of stated preference and willingness to pay methods.* London: Accent.

Cotty, P. J. (2006). Biocompetitive exclusion of toxigenic fungi. In *The Mycotoxin Factbook* (pp. 179-197). Wageningen, the Netherlands: Wageningen Academic Publishers.

Cotty, P. J., Probst, C., and Schulthess, F. (2010). Impact of *Aspergillus* section *Flavi* community structure on the development of lethal levels of aflatoxins in kenyan maize (*Zea mays*). *Applied Microbiology, 108*, 600-610.

Cumming, J. A., and Wooff, D. A. (2007). Dimension reduction via principle variables. *Computational Statistics and Data Analysis, 52*(1), 550-565.

Cummings, R. G., Schulze, W. D., Gerking, S. D., and Brookshire, D. S. (1986). Measuring the elasticity of substitution of wages for municipal infrastructure: A comparison of the survey and wage hedonic approaches. *Journal of Environment and Economic Management, 13*(3), 269-276.

Daberkow, S. G., and McBride, W. D. (2003). Farm and Operator Characteristics Affecting the Awareness and Adoption of Precision Technologies in the US. *Precision Agriculture, 4*, 163-177.

Dare, A. M. (2014). *Rural Households' Access, Willingness to Pay (WTP) and Factors Influencing WTP for Safe Water and Sanitation in Southwest Nigeria.* Minneapolis, MN, July 27-29, 2014: Selected Paper Prepared for Presentation at the Agricultural & Applied Economics Association's 2014 AAEA Annual Meeting.

De Groote, H., Kimenju, S. C., and Morawetz, U. B. (2011). Estimating consumer willingness to pay for food quality with experimental auctions: the case of yellow versus fortified maize meal in Kenya. *Agricultural Economics, 42*(1), 1-16. doi:10.1111/j.1574-0862.2010.00466.x

Delnero, J. A., and Weeks, W. G. (2000). How Secondary Agricultural education Teachers Describe their Work. *Journal of Southern Agricultural Education Research, 50*(1), 7-14.

Desvousges, W., Smith, V., and McGivney, M. (1983). *A comparison of alternative approaches for estimating recreation and related benefits of water quality improvements.* Washington D.C.: Office of Policy Analysis. U.S . Environmental Protection Agency.

Dong, H., Kouyate, B., Cairns, J., and Sauerborn, R. (2003). A comparison of the reliability of the take-it-or-leave-it and the bidding game approaches to estimating willingness-to-pay in rural population in West Africa. *Social Scince and Medicine, 56*(10), 2181-9.

Dror, D. M., Radermacher, R., and Koren, R. (2007). Willingness to pay for health insurance among rural and poor persons:Field evidence from seven micro health insurance units in India. *Health Policy, 82*(1), 12-27. doi:10.1016/j.healthpol.2006.07.011

Edwards, S., and Anderson , G. (1987). Overlooked biases in contingent valuation surveys: Some considerations. *Land Economics, 62*(2), 168-178.

Egal, S., Hounsa, A., Gong , Y. Y., Turner, P., Wild , C. P., Hall, A. J., Hell, K and Cardwell, K. F. (2005). Dietary exposure to aflatoxin from maize and groundnut in young children from Benin and Togo, West Africa. *International Journal of Food Microbiology, 104 (2)*, 215-224.

Everitt, B., and Hothorn, T. (2011). *An introduction to applied Multivariate analysis with R.* New York: Springer.

Fletschner, D., Anderson, C., and Cullen, A. (2010). Are women as likely to take risks and compete? Behavioural findings from Central Vietnam. *Journal of Development Studies, 30*(1), 1-26.

G.O.K. (2006). *Kenya Integrated Household Budget Survey (KIHBS) Basic Report.* Nairobi: Government of Kenya.

G.O.K. (2010). *The 2009 kenya Population and Housing Census.* Nairobi: Kenya National Bureau of Statistics (KNBS).

G.O.K. (2011). *National Food and Nutrition security policy.* Nairobi: Government of Kenya.

Garming, H., and Waibel, H. (2009). Pesticides and farmer health in Nicaragua: A willingness-to-pay approach to evaluation. *The European Journal of Health Economics, 10*(2), 125-133.

Gebremariam, G. G., and Edriss, A. K. (2012). Valuation of Soil Conservation Practices in Adwa Woreda, Ethiopia: A Contingent Valuation Study. *Journal of Economics and Sustainable Development, 3*(13), 97-107.

Greene, W. H. (2002). *Econometric Analysis* (5th ed.). Upper Saddle River, New Jersey: Prentiice Hall.

Gujarati, D. (2007). *Basic Econometrics.* Special Indian edition. 4th edition.

Gujarati, D. N. (2004). *Basic Econometrics* (4th ed.). McGraw- Hill Companies.

Gunduz, O., and Bayramoglu, Z. (2011). Consumer's Willingness to Pay for Organic Chicken Meat in Samsun Province of Turkey. *Journal of Animal and Veterinary Advances, 10*(3), 334-340.

Hanemann, W. (1991). Willingness To Pay and Willingness To Accept: How much can they differ. *American Economic Review, 81*, 635-47.

Harman, H. (1976). *Modern factor analysis (3rd Edition, Revised).* Chicago: University of Chicago Press.

Hoffmann, V., Mutiga, S., Harvey, J., Nelson, R., and Milgroom, M. (2013). *Aflatoxin Contamination of Maize in Kenya: Observability and Mitigation Behavior.* Washington, DC: Selected Paper prepared for presentation at the Agricultural and Applied Economics Association's 2013 AAEA and CAES Joint Annual Meeting.

Horna, J. D., Smale, M., and Von-Oppen, M. (2005). Farmer willingness to pay for seed-related information: Rice varieties in Nigeria and Benin. Washington, DC: International Food Policy Researh Institute.

Hubbell, B. J., Marra, M. C., and Carlson, G. A. (2000). Estimating the demand for a new technology: Bt cotton and insecticide policies. *American Agricultural Economics Association, 82*(1), 118-132. doi:10.1111/0002-9092.00010

Hudson, D., and Hite, D. (2003). Producer willingness to pay for precision application technology: implications for government and the technology industry. *Canadian Journal of Agricultural Economics, 51*, 39-53.

IARC. (2002). *Traditional herbal medicines, some mycotoxins, naphthalene and styrene. IARC Monograph on the Evaluation of Carcinogenic Risk of Chemicals in Humans.* Lyon, France: International Agency for research on Cancer.

IFPRI. (2010). *Aflatoxins in Kenya: An overview.* Washington, DC: IFPRI.

IITA. (2012). *Tackling Killer aflatoxins in African food crops.* Ibadan, Nigeria: Wren Media.

Jaetzold, R., Schmidt, H., Hornetz, B., and Shisanya, C. (2006). *Farm Management Handbook of Kenya* (Vol. II/C1). Nairobi: Ministry of Agriculture, Kenya, in Cooperation with the German Agency for Technical Cooperation (GTZ).

Kalashami, M. K., Heidari, M., and Kazerani, H. (2012). Investigating Consumers' Willingness to Pay for Organic Green Chicken in Iran (Case Study: Rasht City). *International Journal of Agricultural Management and Development, 2*(4), 235-241.

Kaneko, N., and Chern, W. (2005). Willingness to pay for genetically modified oil, cornflakes, and salmon: Evidence from a U.S. telephone survey. *Journal of Agricultural and Applied Economics, 37*(3), 701-719.

Karen, B., Glenn, C., Magnus, J., Nancy, H., and Patricia , F. (2008). Elicitating willingness to pay without bias: Evidence from a field experiment. *The Economic Journal, 118*, 114-137.

KARI. (2012). *Food security Report - Policy responses to food crisis in Kenya.* Nairobi, Kenya: KARI.

Kim, J., and Mueller, C. (1987). *Factor analysis. Statistical methods and practical issues.* Beverly Hills, CA: Sage.

Kim, J., and Mueller, C. W. (1978). *Introduction to factor analysis: what it is and how to do it.* (Vol. 13). Beverly Hills, Califonia: Sage Publications.

Kimenju, S. C., and De Groote, H. (2008). Consumer willingness to pay for genetically modified food in Kenya. *Agricultural Economics, 38*, 35-46.

Kolli, R. D., and Hall, A. (2010). *Socio-economic determinants of farmers practices and perceptions in groundnut based livelihood systems in Andhra Pradesh; An analysis of their implications for reducing aflatoxin contamination.* International Crops Research Institute for the Semi- Arid Tropics (ICRISAT).

Koundouri, P., Nauges, C., and Tzouvelekas, V. (2006). Technology adoption under production uncertainty: Theory and application to irrigation technology. *American Journal Of Agricultural Economics, 88*, 657-670.

KSTCIE. (2012). *Field testing of bio-competitive strains of Aspergillus flavus to reduce aflatoxin in maize fields.* Nairobi, Kenya.

Kumar, S. G., and Popat, M. N. (2008). Assessment of adoption gaps in the management of aflatoxin contamination of groundnut (*Arachis hypogaea L.*). *South African Journal of Agricultural Extension, 37*, 45-57.

Kwadz, G. T.-M., Kuwornu, J. K., and Amadu, I. S. (2013). Food crp farmers' willingness to participate in market-based insurance scheme: Evidence from Ghana. *Research in Applied Economics, 5*(1), 1-21.

Lancaster, K. J. (1966). A new approach to consumer theory. *Journal of Political economy, 74*(2), 132-157.

Lewis, L., Onsongo, M., Njapau, H., Schurz Rogers, H., Luber , G., Kieszak, S., Nyamango, J and Backer, L. (2005). Aflatoxin contamination of commercial Maize products during an outbreak of acute aflatoxicosis in Eastern and Central Kenya. *Environmental Health Perspectives, 113*, 1763-1767.

Lusk, J. L., and Hudson, D. (2004). Willingness-to-pay estimates and their relevance to Agribusiness decision making. *Review of Agricultural Economics, 26*(2), 152-169.

Lwayo, M. K., and Obi, A. (2012). Risk perceptions and management strategies by smallholder farmers in KwaZulu-Natal Province, South Africa. *International Journal of Agricultural Management, 1*(3), 28-39.

McCann, J. (2005). Maize and Grace: Africa's Encounter with a New World Crop. *Cambridge: Harvard University Press*, 1500-2000.

McCorkle, B. (2007). Demographic influences on willingness to pay for cold tolerance technology. *American Journal of Agricultural Economics, 89*(5), 1315-1323.

McFadden, D. (1974). Conditional Logit analysis of qualitative choice behaviour. *P.E. Zarembka, ed., Frontiers of econometrics. New York: Academic Press*, 105-142.

Mitchell, R. C., and Carson, R. T. (1989). *Using surveys to value public goods: The contingent valuation Method.* McGraw: Hill Series in Industrial.

Muhammad, S., Fathelrahman, E., and Ullah, R. U. (2015). Factors Affecting Consumers' Willingness to Pay for Certified Organic Food Products in United Arab Emirates. *Journal of Food Distribution Research, 46*(1), 37-45.

Munasib, A., and Roy, D. (2012). Nontariff barriers as bridge to cross. Foz do Iguacu, Brazil.

Munkvold, G. P. (2003). Cultural and genetic approaches to managing mycotoxns in maize. *Annual Review Phytopathology, 41*, 99-116.

Nayga, R. M., Woodward, R., and Aiew, W. (2006). Willingness to pay for reduced risk of foodborne illness: A nonhypothetical field experiment. *Canadian Journal of Agricultural Economics, 54*, 461-475.

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*, 205-216.

Nelson, A. W., and Temu, A. (2005). Impacts of prices and transactions costs on input usage in a liberalizing economy: evidence from Tanzania coffee growers. *Agricultural Economics, 33*, 243-253.

Niyaki, A. L., Radjabi, R., and Allahyari, M. S. (2010). Social factors critical for adoption of biological control agents *Trichogramma Spp*. egg parasitoid of rice stem borer *Chilo suppressalis* in North of Iran. *American-Eurasian Journal of Agricultural and Environmental Science, 9*(2), 133-139.

Nkamleu, G. B. (2007). Modelling farmers' decisions on integrated soil nutrient management in sub-Saharan Africa: A multinomial Logit analysis in Cameroon. In A. Batiano, B. Waswa, J. Kihara , and J. Kimetu (Eds.), *Advances in Integrated Soil FertilityManagent in sub-Saharan Africa: Challenges and Opportunities* (pp. 891-904). Netherlands: Springer Netherlands.

NTP. (1980). *First Annual Report on Carcinogens. Report on Carcinogens.* Research Triangle Park, NC, USA: National Toxicology Program.

Nyikal, J., Misore, A., Nzioka , C., Nguguna , C., Muchiri, E., Njau, J., and Likimani, S. (2004). Outbreak of aflatoxin poisoning- Eastern and Central Provinces, Kenya, January-July 2004. *Morbidity and Mortality Weekly Report, 53*, 790-793.

Odendo , M., Obare, G., and Salasya, B. (2009). Actors responsible for differences in uptake of integrated soil fertility management practices amongst smallholders in western Kenya. *African Journal of Agricultural Resources, 4*(11), 1303-1311.

Ogunniyi, L. T., Sanusi, W. A., and Ezekiel, A. A. (2011). Determinants of rural household willingness to pay for safe water in Kwara State, Nigeria. *AACL Bioflux, 4*, 660-669.

Owino, A. O., Jillo, A. H., and Kenana, M. L. (2012). Socio-economics and wildlife conservation of a peri-urban national park in central Kenya. Journal for Nature Conservation, 20, 384-392

PACA. (2013). Aflatoxin impacts and potential solutions in agriculture, trade and health. *A background paper for the PACA strategy development-stakeholder consultation workshop.*

PCPB. (2015). *Kenyan Government approves use of Aflasafe KE01 to fight aflatoxins.* Nairobi, Kenya: PCPB.

Qaim, M., and Janvry, A. D. (2003). Genetically modified crops, corporate pricing strategies, and farmers adoption: The case of Bt cotton in Argentina. *American Journal of Agricultural Economics, 85*(4), 814-828.

Radjabi, R., Noorhosseini-Niyaki, S. A., and Masjedi, H. (2014). Socio-economic factors on adoption of biological control in Iran. *Indian Journal of Fundamental and Applied Life sciences, 4*(1), 76-81.

Rao, C. R. (1964). The use and interpretation of principal component analysis in applied research. *The Indian Journal of Statistics, 26*(4), 329-358.

Republic of Kenya. (2012). *Economic Review of Agriculture.* Nairobi, Kenya: Ministry of Agriculture: Central Planning and Project Monitorig Unit.

Republic of Kenya. (2013). *First Tana River County Integrated Development Plan.* Nairobi, Kenya: Republic of Kenya.

Sabah, A., and Wilner, P. (2011). Willingness to pay for renewable energy: evidence from contingent valuation survey in Kenya. *Renewable and sustainable energy reviews, 15*, 2974-2983.

Samuelson, P. (1954). The pure Theory of public expenditure. *Review of Economics and Statistics, 36*(4), 387-389.

Sathya, T., and Sekar, C. (2012). Mangrove Eco-system and their Multifunctionalities: An Analysis of the Provision of Economic and Environmental Livelihoods to the Fishermen Communities in the South-East Coast of India. *Trends in Agricultural Economics, 5*(2), 31-47. doi:1O.3923/tae.2012.31.47

Simberloff, D., and Stiling, P. (1996). Risks of species introduced for biological control. *Biological Conservation, 78*, 185-192.

Singh, A., Vasisht, A. K., Kumar, R., and Das, D. K. (2008). Adoption of Integrated Pest Management Practices in Paddy and Cotton: A Case Study in Haryana and Punjab. *Agricultural Economics Research Review, 21*, 221-226.

Steur, H. D., Gellynck, X., Storozhenko, S., Liqun, G., Lambert, W., Straeten, D. V., and Viaene, J. (2010). Willingness-to-accept and purchase geneticaly modified rice with high folate content in Shanxi province, China. *Appetite, 54*, 118-125.

Steur, H., Gellynck, X., Feng, S., Rutsaert, P., and Verbeke, W. (2012). Determinants of willingness-to-pay for GM rice with health benefits in a high-risk region: Evidence from experimental auctions for folate biofortified rice in China. *Food Quality and Preference, 25*(2), 87-94.

Tabachnick, B. G., and Fidell, L. S. (2007). *Using multivariate statistics* (5th ed.). Upper Saddle River, NJ: Pearson Allyn and Bacon.

Venkatachalam, L. (2004). The contingent valuation method: a review. *Environmental Impact Assessment Review, 24*(1), 89-124.

Villers, P. (2014). Aflatoxins and safe storage. *Frontiers in Microbiology, 5*(158). doi:10.3389/fmicb.2014.00158

Walker, S., and Davies, B. (2013). *Farmer perceptions of aflatoxins: Implications for intervention in Kenya.* Washington, D.C: International Food Policy Research Institute (IFPRI).

Wattage, P. (2001). *A targeted literature review - contingent valuation method.* University of Portsmouth: Centre for the Economics and Management of Aquatic Resources (CEMARE).

Wattage, P. (2002). *Effective management for biodiversity conservation in Sri Lankan Coastal Wetlands: An estimation of economic value for conservation of wetlands.* Darwin Initiative; University of Portsmouth CEMARE.

Wattage, P., and Simon, M. (2008). Total economic value of wetland conservation in Sri Lanka identifying use and non-use values. *Wetlands ecological management, 16*, 359-369.

Widaman, K. F. (1993). Common factor analysis versus principal component analysis: Differential bias in representing model parameters? *Multivariate Behavioral Research, 28*, 263-311.

Wild, C. (2007). Aflatoxin exposure in developing countries: the critical interface of agriculture and health. *The Food and Nutrition Bulletin, 28*, S372-80.

Willis, K. G. (2002). Iterative Bid Design in Contingent Valuation and the Estimation of the Revenue Maximising Price for a Cultural Good. *Journal of Cultural Economics, 26*, 307-324.

Zapata, S. D., and Carpio, C. E. (2014). The Theoretical structure of producer Willingness To Pay Estimates. *Agricultural Economics, 45*, 1-11.

APPENDICES

Annex 1 Questionnaire

UON/KARI/IITA

Management of Aflatoxin Contamination Survey Questionnaire

INTRODUCTION

Dear Sir/ Madam,

The University of Nairobi, Department of Agricultural Economics in collaboration with KARI and IITA is interested in conducting a research survey on farmer's methods of controlling aflatoxin contamination and their perceptions and willingness to pay for a bio-product to control aflatoxins.

The objective of this study is to assess the small scale farmer's perceptions of a biocontrol product to control aflatoxin contamination in their farms. This will enable the involved stakeholders to understand their demand for the product before commercialization of the product to control aflatoxins.

The information you provide will be treated with ultimate confidentiality and used for policy purposes only. This interview will take around 30 minutes and your dedication and time will be highly appreciated. I would like to request your permission to begin the interview now.

The respondent must be an individual who normally makes farm decisions in the household. This must be the household head or the spouse.

Section A: Identification

Date of Survey (dd/mm/yy) _____/____/2014 Time started ________________________Time completed ______________________________

1) Enumerator's name: ____2) Code_________________ 3) County____________________

4) District: ____________________________________5) Division: ________________________6) Location__________________7) Sub-Location:______________________________8) Village: _________________________9) Household Head Name ____________________________

10) Respondent (s) Name __________________________ 11) Respondent's telephone number __________________________

12) Category of the Household: _____ (a = Trial, b = Control, c = Away from trial and control areas)

13 Production system: ____ (a = rainfed agriculture, b = irrigated agriculture)

14) GPS coordinates: Longitude: East_____________________

Latitude: (North/South) ____________

Altitude: Altitude MT. a.s.l MASL (_________ M)

Section B: Household Enterprises

FARM CHARACTERISTICS

15) How many parcels of land are owned and/or accessed by the household? _________and in acres? _____________Acres

16) What is the total size of all the land OWNED (in acres)? ____________________ Acres

17) Area under cultivation ___________acres. **18**) Area under grazing ____________acres. **19**) Area of homestead (s). _____________ Acres.

Provide the following information about each land parcel that the household head or his/her spouse owns and/or uses. (*1 acre = 4046.86* m^2)

	Land 01 (Where homestead is located)	Land 02	Land 03	All other Land
Size (acres)	[__ __ __]	[__ __ __]	[__ __ __]	[__ __]
How far from the homestead (km)?	[__ __ __]	[__ __ __]	[__ __ __]	
What is the type of land tenure for this parcel of land? (See CODE A: below)	[__ __]	[__ __]	[__ __]	
How was the land allocated to the different uses in the last 12 months (*specify area in* ***acres***)				
1. Maize	[__ __]			
2. Beans	[__ __]	[__ __]	[__ __]	
3. Pigeon peas	[__ __]	[__ __]	[__ __]	
4. Cowpeas	[__ __]	[__ __]	[__ __]	
5. Green grams				
6. Other (specify) annual crops	[__ __]	[__ __]	[__ __]	

CODE A: (Land tenure type)	
1. Holds a formal title or allotment letter 2. Owns but has no formal title/document (e.g. inherited) 3. Lease/Rented in	4. Has communal rights to use land (e.g. pastoral land, trust land, group land/ranch) 5. Has use of land s/he considers his/her own but that has never been allocated (squatters)

20) Which livelihood activities does the household **mainly** depend on, e.g. for provision of income, food, fees, etc.

Livelihood activity	Rank them in order of importance **Rank (1 = Most important, n = Least important)**	If **Yes,** please indicate the **proportion of monthly income in an average year, from each enterprise** which is a source of livelihood (Tick one applicable range for each enterprise)			
		Less than quarter (<25%)	Between quarter and half (25-50%)	Between half and three quarters (50-75%)	More than three quarters (>75%)
Crops					
Agribusiness (specify)					
Non-agribusiness					
Livestock *(specify the main one______________)*					
Employment (*salaried employment, casual, etc.)*					
Others *(Specify________________)*					

21) For how many years have you been involved in your main livelihood activity? ____________________years

22) How many days in a month are you normally available in the farm? _____________________days.

Section C: Variable Inputs: Provide the following information for input use on maize crop production in a NORMAL SHORT season.

Input (excluding labor) type		Did you use? 1=Yes, 2=No	Maize crop: Quantity	Maize crop: Unit (CODE B: below	Maize crop: Price/Unit	Source of Input (CODE C) below	Distance to the input source: in KM	What are the Constraints to input access (Code D)
Seed/planting material	Improved seeds	[____]						
	Local seeds	[____]						
Herbicides		[____]						
Planting fertilizer		[____]						
Top dressing fertilizer		[____]						
Organic Manure		[____]						
Foliar feed		[____]						
Irrigation water (*Tick under quantity if crop is irrigated*)		[____]						
Pre-harvest pesticides (field) /Fungicide		[____]						
Post-harvest pesticides (storage) /Fungicide		[____]						

CODE B: Output units			CODE C: Source of input	CODE D: Constraints to input access if any
1. kg 2. 50-kg sack 3. 90-kg sack 4. 130-kg sack 5. 1-litre	6. 2-kg tin (gorogoro/kasuku) 7. 10-kg debe/bucket 8. 15-kg debe/bucket 9. Tonnes 10. Donkey carts	11. wheelbarrows 12. pick-up 13. Others	1. Own seeds 2. Open market Centre 3. Agro vets 4. Gov't (AFC) 5. Donations from NGOs 6. Friends 7. Others (specify)	1. None 2. High prices 3. Distance to input market 4. Poor quality of inputs 5. Lack of access to inputs at the right time 6. Others (specify)

Variable inputs: Provide the following information for input use on maize crop production in a NORMAL LONG season (*USE CODES BELOW*)

Input (excluding labor) type		Did you use?	Maize crop			Source of Input (CODE C) below	Distance to the input source: in KM	What are the Constraints to input access (Code D)
		1=Yes, 2=No	Quantity	Unit (CODE B: below	Price/Unit			
Seed/planting material	Improved seeds	[____]						
	Local seeds	[____]						
Herbicides		[____]						
Planting fertilizer		[____]						
Top dressing fertilizer		[____]						
Organic Manure		[____]						
Foliar feed		[____]						
Irrigation water (Tick under quantity if crop is irrigated)		[____]						
Pre-harvest pesticides (field) /Fungicide		[____]						
Post-harvest pesticides (storage) /Fungicide		[____]						

CODE B: Output units			**CODE C: Source of input**	**CODE D: Constraints to input access if any**
1. kg 2. 50-kg sack 3. 90-kg sack 4. 130-kg sack 5. 1-litre	6. 2-kg tin (gorogoro/kasuku) 7. 10-kg debe/bucket 8. 15-kg debe/bucket 9. Tonnes 10. Donkey carts	11. wheelbarrows 12. pick-up 13. Others	1. Own seed 2. Open market Centre 3. Agro vets 4. Gov't (AFC) 5. Donations from NGOs 6. Friends 7. Others (specify)	1. None 2. High prices 3. Distance to input market 4. Poor quality of inputs 5. Lack of access to inputs at the right time 6. Others (specify)

SECTION D: USE OF FAMILY AND HIRED LABOUR FOR FARM –RELATED ACTIVITIES

23) Do you use hired labour? [____] (1=Yes, 2=No)

Provide the information by gender on number of people involved in maize production activities on your farm for a normal year

Maize Production activities (Normal year)	**Family labour**						**Hired labour**					
	Male		**Female**		**Children (< 18 yrs.)**		**Male**		**Female**		**Children (< 18 yrs.)**	
	No.	Days	No.	Days	No.	Days	No.	Days	No.	Days	No.	Days
Maize Production												
Average wage rate (per day)												

***Average wage rate is irrespective of the season*

Section E: Other Inputs and Services

(ii) *Extension services*

24) Did you get any crop extension services in a normal year? ________ (1=Yes, 2=No)

25) If you accessed extension services, provide information on the type you used and your level of satisfaction

What was the type of service?	**Who was the main provider? *(codes E below)***	**Who in the household accessed? Code F**	**Level of satisfaction of use (*codes G below*)**
Crop production extension service	[____]	[____]	[____]
Animal production extension services			
CODE E		**CODE F**	**CODE G**
1. Public extension agent 2. Private extension 3. Coops/Farmer Associations/CBOs 4. NGO	5. FBO 6. Farmers (paid)	1. Adult male, (>35 yrs.) 2. Adult female (>35 yrs.), 3. Youth Male (18-35) 4. Youth Female (18-35)	1=Very dissatisfied 2=Dissatisfied 3=Neutral 4=Satisfied 5=Very Satisfied

iii) **Access to Credit -** Credit / loan/ in kind loan (e.g. planting seeds, fertilizer, pesticides, etc.)

26) Did any member of the household (18 years old and above) obtain agricultural credit in a normal year? [____] (1= Yes, 2=No)

If yes, provide the following details

Household member who accessed credit	**Main Source of agricultural loan (*see H below*)**	**Amount borrowed (KES)**	**What was the interest rate for the loan (%)**	**Main Purpose of Loan (*see I below*)**	**HHH Satisfaction with credit services *(see J)***
________________ [____]	[____]			[____]	[____]
________________ [____]	[____]			[____]	[____]
________________ [____]	[____]			[____]	[____]

CODE H: Source of Loan		**CODE I: Purpose of Loan**		**CODE J: Satisfaction level**
1. Micro-finance institution 2. Commercial banks 3. Cooperatives 4. NGOs 5. Government credit schemes	6. Agricultural Finance Corporation 7. Local money lender 8. Group/Table banking 9. Family and friends 10. Contractual outgrower arrangements	1. Purchase farm inputs (e.g. seeds, fertilizers etc.) 2. Buy livestock 3. For marketing and value addition activities	4. Buy land 5. Construction of farm structures 6. Buy machinery and equipment 7. Payment of labor costs 8. Irrigation facilities	1=Very dissatisfied 2=Dissatisfied 3=Neutral 4=Satisfied 5=Very Satisfied

27) Was there **any loan** used in maize enterprise? _____________ (1=Yes, 2=No),

28) Has all the cash loan been repaid? ____ (1=Yes, 2= No)

Section F: Market Outlets Section (*for both seasons where it applies*)

Output and disposal of maize crop

Maize crops	Total harvested	Units of measurement CODE K below	Sold		Total given away	Total fed to livestock	Total spoilt/ infected	Total consumed (compute)	If sold, the source of Market (CODE L below)	Distance from your farm to the market/place where sold
			Quantity sold	Farm gate Price at harvest (KES/unit given)						
Maize production		[____]								

CODE K: Output units			CODE L: Market
1. Kg 2. Pieces 3. 50-kg sack	4. 90 - kg sack 5. Tonnes 6. 2-kg tin (gorogoro /kasuku)	7. 10-kg debe 8. 15-kg debe 9. Donkey carts	1. Open market centre 2. NCPB 3. Private buyers 4. Schools, hospitals

29) Do you normally sell your maize after harvest? _____ (1=Yes, 2= No), If **YES,** go to **30**
If NO, why? ____

30) Do the buyers offer uniform prices regardless of the quality of maize offered even if contaminated with aflatoxin or infested by insects? _____ (1 = Yes, 2 = No)

31) Do you think if the prices were offered according to the maize quality that could lead farmers to adopt more improved aflatoxin management technologies that would aim to improve the maize quality? ________ (1 = Yes, 2 = No)

32) Do you normally sell your maize product through prior arrangement (contract agreement) with any of the buyers? ________ (1=Yes, 2=No)
If **YES** with whom contractual agreement was made (**CODE M below**) _____________

CODE M: (With whom contractual agreement was made)		
1. Cooperatives 2. Public institutions 3. Private institutions (schools, hospitals, etc.)	4. Traders (brokers, hawkers) 5. Individual consumers 6. Processors (for human and animal products etc.)	7. Hotels 8. Supermarket chain

Section G: Maize Losses

33) Have you had Maize losses due to the following factors during the last 12 months/season? If **YES** please indicate the intensity (1=sometimes, 2= often, 3=always)

Cause of loss	Did you encounter loss from this cause (*tick appropriately)*		If YES, indicate the frequency (1=sometimes, 2=often, 3=always)	If **YES** at what stage (1 = field, 2 = Storage, 3 = Both (field and storage)
	Yes	No		
Disease				
Insects				
Drought				
Floods				
Destruction by animals				
Other factor (please specify)				

Section H: Farmers awareness and perceptions of a bio-product to control aflatoxins

34) Are you aware of any bio-product to control aflatoxins in maize? _________ (1=Yes, 2=No)

35) Please give your opinion on how you perceive or would perceive a bio-product to control aflatoxins on scale of 1 to 5 (Likert scale) (where 1=strongly disagree, 5=strongly agree). (*Tick one box*)

Statement	**1 = Strongly disagree**	**2 = Disagree**	**3 = Unsure**	**4 = Agree**	**5 = Strongly agree**
i) I consider maize diseases as a serious problem in farming?					
ii) The most serious challenge to maize production is aflatoxin contamination?					
iii) I am satisfied with the current aflatoxin control programmes?					
a) Basic product Design					
i) Do you think a bio-product will be safe for use and will not cause sickness to human health?					
ii) Do you think the bio-product can help in reduction of aflatoxin contamination that has been witnessed in the region?					
iii) Do you think a bio-product is a GMO?					
iv) Do you think the sorghum (carrier) material used for the bio-product can grow on the farm as a weed?					
v) Do you think this bio-product is a foreign material which should not be used in the farmer's farms?					
vi) Do you think that this bio-product can harm other beneficial micro-organisms not initially targeted causing more harm than good?					
vii) Do you think this bio-product will offer real solution to the recurring aflatoxin contamination problem?					

b) Delivery characteristics					
Statement	**1 = Strongly disagree**	**2 = Disagree**	**3 = Unsure**	**4 = Agree**	**5 = Strongly agree**
i) Do you think the distribution of the bio-product should be left to the private sector for effective distribution?					
ii) Do you think there is need to educate farmers why aflatoxin is an important problem and application of a bio-product?					
c) Ease of usage					
i) Do you think bio-product use is difficult and will always require assistance from extension officers?					
ii) Do you think there will be need for promotion of the product to create awareness and demand for the product among the farmers?					
iii) Do you think counterfeiting of the product can be a serious problem (could there be toxigenic fungi packaged and sold as a biocontrol to farmers in future) leading to farmers incurring loss?					
d) Social and environmental acceptability- is the use of this bio-product socially, culturally and environmentally sustainable and acceptable;					
i) Do you think use of this bio-product will go against any culture or beliefs?					
ii) Do you think use of this bio-product can cause environmental pollution?					

Section I: Pricing of a bio-product to control aflatoxin

36) Have you ever experienced aflatoxin contamination on your maize crops, either in the field or in the store? _____ (1=Yes, 2=No)

37) Which method(s) do you use to control aflatoxin contamination? (Codes given)

Pre-harvest method (PH)	**Post-harvest Method**	**Novel Methods (NM)**	**None**	**Action taken in case of maize disease/ outbreak**
CODES M 1. Use of Fungicide (note its name) 2. Crop rotation 3. Use of resistant cultivars 4. Harvesting at maturity 5. Timely planting 6. Maintaining optimal plant densities 7. Controlling other plant weeds and densities	**CODES N** 1. Use of Fungicide (note its name) 2. Rapid drying on platforms to avoid contact with soil 3. Appropriate shelling methods to reduce grain damage 4. Sorting of infected maize 5. Use of clean and aerated storage structures 6. Controlling insect damage 7. Avoiding long storage periods	**CODES O** 1. Use of bio-products e.g. bio-fungicides		**CODES P** 1. Uproot and burn the plant/crop 2. Uproot and feed animals 3. Uproot and leave on the ground 4. Does nothing

38) Have you **EVER** HEARD of a bio-product being used to control aflatoxin? ____________ (1=Yes, 2=No).
39) If YES, from where/ who did you hear it first?

____

40) Have you **EVER USED** the bio-product in **Q38** in aflatoxin control? ____________ (1=Yes, 2=No)

Questions below to be answered by treatment and control farmers only

(NOW the farmers should be reminded of the experiments of IITA but the above answers should remain as stated by the respondent)

41) Would you be willing to use the biocontrol product in your farm in future? ________ (1=Yes, 2= No)
    If **NO, why**? ____

42) If **Yes** in (**Q 41**) above would you be willing to pay for the biocontrol product you mentioned having used (for trial farmers) or heard of (for control farmers) if it is offered in the market by agro-dealers at **Ksh 130 per kg**. Remember you will use your own cash or buy through credit from agro-dealers and repay after crop sales. ((*Applies to those who have* ***used*** *the Bio-product in trials and the control farmers*). __________ (1=Yes, 2=No)
(*Use ksh 130/kg as the base, use ± (increment or decrement of) ksh 20 as the bid until you reach the maximum (or minimum) amount that the farmer would be willing to pay*).
If for the bid in **Q 42** is **YES**, increase the *130/kg* bid by Ksh 20 until you reach the highest bid he/she is willing to pay. Record this highest bid______
If for the bid in **Q 42** is **NO,** decrease the *130/kg* bid by Ksh 20 until you reach the lowest bid he/she is willing to pay and record_____________________

Question 43 below is for farmers outside the trial and control areas. **A hypothetic scenario for eliciting WTP for the bio-product to control aflatoxin**

43) Maize production supports the livelihood of your household in various ways. However, frequent occurrence of aflatoxins in maize causes significant losses in maize yield and income. It also cause health problems such as cancer, stunted growth in children and even death under severe cases as witnessed in 2004 in which 317 people died. The use of the biocontrol product will reduce aflatoxin related health issues and deaths, increase productivity, quality and marketability of maize. The biocontrol product is in use in USA and Nigeria and has been tested in Kenya with positive results. The biocontrol product is developed by scientists and it reduces the contamination by about 90% giving both single-season crop and long-term influences on the average aflatoxin-producing potential of fungal communities resident in target areas. Suppose this product was to be introduced in the market and you were to purchase it using your own cash or through credit by agro-dealers but expected to pay later after harvest, would you purchase it if it was offered at Ksh 130/kg? _________ (1=Yes, 2= NO)
(*Use ksh 130/kg as the base, use ± (increment or decrement of) ksh 20 as the bid until you reach the maximum (or minimum) amount that the farmer would be willing to pay*).
If for the bid in **Q 43** is **YES**, increase the *130/kg* bid by Ksh 20 until you reach the highest bid he/she is willing to pay. Record this highest bid ___________
If for the bid in **Q 43** is **NO**, decrease the *130/kg* bid by Ksh 20 until you reach the lowest bid he/she is willing to pay. Record this bid ______________

CODE Q: (RELATIONSHIP TO HHH)	**CODE R: (HIGHEST EDUCATION)**	**CODE S: (PRIMARY OCCUPATION)**
1. Head 2. Spouse 1 3. Spouse 2 4. Spouse 3 5. Spouse 4 6. Parent 7. In laws 8. Child 9. Grandchild 10. Employee 11. Other	1. None 2. Standard 1 3. Standard 2 4. Standard 3 5. Standard 4 6. Standard 5 7. Standard 6 8. Standard 7 9. Standard 8 10. Form 1 11. Form 2 12. Form 3 13. Form 4 14. Form 5 15. Form 6 16. Craft/vocational/ Certificate 17. Diploma 18. Higher National Diploma 19. University	1. Crop farming (incl. food & cash crops; feed & fodder; gardening/vegetable and fruit production) 2. Livestock keeping (incl. camel, cattle, sheep & goat and renting out livestock for draft power/breeding) 3. Poultry keeping 4. Mixed farming 5. Livestock and livestock product trading 6. Trading in non-livestock agricultural products (e.g. groundnuts) 7. Formal salaried employment (incl. civil servant, private sector employee, non-farming labourer, domestic work in external house) 8. Livestock herder 9. Self-employed business - trade (non-ag., e.g. small shop owner, includes natural products - charcoal, firewood, water, roadside grass etc.) 10. Self-employed business – services (non-agricultural., e.g. carpentry, barber, healer, dress-making, etc.) 11. Farm labourer on other farm 12. Farm worker on household farm 13. Mining (quarry, minerals etc...) 14. Fisherman 15. Fish trading 16. Old/Retired /Pensioner 17. Domestic work in own home 18. Not working/unemployed 19. Infant \ child < 7 years 20. Student/ pupil

Section J: HOUSEHOLD SOCIO ECONOMIC CHARACTERISTICS

44) Household type (Select only one)

[_] Male headed and managed [_] Male headed, female managed (wife makes most household/agricultural decisions)

[_] Female headed and managed [_] Child headed (below age 18)/Orphan

Provide the demographic characteristics of household members (Include students, but don't include employed children not residing or depending on the household). *A household is a group of people who cook together and eat together and drawing food from a common source – share resources together. Family members who work away or are not dependent on the household for at least 6 months are excluded. (For this purpose, household members are not necessarily the same as family members).*

Fill the table each column downwards before moving to the next column

ID	**Full Name of household member (Start with household head)**	**Year of birth (e.g. 1948)**	**Sex of this person? *(1=Male 2=Female)***	**Relationship to current HHH *(Q)***	**Highest level of education completed *(R)***	**Primary occupation (only one) *(S)***
MEMID	**NAME**	**Yborn**	**Sex**	**rshead**	**heduc**	**Hpract**
1						
2						
3						
4						
5						
6						
7						
8						

MEMBERSHIP IN AGRICULTURAL ASSOCIATIONS

45) Did any member of this household belong to an **agricultural** group/association in a normal year? [__ __] (1 = Yes, 2 = No)

46) If yes, provide the following information for the three main groups

	Who in your household is a member of an agricultural group	**Type of group *(See T below)***	***Categorize group (See U below)***	**What main commodity does the group deal in? (*See V below)***	**Main activity of group (*See W below*)**	**Is the group registered? (*1=Yes ; 2= No*)**
1	[_____]	[_____]	[_____]	[_____]	[_____]	[_____]
2	[_____]	[_____]	[_____]	[_____]	[_____]	[_____]
3	[_____]	[_____]	[_____]	[_____]	[_____]	[_____]

CODE T: (TYPE OF GROUP)	**CODE U: GROUP CATEGORIES**	**CODE V: COMMODITY FOR GROUP**	**CODE W: GROUP ACTIVITY**	
1. Producer 2. Cooperative/ Society 3. Marketing 4. Producer and Marketing 5. Processing 6. Water users associations 7. Labor groups 8. Environmental management group 9. Nutrition support groups	1. Women group (majority of members are women >35 years) 2. Men Group (majority of members are men >35 years) 3. Youth Group (if majority of members are between 18-35 years) 4. Mixed Group (with approximately equal number of men and women >35 years)	1. Crops 2. Livestock 3. Fish 4. Tree nurseries Other (specify) -----	1. Produce marketing 2. Input access/marketing 3. Seed production 4. Farmer research group 5. Savings and credit 6. Tree planting and nurseries 7. Soil & water conservation	8. Input credit 9. Water resource management 10. Communal labor provision 11. Environmental management e.g. conflict management, grazing land management 12. Utilization of farm produce 13. Processing

47) Please indicate the approximate average monthly household income from all sources.

Income Category	**Tick One**
Ksh 10,000 or less	
Ksh 10,001 to Ksh 20,000	
Ksh 20,001 to Ksh 30,000	
Ksh 30,001 to Ksh 40,000	
Ksh 40,001 to Ksh 50,000	
Ksh 50,001 to Ksh 100,000	
Above Ksh 100,000	

THANK YOU SO MUCH FOR YOUR TIME

Annex 2.1: Factors influencing WTP for Aflasafe KE 01 for the Tana River households

OLS Regression model estimates

Dependent variable: Max WTP			
Variables	**Coeff.**	**t-value**	**P-value**
Constant	107.77	1.30	0.217
Extcon	30.51	2.13	0.053*
CreditAcc	36.94	2.89	0.013**
Hhsiz	-3.10	-1.74	0.100*
Aflaconta	-2.36	-0.10	0.924
DistMkt	3.32	0.56	0.585
PercEffective	-15.56	-2.03	0.064*
MbrAgric	-8.67	-0.62	0.545
Hhinc	-1.25	-0.15	0.881
HEDUC	-0.05	-0.03	0.974
Disease	8.96	0.67	0.515
Gender	-9.50	-0.85	0.408
Experience	-0.89	-1.79	0.097*
Occup	-0.52	-0.03	0.977
Bura	20.98	1.86	0.086*
AreaCult	-2.43	-0.41	0.688
Initamt	79.31	7.83	0.000***
Number of obs.			30
F(16,13)			10.30
Prob.>F			0.0001
Adjusted R-squared			0.8369
Root MSE			21.01

Note: *, ** and *** implies statistically significant at 10%, 5% and 1% respectively

Annex 2.2: Factors influencing WTP for Aflasafe KE01 for the Lower Eastern trial households

OLS Regression model estimates			
Dependent variable: Max WTP			
Variables	**Coefficient**	**t-value**	**P-value**
Constant	3.27	6.94	0.000***
Extcon	0.06	0.85	0.395
CreditAcc	0.21	1.87	0.064*
Hhsiz	-0.02	-1.19	0.235
AwareBio	0.11	0.91	0.363
CntrtAgrmt	0.16	1.43	0.156
DistMkt	-0.003	-0.26	0.792
MbrAgric	0.10	1.35	0.179
Hhinc	0.08	1.90	0.061*
Prodn	0.002	0.91	0.363
HEDUC	-0.004	-0.46	0.643
Gender	-0.10	-1.34	0.183
Experience	-0.01	-1.90	0.060*
Age	0.01	2.23	0.028**
Occup	-0.004.	-0.05	0.959
AreaCult	0.01	1.26	0.211
Tenure	-0.06	-0.78	0.435
Initamt	0.973	14.74	0.000***
Number of obs.			129
F(17,111)			15.77
Prob.>F			0.000
Adjusted R-squared			0.6623
Root MSE			0.3489

Note: *, ** and *** implies statistically significant at 10%, 5% and 1% respectively

Source: Survey data, 2014

Annex 2.3: Factors influencing WTP for Aflasafe KE 01 for the non-trial Lower Eastern farmers' categories

OLS Regression model estimates			
Dependent variable: Max WTP			
Variables	**Coefficient**	**P-value**	**t-value**
Constant	4.02	0.000***	15.03
Extcon	0.01	0.851	0.19
CreditAcc	0.21	0.020**	2.33
Hhsiz	-0.03	0.001***	-3.42
AwareBio	0.19	0.023**	2.29
CntrtAgrmt	0.26	0.018**	2.39
DistMkt	-0.02	0.071*	-1.81
MbrAgric	0.02	0.698	0.39
Hhinc	0.05	0.067*	1.84
Prodn	0.0003	0.868	0.17
HEDUC	-0.005	0.316	-1.00
Gender	0.07	0.089*	1.71
Experience	-0.002	0.181	-1.34
Occup	0.061	0.260	1.13
AreaCult	0.0003	0.983	0.02
Tenure	0.023	0.576	0.56
Initamt	0.898	0.000***	23.28
Number of obs.			313
F(16,269)			43.03
Prob.>F			0.000
Adjusted R-squared			0.6831
Root MSE			0.3231

Note: *, ** and *** implies statistically significant at 10%, 5% and 1% respectively

Source: Survey data, 2014

Annex 3: Variance Inflation Factors, test for heteroskedasticity and RESET test

3.1: VIF and test for heteroskedasticity for Tana River County

VARIABLE	VIF	1/VIF
Access to crop extension	3.50	0.2858
Experienced aflatoxin contamination	3.21	0.3119
Perception of product effectiveness	3.12	0.3200
Membership to agricultural group	3.07	0.3257
Distance to market	3.05	0.3283
Experienced maize loss to diseases	3.04	0.3291
Education	2.65	0.3777
Household size	2.59	0.3868
Credit use	2.47	0.4045
Main occupation of the house-head	2.44	0.4102
Area under cultivation	2.33	0.4299
Income	2.27	0.4411
Gender	2.09	0.4784
Bura	2.08	0.4798
Experience	1.98	0.5052
Initial bid amount	1.71	0.5834
MEAN VIF	2.60	

Test for heteroskedasticity

Breusch-Pagan/ Cook-Weisberg test for heteroskedasticity
χ^2 (1) = 0.66 Prob > χ^2 = 0.4155

Ramsey RESET test

Ramsey RESET test
F (3,10) = 1.69 Prob > F = 0.2309

3.2: VIF and test for heteroskedasticity for Lower Eastern trial farmers

VARIABLE	VIF	1/VIF
Age	2.26	0.4434
Experience	1.98	0.5048
Education	1.68	0.5968
Area under cultivation	1.48	0.6735
Membership to agricultural group	1.31	0.7646
Gender	1.30	0.7700
Land tenure	1.29	0.7728
Maize production	1.26	0.7963
Access to crop extension	1.25	0.8003
Household size	1.24	0.8036
Occupation	1.22	0.8168
Credit use	1.20	0.8304
Awareness of bio-pesticide	1.15	0.8713
Initial bid amount	1.15	0.8718
Income	1.14	0.8741
Contract agreement	1.09	0.9214
Distance to market	1.05	0.9496
MEAN VIF	1.36	

Test for heteroskedasticity

Breusch-Pagan/ Cook-Weisberg test for heteroskedasticity
χ^2 (1) = 1.14
Prob > χ^2 = 0.2850

Ramsey RESET test

Ramsey RESET test
F (3,108) = 1.98
Prob >F = 0.1215

3.3: VIF and test for heteroskedasticity for Lower Eastern non-trial Farmers

VARIABLE	VIF	1/VIF
Maize Production	1.33	0.7506
Area under cultivation	1.28	0.7812
Membership to agricultural group	1.28	0.7829
Access to crop extension	1.27	0.7846
Experience	1.23	0.8112
Land tenure	1.18	0.8480
Contract agreement	1.18	0.8494
Gender	1.14	0.8784
Credit use	1.12	0.8890
Income	1.12	0.8933
Household size	1.12	0.8938
Education	1.12	0.8952
Awareness of bio-pesticide	1.11	0.8976
Occupation	1.10	0.9060
Initial bid amount	1.10	0.9075
Distance to market	1.06	0.9390
MEAN VIF	**1.17**	

Test for heteroskedasticity

Breusch-Pagan/ Cook-Weisberg test for heteroskedasticity
χ^2 (1) = 4.53
Prob> χ^2 = 0.2333

Ramsey RESET test

Ramsey RESET test
F (3,293) = 2.05
Prob >F = 0.1076