EFFECTS OF SOCIAL LEARNING IN ADOPTION OF AFLATOXIN REDUCTION INTERVENTIONS: A CASE OF MAKUENI COUNTY

BY

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DECLARATION

This proposal is my original work and has not been submitted for a degree to any other University.

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DEDICATION

This work is dedicated to,

My mother, my inspiration and who taught me the virtues of hard work, persistence and faith.

My sisters and brother for pushing me beyond my limits.

My family, words cannot express the love you have shown me as I pursued my studies. Thank you for the moral support and prayers.

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ABSTRACT

The adoption of Aflatoxin Reduction Interventions (ARIs) is facing a new challenge when being adopted in Africa than in other continents, worldwide. There is a growing consensus that modern Aflatoxin Reduction Interventions (ARIs) in Africa, more particularly Kenya has faced socio- economic and cultural challenges. Adoption of Aflatoxin Reduction Interventions (ARIs) is a social, cultural and economic challenge and there is a socio-economic need towards solving the aflatoxin problem. In Kenya, Makueni County, small holder farmers struggle to pursue solution for a contamination that has no 'cure.'

The broad objective of the study was to identify and evaluate how social networks determine farmer's choice in adoption or rejection of Aflatoxin Reduction Interventions in Makueni County. It was guided by the assumption that social networks would be the source of interactive and adaptive learning where knowledge, ideas, trust and collective action facilitates adoption of Aflatoxin Reduction Interventions. The specific objectives of the study were to: analyze how social networks manifest among small holder farmers in Makueni County; analyze how small holder farmers adopt Aflatoxin Reduction Interventions in Makueni County and examine the influence of social networks in small holder farmers' capacity through accessibility and utilization of Aflatoxin Reduction Interventions.

Data was obtained from field survey in Mukuyuni sub-location. The study employed semi-structured questionnaire in a stratified sample of 100 small holder farmers. Stratified sampling was employed in identifying 8 starting points for the villages in a population of 8,500 within Mukuyuni sub-location. This was complimented with 2 key informants and 2 focus group discussions. In analysis, frequency and cross tabulation statistics was calculated using Statistical Package for Social Sciences (SPSS). In addition, thematic analysis was employed for qualitative data through allocating themes in Microsoft excel (Ms- Excel).

According to analysis, social networks are sources of social learning. They manifest in formal, personal and close social ties. Farmers in these networks are able to share ideas and knowledge more efficiently as well as rationalize them according to their own experiences. Traditional aflatoxin reduction interventions are adopted more than the modern interventions. Traditional ARIs are good agricultural practices but do not directly control of aflatoxin despite their use.

Low adoption of modern interventions is brought about by high level of uncertainty, cost in accessing and applying the intervention and lack of knowledge in facts about the aflatoxin problem and how to apply modern aflatoxin reduction intervention. Social networks do influence small holder farmers' capacity to adopt through increased knowledge about the use and effects of Aflatoxin Reduction Interventions; transfer of interactive and adaptive knowledge about aflatoxin and ARIs in a household even where there is incomplete information. There is a need of new aflatoxin reduction interventions that are preventive and promote an integrated approach.

Given the findings of the study, the study recommends: a policy reform on food safety; capacity building that promotes interactive and adaptive learning and partnership in the promotion of aflatoxin reduction interventions.

LIST OF ACRONYMS

AFI	Aflatoxin Reduction Interventions
AgGDP	Agricultural Gross Domestic Product
ARS	Agricultural Research Service
CAST	Council for Agricultural Science and Technology
HAI	Household Agricultural Income
IITA	International Institute of Tropical Agriculture
IFPRI	International Food Policy Research Institute
ISID	International Society for Infectious Diseases
KALRO	Kenya Agricultural and Livestock Research Organization
PACA	Partnership for Aflatoxin Control in Africa
USDA	United States for Department of Agriculture

1.0 CHAPTER ONE: INTRODUCTION

1.1 Background to the Study

Aflatoxin[1] contaminations have led to increased vulnerability in health of the population, particularly farmers and infants (Cardwell & Henry,2005; IFPRI, 2013; Shepherd, G. ,2005). In addition, maize producers and consumers affected by aflatoxin contamination have faced a decline in food production and nutritional levels in food and feeds; resulting to economic losses in tradable agricultural commodities such as maize and groundnuts. African countries including Kenya, Mozambique, Nigeria, Senegal, South Africa, Burkina Faso, Cameroon, Gambia, Ghana, Guinea and Zambia; have made losses of up to $ 1.2 billion dollars from aflatoxin contamination (Science Africa, 2010). Among African farmers, the aflatoxin problem has worsened resulting to deaths. Farmers' exposure to low levels of contamination is not immediately obvious. Minimal amounts of aflatoxin has an invisible physical characteristic (Cardwell & Henry, 2005) and becomes a hazard to populations with limited knowledge on how to detect and screen for contamination at the farm level.

There are global concerted efforts to manage aflatoxin at the farm, industrial and national level since 1960s (CAST, 2003). Developed countries ensure food safety through Sanitary and PhytoSanitary standards such as Codex regulations. The annual regulatory cost of aflatoxin management in the United States is $20–$50 million U.S. dollars (Robens and Cardwell, 2005).The high regulatory and monitoring costs has lead to non-compliance in African countries (World Bank, 2007; Cardwell & Henry, 2005). Instead, African countries manage aflatoxin at the farm level through traditional and modern Aflatoxin Reduction Interventions; both referred as either primary agricultural intervention (Wu and Khlangwiset, 2010) or crop management systems (Shier *et al.*, 2005). Adoption studies including contributors such as Robens and Cardwell, 2005; van Egmond & Jonker, 2005; Cardwell & Henry, 2005; and Shepherd, G., 2005 associate managing aflatoxin with improving the well-being of the population through food safety and public health.

[1] Aflatoxin is toxic secondary fungal metabolites that contaminate foods, feeds and can cause sickness such as immunosuppression or death in humans and animals. Aflatoxin B1 (AFB1), a known human carcinogen, is the most potent and potentially lethal (CAST, 2003).

Currently, Kenya has had new developments in modern interventions such as Aflasafe KE01. Aflasafe KE01 is still under pilot stage by the International Institute of Tropical Agriculture (IITA) and Kenya Agricultural and Livestock Research Organization (KALRO) as well as other external partners such as Agricultural Research Service (ARS) of USDA, Melinda and Gates Foundation, African Agricultural Technology Foundation and Partnership for Aflatoxin Control in Africa. There is no single effective method, either traditional or modern; hence there is need for an integrated approach to interventions.

Despite the aflatoxin problem since 1981 in Kenya and the widely investigated interventions such as genetically modified seeds, the adoption in Sub- Saharan Africa is low (Marecherwa and Ndigwa, 2014). Populations are still exposed to levels of aflatoxins. Several literature investigates why small holder farmers are not adopting by investigating farmers' attitudes towards these interventions (Marecherwa & Ndwiga, 2014) and which kind of incentives that producers need to maximize and utilize the most effective interventions for high agricultural productivity, improved food security as well human productivity (Wu *et al*., 2008). This current study moves from existing narrative that farmers' attitudes influence adoption to investigate farmers' social learning in determining why some farmers are not adopting traditional and modern interventions while other farmers are adopting.

The study site was Makueni County due to existence of two factors: highest contamination of aflatoxin in crops (ISID, 2001; ISID, 2004) and traditional and modern interventions. Makueni County is located in the lowlands of southeastern Kenya with a population of 253,316 people in 52,004 households (KNBS, 2013). It covers 8,034.7 kilometer squared and borders Kajiado County to the west, Taita- Taveta County to the south, Kitui County to the east and Machakos County to the North (GoK, 2013). Agriculture is the predominant source of livelihood in the county which contributes to Agricultural Gross Domestic Product (AgGDP) of approximately Kshs. 10,234 million. Each Household Agricultural Income (HAI) contributes approximately Kshs. 20,000 which is equivalent to 22% of the total household income and Kshs. 1,506 HAI per acre (Ndiritu et al., 2004). Further, the County is characterized by falling food production and low resilience to climate change further reinforcing poverty and food insecurity (KNBS and UNICEF, 2009).

The potential implication of the study in Makueni ensures the contribution made on the determinants of adoption in managing aflatoxin can be replicated to other contaminated areas in Kenya and other developing countries.

1.2 Statement of the problem

One major problem is that the adoption of aflatoxin reduction intervention is low (Marecherwa and Ndigwa, 2014; Wu *et al.,* 2008). In addition, the adoption is lower among small holder farmers despite the high health risks of cancer and death in South Eastern part of Kenya.

There is evidence of aflatoxin poisoning among small holder farmers since 1981 until 2004 (ISID, 2004). Small holder farmers are mainly subsistence farmers with unequal social economic stratifications hence their preference towards adopting an intervention is influenced by their capacity to access and utilize interventions. Further, it is influenced by farmers' prior knowledge of intervention which shapes attitudes whether to adopt or reject the interventions (Marecherwa and Ndigwa, 2014). These inequalities in exposure and vulnerability result to disparities in attitudes and adoption practices. Literature shows that traditional Aflatoxin Reduction Interventions are locally available to the farmers (Hell and Mutegi, 2011; Fandohan *et al.*, 2005) in Makueni county (Nzioki, 2016). However, modern interventions are more effective than traditional but not economically viable for farmers who have limited financial resources (Plasencia, 2005). Conclusively, good agronomic practices and appropriate traditional or cultural methods are simple (Hell et al., 2008) and cost effective interventions at the farm level. It is clear that the aflatoxin problem still persists despite widely investigated recommendations.

There are no studies that show how social and adaptive learning is a determinant of choice in improving the low adoption and adopting either simple, cost effective interventions or complex, highly technical and effective modern interventions at the farm level. Literature shows that farmers' uncertainty can be reduced by communal ownership but we are yet to understand how such communal participation among other elements of interactive and adaptive learning can improve low adoption in vulnerable populations.

1.3 Research questions:

This study seeks to investigate the how social networks among small holder farmers influence their capacity to adopt or reject Aflatoxin Reduction Interventions in Makueni County?

To answer this broad question, the following specific questions will be addressed:

(i) How do social networks manifest among small holder farmers in Makueni County?
(ii) How do small holder farmers adopt Aflatoxin Reduction Interventions in Makueni County?
(iii) How do these social networks influence small holder farmers' capacity to access and utilize Aflatoxin Reduction Interventions in Makueni County?

1.4 Objectives of the Study

This study seeks to identify and evaluate how social networks determine farmer's choice in adoption or rejection of Aflatoxin Reduction Interventions in Makueni County.

This study will be guided by the following specific objectives:

(i) To establish how social networks manifest among small holder farmers in Makueni County.
(ii) To establish how small holder farmers adopt Aflatoxin Reduction Interventions in Makueni County.
(iii) To examine how social networks influence small holder farmers' capacity through accessibility and utilization of Aflatoxin Reduction Interventions.

1.5 Justification of the Study

The knowledge of how social networks lead to adoption or rejection of the interventions will guide setting up incentives on interactive learning for improving adoption of Aflatoxin Reduction Interventions. The study contributes to farmer-centered approaches to development introduced in the early 1900s and in participatory development agenda by providing guidance to governments and the international community on designing and implementing technologies that reflects farmers' learning capacity to cope with the adoption process. The capacity of the farmer to cope with knowledge and uncertainty of the interventions are the primary factors that influence behavior change.

The findings of the study make recommendations to development responses in the diffusion of agricultural technology by concentrating only on building interactive learning that determine choice in adoption of interventions. Farmers' social networks is vital for demand and sustainable use of new initiatives and investments in technologies and policies made by government, private and public research institutions, regional and international donor organizations such as World Bank and partnerships such as Partnership for Aflatoxin Control in Africa (PACA); leading to farmer-centered research, innovation and development.

The study was in Makueni County where the severity of the aflatoxin problem is higher than other Counties in Kenya and more prone to occurrence of aflatoxin and interventions. Makueni represents a fragile agro-ecology with vulnerable livelihoods that are mostly dependent on agriculture. The study is significant in understanding how farmers' determine adoption of food safety interventions and agricultural innovation despite farmers' vulnerability and the existing food safety problem which has led to increased deaths (ISID , 2001; ISID, 2004) and low adoption of effective interventions (Marecherwa and Ndigwa, 2014; Wu *et al.*, 2008).

2.0 CHAPTER TWO: LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Literature Review: Introduction

This section analyzed relevant literature of managing aflatoxin and factors that determine adoption of the interventions. Literature was illustrated on four main themes that contributes to this study. In the first theme, Aflatoxin Reduction Interventions are described and related to how they contribute to managing aflatoxin in Unites States and Africa, particularly Kenya. Second theme outlined the factors that facilitate or inhibit adoption of these interventions. These interventions are described in a multi-disciplinary way, through rural livelihoods; agricultural research and development; and agricultural economics, science and technology. The fourth theme explores the debate on key gaps- social networks and their contribution to general issues and where possible, adoption of Aflatoxin Reduction Interventions. A review of these themes underlies gaps in the literature that would be the basis of further investigation.

2.2 Aflatoxin Reduction Interventions

The main objective of adopting traditional and modern Aflatoxin Reduction Interventions is to address food safety among small holder farmers. In both developed and developing countries, there are several benefits of reducing aflatoxin concentration in foods. First, it improves livelihoods by reducing financial burden on health care such as cancer and interventions (Wu *et al*., 2008). These interventions go hand in hand with increasing crop yields (Hell and Mutegi, 2011). With high production, African countries are able to comply with exports' regulations to the attractive markets (World Bank, 2007).

2.2.1 Modern Aflatoxin Reduction Interventions

A) Bio controls technologies

Kenya and Nigeria leads in the development and commercialization of Aflasafe, a bio-competitive product which contains atoxigenic strains. Aflasafe is applied once every several years to the soil before the flowering of the crop for protection of maize and groundnuts along the entire value chain, that is from field to fork. The reduction levels in aflasafe is more than 80% (Nzioki, 2016).

Other bio control methods include fertilizer use which is recommended as among appropriate agronomic practices (Hell and Mutegi, 2011; Hell *et al.,* 2005; Guo *et al.,* 2005; Cardwell and Henry, 2005 and Shier *et al.,* 2005) to support plants from water and nitrogen stress.

B) Genetically modified seeds

In developed countries, Wu & Khlangwiset (2010) and James (2003) identifies genetically modified seeds which prevents environmental agents such as insects and plant stress on maize crops further inhibiting aflatoxin contamination. Genetically modified seeds are more convenient, improves food production and maintains a cleaner environment compared to applying pesticide (James, 2003). There is higher adoption of transgenic seeds in industrial countries than developing countries.

United states were the first to adopt the seeds. By 2003, adoption of transgenic seeds increased in Argentina (main maize exporter), China, India, South Africa, Canada, Australia, Romania, Spain, Uruguay, Mexico, Bulgaria, Indonesia, Columbia, Honduras, Phillipines, Portugal, France and Germany.

Bt Corn, one of the transgenic seeds, reduces aflatoxin levels between 2.5% to 53% (Wu *et al*., 2005). In Africa, research has shown existence of non-toxigenic strain in developing new maize varieties. These strains are known to reduce aflatoxin levels in both laboratory and field trials by 70 to 99%. However, most of the improved varieties in Africa are developed to resist the environmental agents and plant stress unlike the United States who breed varieties developed with non-toxigenic strains (Hell and Mutegi, 2011).

C) Mechanized controls

Sorting by electronic sorters is most effective (Hell *et al.,* 2008) to the extend it hinders accumulation of aflatoxin, determines prices in grading hence higher income for the farmers (Hell and Mutegi, 2011).

Drying reduces moisture content in agricultural products; Less than 13% moisture content hinders aflatoxin producing fungi. Artificial drying is practiced in industrialized countries whom have advanced in agricultural technology. It involves forced air and supplemental heat of upto 70 degrees celcius (Wu & Khlangwiset, 2010).

Other artificial drying include propane fueled drier and maize driers. Maize driers are promoted by the government of Kenya and applied in Kenya (Nzioki, 2016). Aflatoxin reduction levels of artificial driers is unknown. However, artificial dryness of the grain suppresses moisture content and ultimately aflatoxin production.

There are two types of storage system, that is, temporary storage system (Hell *et al.,* 2008) and permanent storage (Fandohan *et al.,* 2005; Hell *et al.,* 2008). Farmers would manage aflatoxin more effectively by using modern and permanent storage interventions such as metal silos (Nzioki, 2016), cement bins and hermetic storage bags meant to be airtight but their adoption is slow because of the high cost of delivery.

In West Africa, mechanical shelling, particularly IITA® Sheller favors the farmers due to low labor and time cost but causes up to 3.5% of damage in grains (Fandohan *et al.,* 2006), further causing crack stress which leads to accumulation of fungi. Dehulling is more appropriate to use than mechanical shelling. Fandohan *et al.,* 2006 identifies and recommends Engelberg, Mini-PRL and attrition disc mill as mechanical dehulling methods for farmers which could potentially reduce aflatoxin levels in maize.

D) Chemical controls

Chemical controls such as herbicide reduce plant competition while insecticides reduce insect damage. Both herbicides and insecticides are effective for managing aflatoxin causal agents and accumulation (Shier *et al.,* 2005). Insecticides and prophylactic pesticides (Hell *et al.,* 2008) should be applied at the storage facility to prevent futher grain damage from weevils and sap beetles which are the most implicated paths of the fungi (Fandohan *et al.*, 2005). Chemical controls are not adopted in Kenya because of their accessibility and cost of purchase (Nzioki, 2016).

Modern interventions are complex and need of technical expertise. These interventions reduce fungi strains and inhibit aflatoxin production and accumulation either directly or indirectly. Application of fertilizer, herbicide, insecticide and pesticide; Maize driers, Metal Silos, Aflasafe and non-toxigenic maize strain under research are modern interventions applicable in Makueni County, Kenya. Table 1 below shows an inventory of appropriate modern intervetions in Kenya and their known effects on aflatoxin.

Table 1: Inventory of recommended modern ARIs and effects on aflatoxin

Modern ARIs	**Country/ Region/ Continent practiced**	**Aflatoxin Reduction levels (%)**
New maize varieties with non-toxigenic strain	Africa, Eastern Kenya (under research)	70 to 99% (Hell and Mutegi, 2011) 2.5 to 53% on Bt Corn (Wu *et al.*, 2005)
Fertilizer, Diammonium phosphate fertilizer	Global, Kenya	Unknown
Weeding through herbicide use	Global, Kenya	Unknown
Insecticides	Global, Kenya	Unknown
Pesticides	Global, Kenya	Unknown
Artificial Drying such as Maize Driers and propane fueled drier	Africa, Kenya	Unknown
Mechanized storage facility including cement bin, metal silo, and hermetic storage bags.	Africa, (Metal Silo) Eastern and Western Kenya.	Unknown
Aflasafe K01	Eastern Kenya, Burkina Faso, Nigeria, Senegal	More than 80% (KALRO & IFPRI, 2010)

Source: Hell and Mutegi, 2011; Wu et al., 2005; KALRO & IFPRI, 2010

2.2.2 Traditional Aflatoxin Reduction Interventions

There are emerging African perspectives of aflatoxin management practices that have differentiated traditional interventions from modern ones. Good agronomic practices such as applying lime, farm yard manure and cereal crop residues reduces aflatoxin levels by 50-90% (Hell and Mutegi, 2011) as well as crop rotation (Cardwell and Henry, 2005) and tillage practices (Hell *et al.,* 2005) have been shown to minimize plant stress hence confer significant levels of aflatoxin reduction.

A) Early harvesting and sanitation

In Africa, particulary Kenya, early harvesting followed by sanitation and drying is vital (Hell and Mutegi, 2011) and practiced simultaneously by preventing any or further contamination from the soil and grain. Wu & Khlangwiset, 2010; Fandohan *et al.,* 2005; Bankole and Adebanjo, 2003 identifies early harvesting as an effective first approach method to stop any fungal accumulation. Late harvesting has increased aflatoxin levels for 4 to 7 times more (Hell and Mutegi, 2011; Hell *et al.*, 2008).

B) Sorting and flotation

Sorting involves hand sorting or color sorting and flotation also known as washing. Hand sorting is mostly recommended as the best method (Wu & Khlangwiset, 2010; Bankole and Adebanjo, 2003) which can result in 40-80% reduction in aflatoxin levels (Fandohan *et al.,* 2005) but commercially impractical because it is time consuming and monotonous (Fandohan *et al.*, 2006). Sorting by hand (Hell *et al.*, 2008) has several advantages: maintains safe level of aflatoxin for consumption; the crop retains its nutritional value and more so, determines prices in grading (Hell and Mutegi, 2011).

C) Proper drying and storage

Drying and storage are the most common interventions used in Africa. Drying facilities could last 3 to 4 years if used and maintained properly (Wu and Khlangwiset, 2010). Reports proposes proper drying including natural and artificial drying and storage as interventions that could be potentially localized owing to lesser intensive labour compared to other processes (Hell and Mutegi, 2011;Wu & Khlangwiset, 2010; Shier *et al.*, 2005). Drying on a platform has the least percent occurences of the fungi (Hell *et al.*, 2008).

Aflatoxin is the most important toxin associated with storage facilities (Robens & Cardwell, 2005) and stored maize (van Egmond & Jonker, 2005) which normally produces and accumulates fungi at conducive moisture content of above 10-15 percent (Hell and Mutegi, 2011) for cereals (Hell *et al.,* 2005). Further, the growth of the fungi in storage facilities is favored by humidity above 85% (Shepherd, 2005). In Sub Saharan Africa, a granary made of bamboo materials with a thatched roof was the most appropriate storage system compared to a house with cemented floor, granary made from platform or a mud silo (Fandohan *et al.*, 2005). The storage facility should be well ventilation in order to reduce moisture level to below 15 percent. Irrespective of the storage systems, maize kernels stored on the cob with the husk had less than (<) 1.3% of aflatoxin concentration (Hell *et al.,* 2008). In addition, farmers need aerated bags such as Pic bags during transportation and in informal marketing to avoid any further contamination (Hell and Mutegi, 2011) and maintain food safety.

Storage period and the infrastructure used is important hence long period of storing grain in an aerated granary may accelerate aflatoxin production due to insects, pest and rodent damages (Hell and Mutegi, 2011). The maize weevils and sap beetles create grain wounds and spreads fungal spores causing accumulation of post-harvest aflatoxin. Other factors should be considered apart from storage materials such as sanitation and use of natural protectants. Sanitation by cleaning stores of previous harvest in preparation for the next harvest is a basic factor is maintaining storage system thereof improving conditions meant to reduce aflatoxin concentration in the storage system.

Apart from drying and storage, scientists have also proposed the use of Indigenous African plants as possible natural protectants against insect and fungal damage in storage (Shepherd, 2005). In Eastern Kenya, natural plant protectants are under pilot studies (Kiswii *et al*., 2014). So far, there is no large scale trial of the natural products (Bankole & Adebanjo, 2003) and there lacks substantial information about their efficacy (Hell and Mutegi, 2011).

D) Food Processing

Proper processing of food minimizes aflatoxin to up to 93%. Village food processing techniques in Ghana, Zambia, and Nigeria includes fermentation (Shepherd, 2005; Hell and Mutegi, 2011 and Fandohan *et al.*, 2005) and smoking (Bankole and Adebanjo, 2003). Both have reduced aflatoxin levels considerably but only fermentation is evidently practiced in Kenya in form of *Busaa* (Kirui *et al*., 2014). Natural fermentation highly reduces aflatoxin concentration by up to 93% (Hell and Mutegi, 2011). Aflatoxin levels were lower in processed maize in mills than whole grain from farms in Machakos which had high levels of aflatoxin of at least 160 parts per billion (Muthomi *et al*., 2005) compared to acceptable consumption levels of a maximum of 4 parts per billion.

Apart from milling of maize, traditional shelling and dehulling are among other forms of milling but common in West Africa. Traditional shelling has less friction on the grain hence limited grain stress but uses more labour and time hence not appropriate for farmers. The aim of the dehullers is to remove the pericarp and the embryo from the grain where aflatoxin usually accumulates (Fandohan *et al.*, 2006) shown to reduce aflatoxin contamination by 55% (Fandohan *et al.*, 2006) – 92% (Hell and Mutegi, 2011).

Smoking is one of the common decontaminants used in Nigeria found to lower aflatoxin (Bankole & Adebanjo, 2003; Hell and Mutegi, 2011). Commercial decontaminants for stored peanuts and melon seeds and feeds are not economically viable (Hell and Mutegi, 2011).

There is no absolute intervention available for eliminating aflatoxin because of the diversity of contamination in a wide variety of crop species (CAST, 2003). Hell and Mutegi (2011) recommend immediate drying but the duration period of drying for effective prevention of aflatoxin production is unknown. Therefore, qualitative research biased to one intervention such as drying or storage facilities (Fandohan *et al.*, 2005) or transgenic maize (Wu and Khlangwiset, 2010) are incomplete and are not applicable in developing countries.

There are good agronomic and cultural practices applicable in Eastern Kenya reduces plant stress and indirectly prevents aflatoxin production and accumulation. Table 2 below lists appropriate traditional Aflatoxin Reduction Interventions applicable and their effects on aflatoxin levels which are implemented in Africa, particularly practiced in West Africa and Kenya.

Table 2: Inventory of recommended traditional interventions and effects on aflatoxin

Traditional intervention	**Country/ Region/ Continent practiced**	**Aflatoxin Reduction levels (%)**
Irrigation	Global, Kenya	Unknown
Applying lime, farm yard manure and cereal crop residues	Africa, Kenya	50-90% (Hell and Mutegi, 2011).
Manual weeding	Africa, Kenya	Unknown
Crop rotation	Global, Kenya	Unknown
Early harvest at crop maturity	Africa, Kenya	Unknown
Harvest of maize with the husk	Africa, Kenya	< 1.3%(Hell *et al.*, 2008)
Hand sorting	Africa, Kenya	40-80%(Fandohan *et al.*, 2005)
Sun drying on a platform	Africa, Kenya	98%
Drying of maize without the husk	Africa, Kenya	Unknown
Storage with continuous sanitation of storage structure	Africa, Kenya	Unknown
Store in bamboo constructed granary with thatched roof	Africa, Kenya	(24.4 ± 11.0%)(Fandohan *et al.*, 2005)
Natural fermentation	West and Eastern part of Africa	93% (Hell and Mutegi, 2011)
Traditional dehulling	Africa, Kenya	55% (Fandohan *et al.*, 2006) – 92% (Hell and Mutegi, 2011).

Source: Author's conceptualization

Both traditional and modern aflatoxin control methods function interdependently and evidently reduce aflatoxin in main African crops such as maize and groundnuts. In addition, sanitation is recommended before drying grain and also to maintain a storage facility during post- harvest period while storage is effective with prior sorting and application of insecticide on stored grains (Hell and Mutegi, 2011).

There is a growing concern to improve livelihoods through managing aflatoxin thus Table 1 and 2 above highlights interventions applicable in Kenya in which most are difficult to estimate reduction levels. Further, there is need to outline what the literature outlines about factors affecting adoption of Aflatoxin Reduction Interventions.

2.3 Determinants of adoption of Aflatoxin Reduction Interventions

The three main determinants of adoption are the different socio-economic stratifications of the adopters and the capacity to manage contaminated foods and diversify options on aflatoxin reduction intervention. In Sub- Saharan Africa, low levels of either income, literacy and food security status of the populations inhibit adoption of interventions and inhibit adoption of dietary substitutes from high risk stable foods such as maize (Hell and Mutegi, 2011).

In developing countries, approximately 80% of rural farmers (World Bank, 2007) incur all the cost of the intervention because public sector management in charge of food safety issues are unresponsive in regulating and reducing aflatoxin exposure (Robens & Cardwell, 2005). The burden of managing aflatoxin is higher among rural farmers who solely rely on one stable diet such as maize (Hell and Mutegi, 2011). Farmers pay for excessive moisture in storage through losses in yields hence less in consumption and income from the rejected foods (Wu *et al*., 2005). Moreover, government and commercial millers are not liable to pay for cost of excessive moisture because it outweighs benefits of trading quality commodities (Wu *et al*., 2008).

Farmers who have access to information adopt interventions (Cardwell and Henry, 2005) while farmers' uncertainty of modern interventions and their lack of knowledge on the aflatoxin problem and its interventions determines low adoption rate (Marechera and Ndigwa, 2014). It is for this reason, that traditional interventions are more adopted because they require basic training and experience to adopt hence easy to understand (Shier *et al*., 2005). Farmers' uncertainty is hightened among small holder farmers who rely on maize for subsistence. Food insecure farmers are more likely to feed on contaminated stable foods than those with the capacity to diversify food thus reinforcing poverty and poor human health (Wu *et al*., 2005). Other social factors such as literacy (Cardwell and Henry, 2005) determines farmers' choices about the interventions (Marecherwa and Ndigwa, 2014). Fortunately, farmers' uncertainty could be reduced by communual ownership of resources though administering shared capital and utilization (Bankole and Adebanjo, 2003).

The characteristic of the interventions determine if they will be adopted or rejected. Traditional Aflatoxin Reduction Interventions relies heavily on the farmers to use, deliver and maintain with community resources. In traditional drying, farmers use locally made, low cost materials such as fiber mats (Wu and Khlangwiset, 2010). However, modern interventions are effective but the resources used are alien and expensive. Farmers are more likely to adopt traditional than modern interventions.

Most farmers are also aware of the need for early harvesting, but labour constraints and income to finance early harvesting activities compels farmers to harvest at inappropriate time (Bankole and Adebanjo, 2003). In West Africa, hand shelling and dehulling are generally carried out by women. Women incur losses in up to 16 days of labour per hectare and losses in productive time per hour. “A woman can dehull approximately 10 kg of maize in one productive hour.” (Fandohan *et al.*, 2005) There is limited use of insecticide and mechanized driers due to large capital investment which would inhibit farmers to puchase and apply (Plansecia, 2005, Wu *et al.*, 2008).

The cost of intervention also vary depending with the location and resources used for such interventions (Wu and Khlangwiseta, 2010). In the United States, factors associated with aflatoxin contamination are rarely health-related because they have adopted effective food and feed screening methods and their food safety practices responds to the international aflatoxin standards in foods (Cardwell & Henry, 2005). In Africa, particularly Sub- Saharan countries, It is unlikely that codex regulations as well as EU stringent regulations would affect the health of Africa’s population. Due to limited financial support, sample procedures are costly to the rural producers. Testing agencies in Africa limit themselves to trial sampling because of inaccessible locations of the sample and high quantity of food samples from a season of low production which eventually becomes unacceptable for farmers (Robens and Cardwell, 2005).

There are two categories of factors that are considered to influence choice in adopting or rejecting interventions: first, socio-economic factors of the adopters, that is food insecurity and literacy and secondly, characteristics of the interventions.

2.4 Gaps arising from existing literature

Literature shows that access to knowledge and literacy are essential for a farmer to adopt. In addition, farmers' uncertainty can be reduced by "communal ownership" (Bankole & Adebanjo, 2003) but we are yet to understand how such ownership can facilitate adoption of these interventions. There is no certainty on which factors are more significant in a household hence over generalization in determinants of choice in adoption.

The dangers of aflatoxin accumulation in foods have been experienced in larger parts of Makueni County. As per the inventory gathered in table 1 and 2, there are no consensus on how effective the Aflatoxin Reduction Interventions are in reducing aflatoxin levels in foods. Further, there are gaps in identifying and demonstrating how these interventions are transferred from one user to the other.

There are contradictions in the nature and type of social networks at the grass root and how they contribute to knowledge and transfer of technologies. In addition, there are no studies that show how social networks lead to adoption or rejection of Aflatoxin Reduction Interventions at the household. The role of social networks are not only personal but developmental which emphasizes on interactive and adaptive learning during the 1990s to early 2000s. The shift was attributed to a huge disconnect between transfer and adoption of knowledge and technologies because farmers' uncertainty of alien and highly centralized technologies were not addressed and the top-down approach eventually undermined traditional values such as communal learning and livelihoods (Chambers, 1983).

2.5 Theoretical Framework: Social Network Theory

The discussion in this sector focusses on the following issues;

2.5.1 Definition of social networks

Social networks were originally defined as informal interactions and friendships. The focus was more on the intensity of these interactions and their characteristics and at some point comparing interactions between different geographical spaces in areas of gender, reproductive health and behavior. According to American and British literature, the origins of investigating social networks started as early as 1950s focusing on personal networks within African societies particularly on kinship and community structure (Scott, 1988). Up to now, there are several debates on what social networks refer to. Social networks are referred as an innovation and a technical approach for transfer of technologies (Thuo *et al*., 2013) and information. Sociologists refer to social networks as social structures that impacts change (Allen *et al*., 2008) while practitioners under sustainable development refer to them as knowledge networks that are avenues for information flow. Clark (1998), categorizes social networks as informal and formal. Formal knowledge networks are developmental; formed according to specific themes where one joins by the group's rules and regulations as well individual credibility. They generate knowledge to share and apply; they also mobilize scarce human resources unlike informal networks. Informal are open without credibility to join and formed for an arising need without rules and regulations (Clark, 1998).

2.5.2 Forms of social networks

According to the theory, there are three kinds of networks: ego-centric, socio-centric and open networks. Ego centric networks have one connection, connected to many diverse networks. Socio-centric networks are interactions within a closed system unlike the open networks where networks have unclear boundaries hence "difficult to study." In all categories of networks, "flows" that is sharing of behavior, attitudes and exchanges are important.

Social Network theory explains and describes "a set of relationships." The "centrality of the position" or "degree" of these relationships are important (Allen *et al.*, 2008; Kadushin, 2004). They may have a certain direction "directional" or not "non-directional." Where there are directional relationships, considerations include "reciprocation or not and the degree of their mutuality." Degree refers to the number of connections or "nodes" with which a given connection or "node" is directly connected. Several connections "flowing" into a given connection is called "in-degree" or "popularity", while the number of connections flowing from a given "node" is called "out-degree."

Multiple degrees refer to one connection with different relationships with another connection whereby in each set of connection the values and organization are different. These different relationships between a pair of connection are "content multiplexity." For instance, one farmer whom adopted different types of intervention would have a number of different kinds of ideas such as "a solution to a problem, how to obtain information about the solutions and reaffirmation of an already identified solution, and the credibility of a proposed." These multiple networks seem to occur in rural more than the urban setting whereby "access and trust" are suitable conditions to boost development (Kadushin, 2004).

2.5.3 Social networks and adoption of interventions

Having understood social network theory and its elements, social networks result to collective action through social ties, density and cost in group communication or organization (Marwel & Oliver, 1988). Weak and close social ties are among the main concepts in the theory that facilitates sharing of information (Thuo *et al*., 2013; Kadushin, 2004). "Weak ties" are 'bridges' that facilitate new ideas and information from outside the system while close ties is where kinship and trust is important and can facilitate sharing and diffusion of these new ideas and technologies (Thuo *et al*., 2013). Therefore, both strong and/or weak ties with close geographical proximity is essential for the adoption of intervention.

Participation of a member in any social network is made possible by pre-existing social ties of an existing participant in the system. Pre-existing ties are referred by Kadushin (2004) as smaller social circles in larger social circle. Open networks or "weak ties" have diverse connections that allows interdependent decisions while closed network "close ties" allows collective action but hindrance in allowing new ideas and information hence cannot adapt to new changes or shift in technologies. Another concept that facilitates collective action is cost. Network costs declines as weak ties increases which allows diversity in resources and capacity.

Collective action brings about interactive and adaptive learning to sustainable adoption of interventions through communal participation in informal and formal learning environments. Interactive learning is described by how an individual is influenced by social pressures to make the decision to adopt or reject the interventions (Andrew & Alvare, 1982) even where there is incomplete information about the effects of the interventions being adopted within a social system. Adaptive learning is encouraged through "geographical proximity" and "household characteristics of the farmers" (Abdulai & Huffman, 2005).

2.5.4 Conclusion

What is common irrespective of different definitions and nature of social networks is that there is an understanding that social networks have distinct properties. The direction of the current study focusses on the field of community studies, whereby social networks are referred to as personal networks and networks within rural societies were closely knit (Scott, 1988). They are common attributes to informal networks that cannot be ignored: they create knowledge and influences and decisions making avenues hence easier transfer of knowledge and ideas in the adoption of Aflatoxin Reduction Interventions. In addition, farmers are able to share ideas and knowledge more efficiently as well as rationalize them according to their own experiences.

2.6 Study Propositions

We draw several propositions from the theory:

1. Social networks among small holder farmers are mainly open, personal and more closely knit ties with unclear structures and boundaries and high geographical proximity.
2. Small scale farmers adopt Aflatoxin Reduction Interventions that are easily accessible in knowledge, resources and skills and observed by others as effective.
3. The higher the level of farmers' participation in informal social networks, the higher the interactive and adaptive learning where knowledge, ideas, trust and collective action facilitates adoption of Aflatoxin Reduction Interventions.

2.7 Operationalization of the propositions

The basic "social" unit of analysis is the interaction between small holder farmers and their social networks that is the independent variable; the processes that involve interactive and adaptive learning which is the interdependent variable; in influencing decision to adopt or reject Aflatoxin Reduction Interventions that is dependent variable.

In the first proposition, the study will investigate open, personal and closely knit social networks that farmers interact with for a period of a month over the course of six months which is as far as the interviewee could recall specific details. The study will measure the personal interactions through investigating the type of social ties- weak or close. The study will measure open interactions through the degree of connections- single or multiple per connection. Structures will be measured by the level of diversity in such interactions per the farmers' socio-economic background and exposure to internal and external social learning, and the level of geographical proximity. Further, the study will measure the structures and boundaries of the interaction through origin of the interaction, requirements needed for such interaction and level of communication.

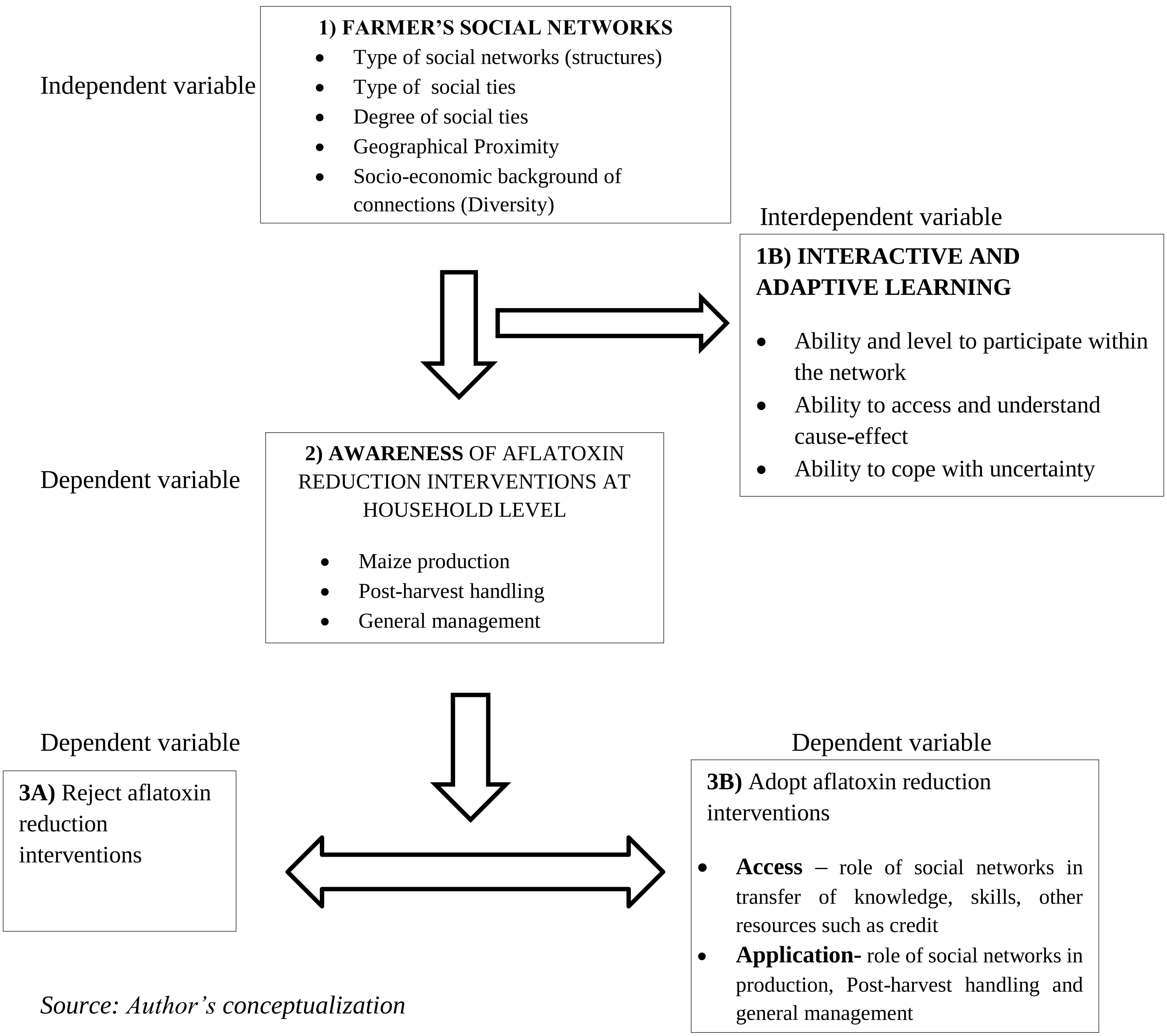
In the second proposition, the study will investigate the level of awareness of interventions among small holder farmer in different stages of farming. The level awareness will be measured by the level of knowledge acquired in crop production, post- harvest handling and general management. The study will also measure awareness through visual estimates of contaminated maize grain and observation of adaption of interventions from other interactions. The study will also measure the role of resources and skills though how farmers intervene on aflatoxin problem and in crop production, post- harvest handling and general management.

In the third proposition, the study will measure how farmers' social interactions enhance interactive and adaptive learning for adoption or rejection of Aflatoxin Reduction Interventions. Adoption of Aflatoxin Reduction Interventions will be measured through access and application. There variables to be measured entails the level of farmer's participation and level of access acquired as part of a social network in leadership, trainings, communication and use of groups' benefits such as credit and/or other resources. These variables will be investigated further to understand their role and contribution in sharing knowledge and ideas of the interventions hence making the decision to adopt or reject.

2.8 Conceptual Framework

The design below describes how variables in these study interact.

Figure 1: Conceptual framework of an adoption process



Source: Author's conceptualization

In the conceptual framework above, the first box, farmers' social networks identifies the nature and type of social networks as an independent variable.

In box 1B, interactive and adaptive learning is the process that results from farmers' interaction with social networks; further stimulating awareness in Aflatoxin Reduction Interventions. The level of interaction by the farmers to their social networks stimulates awareness of interventions and their causal-effect, participation in learning, ability to cope with uncertainty.

The second box, 2A- awareness of Aflatoxin Reduction Interventions measure the level of awareness through different stages of maize production.

In box 3A and 3B, adoption in described in dichotomous terms- whether to reject as shown in box 3A or adopt as shown in box 3B. In box 3B, adoption of aflatoxin reduction intervention is measured through role of social networks in accessing and applying interventions. Farmers' interactions within social networks becomes avenues for knowledge, innovation and technical approach to transferring and adopting Aflatoxin Reduction Interventions. However, there is a likelihood that such interactions may lead to rejection of aflatoxin reduction intervention, as shown in 3B.

3.0 CHAPTER THREE: METHODOLOGY

3.1 Introduction

This section presents the research methodology that the current study has employed. The specific issues discussed include sections in research design, study site, population and sampling procedure, data needs, data sources, data collection methods, and data analysis procedure.

3.2 Research Design

The current study has been guided through a cross- sectional design which compares relationship in multi-variables at the same time. It has employed mixed methods that is both quantitative and qualitative research techniques in order to provide answers to the research questions. Mixed methods was useful in obtaining in-depth information from the field and providing a better understanding of the research problem. Quantitative research techniques was employed in collecting and analyzing numerical data and codes in semi- structured instruments while qualitative research techniques using key informants and focus group discussions have been employed in collecting and analyzing open responses from research instruments.

To answer the three research questions, the study adopts the inductive research strategy. It collected data related to social network as a concept, produced generalizations and patterns showing the role of social networks in adoption or rejection of Aflatoxin Reduction Interventions.

3.3 Study Site

The study was conducted in Makueni sub-County, Kaiti division, Mukuyuni sub-location. Makueni Sub-County had a population of 8,500 people. Mukuyuni sub-location was selected as the study site because of two main factors: the existence of aflatoxin problem and aflatoxin reduction intervention. The selected study site have experienced more deaths from aflatoxin poisoning than any other parts of Makueni County (Marecherwa and Ndigwa, 2014; Nzioki, 2016). The findings was homogenous to the rest of the affected areas.

Ukia ward had 38,490 population with four locations: Utaati (11 villages); Kyuasini (6 villages); Nzuuni (5 villages) and Mukuyuni (10 villages) (Agricultural office, Ukia ward, 2017).

As a result of the study, the information gathered identified and measured adoption strategies in rural, arid and semi-arid areas in Kenya such as Makueni County.

3.4 Population and Sampling Procedure

The unit of analysis for this study was small holder farmers. There were several factors that determined the unit of analysis was a small holder farmer. First, the study had to provide evidence that the farmers were involved in maize production for subsistence, size of acreage and household analysis.

Mukuyuni sub-location has a population of 8,500 (online data: Afrotrack East Africa Limited) and was purposively sampled among other four sub-locations in Ukia ward because of highest incidences of aflatoxin accumulation and interventions (Nzioki, 2016). Stratified sampling was employed in identifying starting points for the villages in Mukuyuni sub-location because the population was large.

First, we identified eight villages as stratas in Mukuyuni sub-location. Followed by ensuring the stratas are the starting point of the researcher in systematically selecting farmers within the household. The researcher completed a full circle by selecting on the left hand side every 5th household from starting point to the last respondent. The selection of the study site and stratas were assisted by Research Officer in Kenya Agricultural and Livestock Research Organization (KALRO), Katumani and Agricultural extension officer, Ukia headquarters.

The sample size for the current study was 101 farmers in 8 stratas as shown in table 3. The study reached 85% of the population to answer particular questions.

Table 3: Number of farmer interviewed per strata

		Frequency	Percent	Cumulative Percent
Villages	Itulu	11	10.9	10.9
	Kavukuni	11	10.9	21.8
	Kiome	15	14.9	36.6
	Mung'eli	11	10.9	47.5
	Mutunduni	15	14.9	62.4
	Ngele	12	11.9	74.3
	Thui	12	11.9	86.1
	Wathu	14	13.9	100.0
	Total # of farmers	101	100.0	

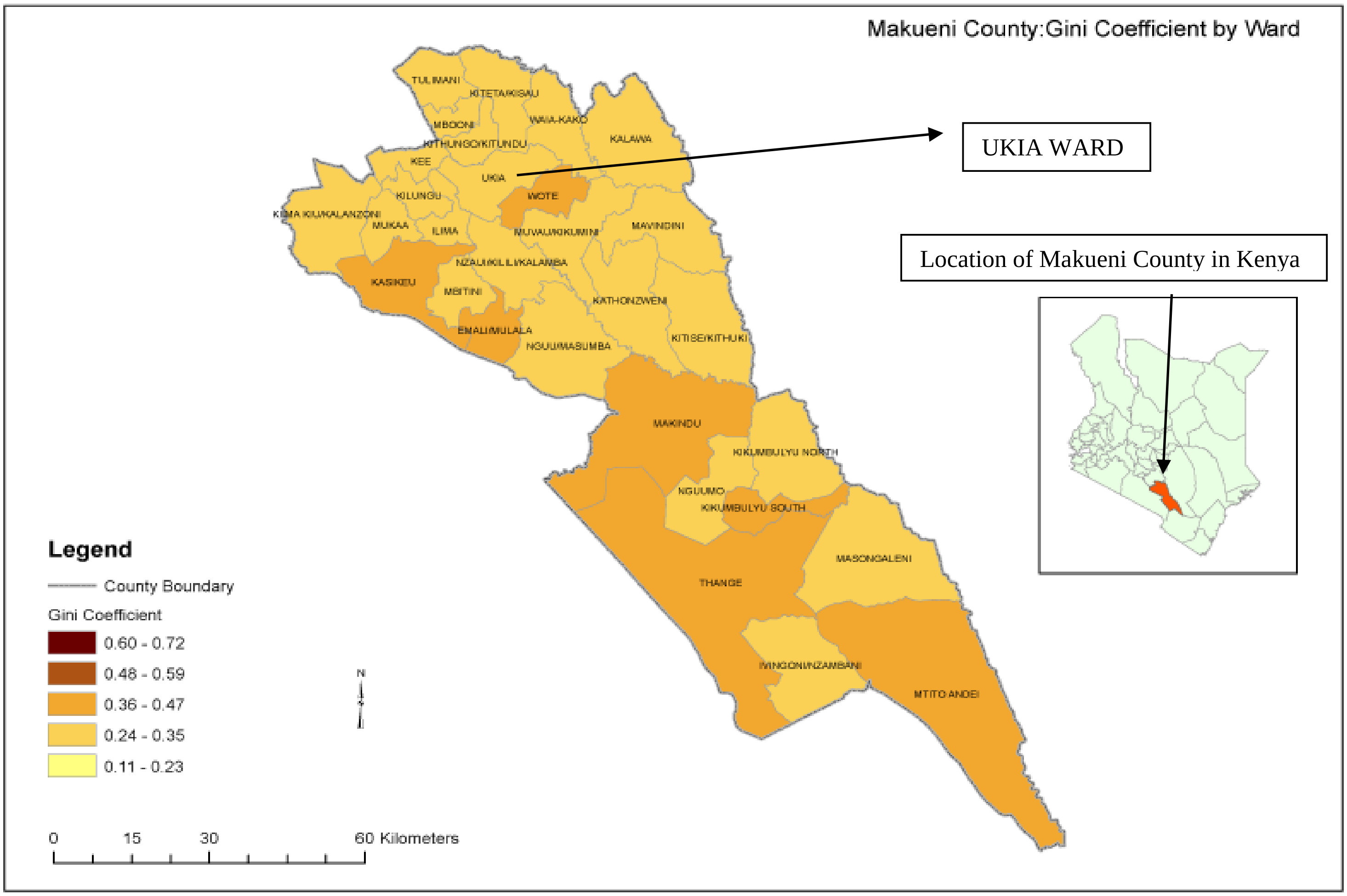
Source: field data

The information gathered in focus group discussions and key informant interviews has been used to complement the findings from individual small holder farmers. The study purposively selected 2 key informant. 1 key informant was selected from Ukia ward with 20-25 years' experience in areas of social networks, knowledge in agriculture and trainings and/ or introduction of Aflatoxin Reduction Interventions to small holder farmers. Another key informant had expertise in production and dissemination of Aflasafe technology among modern ARIs in Makueni County and aflatoxin management.

Stratified sampling was employed to select two social networks as focus group discussions. The focus group discussions investigated the level of social interactions and learning as a determinant of choice in adoption of Aflatoxin Reduction Interventions. The first focus group discussion had eight (8) discussants while the second focus group had ten (10) discussants as small holder farmers who were identified from a list of farmers interviewed in the first 4 strata and second 4 strata respectively. We expected focus group participants to be members of one or more social networks. The social networks were generally relationships formed as groups, which are *chama*, cooperatives and society.

The knowledge and expertise in both key informants was enough to make inferences on the role of social networks in adoption of current and new Aflatoxin Reduction Interventions.

FIGURE 2: MAP OF MAKUENI COUNTY AND ADMINISTRATIVE WARDS



Source: Soft Kenya Website

3.5 Information required to address research questions

Data needs table below summarizes the data required to answer three research questions, the sources of data, instruments and analysis required to capture the information in the study. To answer the three specific research questions, section (2.4) of this study operationalizes each research question. As a result, these questions highlights data needed to answer them fully.

Specific research question 1: How do social networks manifest among small holder farmers in Makueni County?

Information required to address this question was gathered from individual small holder farmers, focus group participants and key informants. The study determined whether the respondent was a maize producer and if he or she is a small holder farmer through farmer count of maize producers and acreage of maize production.

Social networks were investigated through measuring the type of social ties, degree of social ties, structures of social interactions, geographical proximity and socio-economic background of member and non-member farmers (diversity). The responses helped in describing how social networks manifest within Mukuyuni sub-location and generalization to Makueni County.

In the type and degree of social ties, the study investigated the interconnected relationships between individuals and their social networks. We investigated further from members of the same group on how they knew the group existed and how they have been able to transfer information and new ideas.

In order to understand the socio economic background of small holder farmers, the study measured the diversity in gender, age, education, and acreage of farming from members within the social networks and outside the social networks. In addition, the study employed household analysis by measuring the number of members in a household and household head sex.

Specific research question 2: How do small holder farmers adopt Aflatoxin Reduction Interventions in Makueni County?

In order to address the second research question, the study investigated the level of awareness by the small holder farmers through the number of occurrences of aflatoxin in exposure annually, described attributes towards aflatoxin and interventions, the type of interventions in crop production, post-harvest handling and general management and factors affecting access and application of intervention.

The objective was to understand the level of awareness among small holder farmers on modern and traditional Aflatoxin Reduction Interventions in Mukuyuni sub-location. The study investigated the level of awareness by the small holder farmers using both visual observation of photo with fungal contamination as shown in appendix 5 and descriptions of occurrences by the famer. Visual experimentation was done by comparing a photo of possible aflatoxin producing fungus contamination in maize corn with a four photo grid sheet that shows visibly clean maize seed to maize seeds affected with insects and possible aflatoxin producing fungus contamination.

The study further investigated the level of awareness among small holder farmers in Aflatoxin Reduction Interventions from planting season to plate, that is after storage. Farmers were asked a range of questions that ultimately describes the steps they would likely follow in planting, harvesting, drying, threshing, storing maize and maintaining safety of the maize as food.

Specific research question 3: How do these social networks influence small holder farmers' capacity to access and utilize Aflatoxin Reduction Interventions in Makueni County?

To answer research question 3, small holder farmers using mixed methods and focus group discussions were administered. The study investigates the relationship between social networks as a determinant of choice to adopt or reject Aflatoxin Reduction Intervention. The study investigated the benefits of social networks towards small holder farmers. The benefits asked were in relation to receiving knowledge on Aflatoxin Reduction Interventions. The study formed discussions on how each social networks generated and transferred knowledge and ideas and also, farmers' perspective on the information gathered within and outside the social networks.

3.6 Data sources

Primary data, as shown in table 4 was provided by the individual small holder farmers. In addition, complemented by findings from key informants and focus group participants. Secondary data was collected to provide relevant literature on what has been done with respect to any studies on social networks and adoption of Aflatoxin Reduction Interventions. Secondary sources include academic journals, books, government publications, reports and theses and viable unpublished data from a period of 1982 to 2016.

3.7 Data collection Methods

Primary data was collected through quantitative research methods and qualitative research methods such as semi structured interviews, key informant interview guide and focus group discussion guide which were administered by the researcher and a translator whom interpreted the questions in local dialect. The section below shows procedures of conducting each research method:

a) Semi- structured interview

Semi structured interviews was employed through Semi structured questionnaires and administered to individual farmers. Semi structured questionnaires had open-ended questions which enabled farmers to give an in-depth description of the relationship between social networks and adoption or rejection of the interventions while the closed-ended questions comprised pre-coded responses. Pre-coded responses consisted of numbers representing descriptions to measureable tangible components and type of interventions from planting to post- harvesting period. Questions were translated in Kamba for respondents who were not able to understand English.

The semi- structured questionnaire had questions which required the use of simple observation techniques. The individual farmer was asked to observe using a photo sheet within the questionnaire while the researcher recorded what the farmer has observed.

b) Focus Group Discussions Guide

The focus group interview had 8 and 10 participants in first and second focus group discussion respectively. The style of questioning in the focus group discussions was set up for an open ended discussions, where questions were asked by the interviewer and each participant was given a chance to answer in depth through descriptions.

The study considered several factors before starting a focus group discussions: First, how to effectively record the discussions and availability of materials. For this study, a note book and pen was used to record the discussions contributed and then, the interviewer and her assistant who understands local dialect would each record their notes. Secondly, the discussions were held in a convenient location for all participants with little interruptions from an outsider. Thirdly, a count exercise of the participants and gender was done to ensure proper representation.

During the discussions, first, there was a brief introduction of the facilitator and his/ her role as the moderator of the discussions; the moderator gave the objective of the day, time taken and rules on the use of mobile phones and participation for the discussions to be meaningful. Secondly, each participant briefly introduced themselves and received a tag with their name so that the facilitators kept note of the relevant participants who would contribute to the discussions. Thirdly, the moderator started by asking questions as per the printed focus group discussion guide. There was probing of questions in cases where the moderator would like to understand the responses and where the group was struggling in its discussions.

At the end of the discussions, the participants were asked to briefly suggest or comment about the discussions. Incentives were given to each participant as we concluded. Later, the interviewer and her assistant concluded the discussion by saying a word of gratitude.

Information acquired from the Focus Group Discussion Guide was compared by the findings from the Semi structured Interview. These information related to knowledge farmers acquire and receive about access and application of Aflatoxin Reduction Interventions in order to make the decision to adopt or reject.

c) Key Informant Interview Guide

This method was administered to two key informants. The information needed from key informants focused on technical questions related to social networks and Aflatoxin Reduction Interventions in Makueni County and Ukia ward.

First, the interviewer scheduled an appointment with key informants representing Makueni County and Ukia ward. During the interview, the interviewer established rapport by briefly introducing herself. The interviewer introduced the study including overall objective of the study and the role of the key informant interview to the study. The interview started by asking the questions as per the key informant interview guide. Lastly, the interviewer concluded with a word of gratitude.

3.8 Data Analysis Procedure

The primary analysis would make interpretations to farmer's social networks as a determinant of choice in adoption or rejection of interventions and will evaluate the relationship and contributions made by social networks in interactive and adaptive learning. Open ended questions will be coded after primary data collection through thematic analysis.

Bivariate analysis analyzed the relationship between two variables – social network and adoption or rejection of interventions. Statistical data was generated through IBM SPSS which generated contingency table and Chi square test to measure patterns of association between two nominal variables and statistical significance of the relationship respectively.

To analyze the research questions, the study analyzed quantitative data through SPSS in form of descriptive tables such as frequency tables and cross tabulation of variables. The study analyzed qualitative data such as names of social networks through Microsoft Excel (MS-Excel) which involved coding responses and providing interpretation. This combination of mixed method had brought about in-depth research and interpretation in describing benefits of the intervention and how knowledge and ideas are generated and transferred and for adopted and rejected Aflatoxin Reduction Interventions among others.

Table 4: Summary of data needs

Objectives	Research questions	Data need	Type of Data	Source of data	Instrument	Data analysis
1) To identify social networks among farmers in Makueni County.	1) What are the social networks among farmers in Makueni County?	- Type of social network (structures)	- Qualitative - Quantitative (structures)	Farmer Key Informant FGD	Semi-structured questionnaire Key Informant Interview Guide Focus Group Interview Guide	SPSS Thematic analysis
		- Type of social ties (existence of social networks)	- Qualitative	Farmer FGD	-Semi-structured questionnaire Discussion notes	SPSS Thematic analysis
		- Degree of social ties (participation)	- Qualitative	Farmer FGD	Semi-structured questionnaire Discussion notes	Thematic analysis
		-Geographical Proximity	- Quantitative	Farmer	Semi-structured questionnaire	SPSS
		- Socio-economic background of farmers (age, education, household analysis, acreage)	- Qualitative -Quantitative	Farmer	Semi-structured questionnaire	SPSS
2. To identify adopted Aflatoxin Reduction Interventions in Makueni County.	2. What are the adopted modern and traditional Aflatoxin Reduction Interventions among farmers	-awareness of aflatoxin problem (occurrences, visual observation)	- Quantitative (no. of occurrences; coded responses)	Farmer Key Informant FGD	Semi-structured questionnaire (observation notes) Discussion notes	SPSS Thematic analysis
		- Type of interventions in crop production, post-harvest handling and general management.	- Qualitative -Quantitative (practice)	Farmer Key Informant FGD	Semi-structured questionnaire Discussion notes	SPSS Thematic analysis

	in Makueni County?	- factors affecting access and application of intervention	- Quantitative (level of importance per response) -Qualitative (important factors)	Farmer Key Informant FGD	Semi-structured questionnaire Discussion notes	SPSS Thematic analysis
3. To evaluate how social networks generate and share knowledge through accessibility and utilization of Aflatoxin Reduction Interventions	3. How do these social networks influence farmers' capacity to access and utilize Aflatoxin Reduction Interventions in Makueni County?	- role of social networks in benefits	- Qualitative	Farmer FGD	Semi-structured questionnaire Discussion notes	Thematic analysis
		- Individual and group role in transferring technologies. *trainings received- internal or external *participation in training (relation to diversity)	- Quantitative (coded responses)	Farmer FGD	Semi-structured questionnaire Discussion notes	SPSS Thematic analysis
		- how networks generate knowledge, ideas -how networks transfer knowledge and ideas	- Qualitative	FGD	Discussion notes	Thematic analysis
		-Information gathered from interactions within and outside networks	- Qualitative	FGD	Discussion notes	Thematic analysis

4.0 CHAPTER FOUR: FINDINGS AND DISCUSSIONS

4.1 Introduction

This chapter sought to answer three research questions, that is, how do social networks manifest among small holder farmers in Makueni County; how do small holder farmers adopt Aflatoxin Reduction Interventions in Makueni County and how do these social networks influence small holder farmers' capacity to access and utilize Aflatoxin Reduction Interventions in Makueni County. The study answered the first research question by describing and conceptualizing the common characteristics in the social networks formed in the area and the socio-economic stratifications of the small holder farmers who join the social networks. Thereon, the findings described how aflatoxin reduction interventions are adopted in relation to farmer awareness towards the aflatoxin problem and interventions in the farm. The chapter concludes with describing how social networks influence behavioral change and capacity in small holder farmers to adopt aflatoxin reduction interventions.

4.2 Manifestation of social networks

The study described how social networks manifest among small holder farmers; in type and degree of social ties; structures of social networks; geographical proximity and diversity of the members in social networks. The findings were interpreted from field data, 2017.

4.2.1 Structures of social networks

The study found that social networks are social structures which determined collective action in sharing of information. The study noted that this collective action in sharing information were met through engaging with members irrespective of the number of social networks formed by the farmers. 68 farmers, equivalent to 67.3% of farmers interviewed had joined and/or started their own first social networks. Of these 68 farmers, who had joined one social network, 29 farmers which is 43% had joined two social networks, 11 farmers, equivalent to 16% were members of three social networks and 2 farmers equivalent to 3% were members of four social networks. The percentage of farmers who later joined second, third and fourth social networks decreased to 28.7%, 10.9% and 2% respectively. Therefore, farmers are more satisfied joining one social network which they could easily engage and gain knowledge.

The study found that the motivation to acquire information and share knowledge was influenced by social and economic challenges. During the year 2013 to the year 2014, social networks had the largest number of farmers and increased human capital in the social networks. 2% of the farmers interviewed, joined the first social network as early as 1968, further increasing in 2004 to 2016. The study supports literature on Clark (1998) that show social networks are formed from an arising need.

The study found out that social structures formed were formal and personal. Membership fee and age were the common requirements for joining social networks across respondents. 41 farmers which is 41% of the farmers ranked membership fee as their first requirements while 8 farmers which is 7% ranked membership age limit as their second requirement which is 22 years or older. The requirements of the networks determined the structures of the group. The study found that social structures were formal and personal based on the social and economic activities of the social network. They include: abide to the constitution by attending meetings and pay money for group's activities like table banking, to be in the same area, to be related, be of the same gender- mostly a woman, be in the same church, have a group's uniform, have a bank account, be of the same profession, in this case, community health worker and/or farmer, be a widow with a child in secondary school. These requirements, as shown in table 5 became more formal with time, as shown in table 6.

The findings support the literature addressed by Scott (1998) and Clark (1998) where social networks were originally defined as informal interactions build on kinship and trust. These social structures were identified in "a set of relationships" with structures (Allen *et.al*, 2008; Kadushin, 2004).

Table 5: Requirements for joining social network

	First requirement	Frequency (%)	Second Requirement	Frequency (%)
	Membership age limit	8 (7.9)	Membership age limit	7 (6.9)
	Membership fee	41 (40.6)	Membership fee	4 (4.0)
	Attend meetings	5 (5.0)	Attend meetings	2 (2.0)
	Pay money to start group's activity	3 (3.0)	Pay money to start group's activity	4 (4.0)
	Be a farmer	6 (5.9)	Be a farmer	3 (3.0)
	Other	4 (4.0)	Other	2 (2.0)
	Do not know	1 (1.0)	Do not know	9 (8.9)
	Total	68 (67.3)	Total	28 (27.7)
Missing	# of farmers without social networks	33 (32.7)	# of farmers without social networks	59 (58.4)
Total		101 (100)	Total	101 (100)

Source: Field data, 2017

The study found out that the common requirements within a social network changed across time. These changes in social networks were influenced by external relationships such as government extension services; leaders and members within the group as shown in table 6. According to literature, "centrality of the position" or "degree" of relationship influenced these "set of relationships" (Allen *et al.*, 2008; Kadushin, 2004).

Table 6: Reason for joining the group: Changes from previous to current

Previous reasons	**Current reasons (in addition to previous reasons)**
Save together	Access initiatives from government and non-governmental organization such as FAO
Financial empowerment	To be registered under societies
Learning agricultural practices	To open a bank account
For our children- school fees	

Source: Field data, 2017

Formal social networks were interpreted differently by both farmers and the government. The study showed farmers understood social networks as formal once a network was formed towards a common goal and collectively contribute towards achieving this goal. The government noted that for social networks to be formal, they should be registered under Societies Act. Of the 75 social networks listed by member- farmers, 15 social networks are identified by the government extension services as formal. Of the 15 formally registered, 10 social networks contribute towards soil management, 2 networks practices fruit farming and 3 networks advocate for aflatoxin control within Mukuyuni sub-location.[2] The increased demand for social networks improved farming techniques and management and only three were formed for a collective action towards aflatoxin control.

The study agrees with the proposition that social networks were personal. However, they were not entirely open because they a set of rules to inform members interaction. The study agreed with the social network theory that farmers formed the social networks because of an arising need and with time, members came up with rules and regulations that reflect their vision and the new members' capacity to join. According to empirical and theoretical data by Clark (1998) both formal and informal social networks had the capacity to bring about change and development.

4.2.2 Type and degree of social ties

Social networks had close social ties which enabled them to be open and the growth of these networks was based on personal relationship between members which formed trust and multiple connections per member[3]. 28 out of 68 farmers, equivalent to 41% who joined a social network found out about its existence from a friend who was previously a member of the social network as shown in table 7. 5 out of 68 farmers, equivalent to 7% decided to form their own group so that to assist each other on social challenges such as "accessing loans to pay for school fees."

[2] Key informant interview, July 2017. Verbatim from the qualitative research
[3] Wendano wa Ndiwa Women Focus group interview, July 2017. Verbatim from the qualitative research

Table 7: Degree of social ties

	Degree of social ties (existence of social ties)								
	from non-member friend	from member friend	in church	from chief's meeting	my neighbor joined	observed the benefits of others	Other	Do not know	Total
# of farmers	16	28	9	1	4	3	5	2	68
%	24%	41%	13%	2%	6%	4%	7%	3%	100%

Source: Field data, 2017

The close, multiple social ties and high members' participation in the network allowed flow of new ideas and information. 33 out of 68 farmers, equivalent to 49% participated in weekly and monthly interaction in their social networks.

The study agrees with literature that social networks with close ties where kinship and trust is important can facilitate sharing of new ideas essential for the adoption of aflatoxin reduction interventions (Thuo *et al*., 2013). However, kinship and trust is not enough. High level of participation which was influenced by pre-existing social ties "smaller circles" or personal relationships of an existing member within the social network "a larger social circle" are important (Kadushin, 2004).

4.2.3 Geographical proximity

The study found that farmers joined social networks that were close to their homes. The closer their homes were to the meetings, the more it encouraged learning that was engaging and adaptable to the members due to their constant interactions. 68 farmers out 101 farmers interviewed equivalent to 68% joined social networks that were less than and/or equivalent to one (1) km. The study showed that there was high participation when distance is less than or an equivalent to 1 kilometer (km) and also between 1 kilometer (km) to 23 kilometer (km) which is the farthest distance given. In addition, collective action towards change depends with how the members participate in the social networks.

33 out of 101 farmers, equivalent to 33% who have not joined any social network gave the following reasons: they were engaged on other personal matters, they found social groups' finances mismanaged; they did not have spare money to contribute for group's activities and believed social groups are meant for more wealthier farmers who had large tracts of land for

farming and diversifying. However, even for the 68 out of 101 farmers who had joined the social networks, distance and cost became a recurring reason why they did not participate in meetings.

1 out of the 37 farmers, equivalent to 3% who missed on one or more meetings did not have fare to attend the meetings. Social networks were formed at the village level in member's homestead where meetings and field demonstration took place. Of the 68 farmers who joined social networks, 54% of the farmers were very satisfied with attendance of meeting since they joined.

Both empirical data and literature show that participation in social networks is costly and would decline with higher geographical proximity further resulting to increase in adaptive learning (Abdulai & Huffman, 2005).

4.2.4 Socio-Economic background of farmers

The study showed that socio-economic stratifications contributed to increase in social networks' diversity, as a result, led to adaptive learning and adoption of aflatoxin reduction interventions.

Gender and Age

The study showed that division of labor in planting, harvesting and in crop management depended on gender and to an extent, age. Of the 101 farmers interviewed, 29 farmers equivalent to 29% were male and 72 farmers, equivalent to 71% were females, reason being that more women were available in the homesteads taking part in planting, harvesting and management such as drying, sanitation and storage [4] and keen in learning from each other about agricultural activities as their main responsibility. In addition, men held the land rights. Therefore, the findings showed that more women were more likely to joined social networks more than men.

Age is the second common requirement in joining social networks. Farmers who mostly join social networks are women between the age of 46 and 65 years while the lowest proportion of farmers who have participated are less than or equivalent to 25 years. However, age alone may not necessarily measure participation of social networks.

[4] Key informant interview, July 2017. Verbatim from qualitative research.

The current literature found out that social networks were sources of adaptive learning which were influenced by household characteristics of the farmers such as gender as narrowed down in this study (Abdulai & Huffman, 2005). Studies in West Africa show that challenges are faced by the bearers of labour and time who are mostly women (Fandohan *et al*., 2005).

Education

The level of education influenced their intake of knowledge regarding aflatoxin and aflatoxin reduction interventions. The populations with low levels of education tend to be less receptive to new interventions because it was much more difficult to understand. 90.1% of the farmers have access to formal education. 3% of farmers attained adult education and 7% of farmers lacked any formal and informal education. As expected, those who attended informal to no education were all female as shows in table 8. As a result, more women joined social networks and found avenues for learning hence facilitating adoption of aflatoxin reduction interventions.

Table 8: Cross tabulation of Gender and Education of respondents

			Literacy levels					
			Primary education	Secondary education	Tertiary education	Adult literacy education	None	Total
Gender	Female	Count	26	29	7	3	7	72
		% per education	68.4%	72.5%	53.8%	100.0%	100.0%	71.3%
	Male	Count	12	11	6	0	0	29
		% per education	31.6%	27.5%	46.2%	.0%	.0%	28.7%
Total		Count	38	40	13	3	7	101
		% per education	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Source: Field data, 2017

The study supports literature from Sub- Saharan Africa, that levels of literacy are determinants of choice in adoption of interventions (Hell and Mutegi, 2011; Cardwell and Henry, 2005; Marecherwa and Ndigwa, 2014).

Household count

The study showed that a decision to either adopt or reject interventions depends on who was making the decision and the availability of resources. According to household analysis, 21 farmers out of 101 farmers interviewed, equivalent to 21% had a household of 5 members. The highest number of household members was 14 and the least, 1 member. The study shows that most household in rural areas strain in accessing household resources which reduce the level of participation in social networks.

Findings showed that female-headed households led in allocation and management of the available resources and in the adoption of aflatoxin reduction interventions. 46 of the 72 female respondents were female-headed household while 27 out of the 29 male respondents were male-headed households. The total number of male- and female-headed household is 53 and 48 in number respectively.

Table 9: Cross tabulation of gender and household head

		Household Head		
		Female	Male	Total
Gender	Female	46	26	72
	Male	2	27	29
Total		48	53	101

Source: Field data, 2017

The study concluded that household contraint in resources is a determinant of choice in adopting to interventions. The study supports literature that small holder farmers have scarce financial resources because of sorely taking up all the cost of household and the interventions related to food safety thus reinforcing poverty and poor human health (Robens & Cardwell, 2005; Hell and Mutegi, 2011; Wu *et al.*, 2005).

Maize production and acreage

One of the key concerns in the study was how to understand the economic capacity of a small-holder farmer in the area. Findings show that all farmers in Mukuyuni sub-location were mostly small holder farmers who were subsistent producers of maize. 41 out of 101 farmers interviewed, equivalent to 41% of maize producers and consumers have less than or equal to 1 acre of maize planted every season. 73 farmers out of 101 farmers, equivalent to 73.3% of farmers own less than or equal to 2 acres of maize farm every year for subsistence production.

Small holder farmers are the most affected by aflatoxin contamination. They face a decline in food production and nutritional levels in food and animal production; which resulted to low capacity to access and utilize sharing of knowledge and ideas. Literature shows that food insecure farmers are more likely to be uncertain about which interventions to adopt and feed on contaminated stable foods than those with the capacity to diversify food (Wu *et al.*, 2005).

The study was able to answer how social networks manifest among small holder farmers and to what extends the study views farmers as small scale producers as well as their level of vulnerability towards the aflatoxin problem. It was crucial to understand the social economic background of the farmers so as to understand their capacity to engage in learning and adaptive learning. The study shows that small holder farmers sorely rely on one stable diet such as maize because of their low level of diversification and household constraints (Hell and Mutegi, 2011).

4.3 Determinants of choice in adoption of aflatoxin reduction interventions

4.3.1 Awareness of aflatoxin problem

Small holder farmers adopted aflatoxin reduction interventions depending on their level of awareness, knowledge received and experience. 80% of the farmers knew and understood that aflatoxin was visible and would mostly cause death in human beings as shown in table 10. They further described the measures used to control aflatoxin contamination by drying maize properly and proper storage and sanitation. They learnt of the occurrences of aflatoxin from neighbors, or in their own farms, in radio and meetings with chief and agricultural officers. The table below shows their description per farmer count:

<u>Table 10: Descriptions of the aflatoxin occurrences per farmer count</u>

What occurred	**Farmer count**
Aflatoxin is called “Mbuka”	7
Mbuka “occurs in soils”	3
Mbuka occurs in maize as grain and food. The affected maize becomes “soft and black” “My neighbor …consumed contaminated food.” “Heard from agricultural extension officer in the church that it affects maize.”	25
It is visible. “I separated the affected maize cobs.” “I understand that I should destroy the produce once I see any contamination.”	3
It is “poisonous.” “It is poison hence if you see it in your farm you remove it.”	3
Occurs yearly, each season. “…occurred in my village.” “Someone consumed contaminated maize in Kavukuni village.” “It occurred in the whole village when I was in high school back in 2008.”	16
Occurs in the farmer’s farm, schools and market. “It was present in my farm this season as well as previous season.” “I saw it my harvest.” “My daughter got sick from consuming maize contaminated with 'mbuka' from school.” “Also some household have been affected by having bought the maize from the market.’	30
Aflatoxin is caused by wet areas such as "wet farm," "wet store," “a lot of rains,” and “water-fed farm.”	6
Aflatoxin is caused by “wetness in maize” and “lack of proper drying.” “I threw 50 kgs of maize produce that had been contaminated because I stored them for a long time in the store without sufficient drying.”	11
Aflatoxin is caused by “poor storage.”	1
Aflatoxin is caused by lack of proper sanitation. “We had some trainers who told us to prevent drying maize in the soil.”	2
Aflatoxin is caused by cold environment and “cold maize.”	4
Once contaminated maize is consumed, it affects, people and children with symptoms such as stomach pain and death. “Children who consumed contaminated grains were taken to hospital in Wote.” “Children were affected with symptoms such headache and turning yellow.” “A woman died of *Mbuka*.” “*Mbuka* kills and has no cure.”	33
Farmers managed aflatoxin by “burning,” “hand sorting,” “applying supper acetylic,” “feeding the chicken,’ and “drying maize well.” “I separated the affected maize cob and placed them in the bucket for chicken feeds.” “Sub-chief told us about *mbuka* that we should dry maize well.” “The agricultural officers took the maize; and the rest told us to dispose by burning and we will be refunded the maize.” “I was told if I applied supper acetylic, there will be no contamination.”	6
Few heard about aflatoxin and to control it from the “radio, *barazas* and in my professional work”; from agricultural officer and chiefs. “The extension officer told us it affects human health.” “Sub-chief told us about '*mbuka* that we should dry maize well.”	14

Source: Field data, 2017

Aflatoxin problem in maize had caused much more adverse effects in maize production. The study shows that aflatoxin problem was associated with victimization and social exclusion of the affected households. According to the discussions of the aflatoxin problem, farmers were too embarrassed to share that their field and maize were affected for fear of victimization. Aflatoxin problem was so grave that they compared aflatoxin to HIV/AIDS because they believed that once maize had been contaminated with the fungi producing the aflatoxin, there was no cure.

Farmers refer aflatoxin contamination to ‘mbuka’ in maize. Aflatoxin was first discovered in 2009. The last occurrence from the government extension services was record on 2015[5]. 63 farmers out of 101 farmers, equivalent to 62% were exposed to aflatoxin in their own farm. Farmers pointed out that maize affected with aflatoxin was similar with ‘visibly’ high levels of fungal infection in photo sheet 4 which was a picture of a maize cob with visible fungal contamination turned black and greenish as shown in table 11 below.

This study adds that 68% of farmers were able to identify an aflatoxin producing fungus called *Aspergillus* which is greenish brown/ black as shown in appendix 5. Other aflatoxin strains are different in color including *Penicillum* which is usually light green and *Fucarium* which is white. The study support global literature on the nature of aflatoxin strain, *Aspergillus* being the most dangerous aflatoxin producing fungus and found in Kenya[6].

The study supports literature that there was a wide gap between scientific facts and farmers’ perspective towards the nature of aflatoxin. Farmers face great danger in adopting interventions with incomplete knowledge on what aflatoxin is and to what point contaminations are visible to the human eye (Cardwell & Henry, 2005). 100% of those farmers, who were aware, never knew that aflatoxin was invisible to the human eye but only the fungal contamination was visible. According to IITA, aflatoxin is not visible even on high content. The fungus can be identified in color but it is safer tested to identify if it is aflatoxin producing fungus or not[7].

[5] Key Informant Interview, July 2017. Verbatim from qualitative research
[6] Key informant interview, July 2017. Verbatim from qualitative research
[7] Key informant interview, 2017. Verbatim from qualitative research

Table 11: Comparison of affected farmers and level of knowledge in exposure of fungal contamination (greenish black color)

Affected by aflatoxin contamination (YES)		Visual experiment of fungal contamination (greenish black color)				Total
		maize seeds with/without fungal contamination	maize seeds with/without fungal contamination and affected moderately by insects	maize seeds with fungal contamination and highly affected by insects	maize seeds with high levels of fungal infection	
Total	Count	3	1	16	43	63
	% within Affected by aflatoxin contamination	4.8%	1.6%	25.4%	68.3%	100.0%

Source: Field data, 2017

Farmers who were aware of the aflatoxin problem, knew the cause of aflatoxin contamination in maize was wet maize cobs or grains, too much rain and/ or a sack leaned against the wall, and pests such as weevils among others. They were also aware the contamination would accumulate at storage hence farmers reduced storage season by producing maize for subsistence and improved proper storage practices. Farmers knew that causes of the aflatoxin problem, they were able to identify the fungal producing aflatoxin but were not able to know the difference between the fungi, as visible and aflatoxin contamination which was not visible. The study adds Marecherwa & Ndwiga (2014) literature that it was more about incomplete knowledge by the farmers rather than their attitudes towards change that inhibits adoption of aflatoxin reduction interventions.

4.3.2 Awareness of Aflatoxin Reduction Interventions

Farmers were aware of aflatoxin reduction interventions and how to adopt interventions depending on the period. Of the 63 farmers who had been exposed to aflatoxin, 56 farmers were aware of modern and traditional interventions in crop production, post-harvest handling and in crop management. Farmers used an integrated approach which entailed good agronomic practices of both modern and traditional aflatoxin reduction interventions[8] at the beginning of their planting season to post-harvest handling of maize up to the plate.

[8] Key informant interview, July 2017. Verbatim from qualitative research

Aflatoxin Reduction Interventions (ARIs) in Maize production

On average, 97 out of 101 farmers, equivalent to 96% adopted up to four types of interventions in maize production.

Table 12: Number of interventions used and preference of adoption

	Adopt one (1) intervention when planting maize	Use two (2) interventions when planting maize	Use three (3) interventions when planting maize	Use four (4) interventions when planting maize	Other
Preference of adopting interventions	Improved maize varieties	Fertilizer	Lime and/or farm yard manure and/or cereal production	Herbicide	Local maize seeds, *Kikamba*
#of farmers adopted	99	79	43	5	24
Other	2	22	58	96	0

Source: Field data, 2017

Traditional interventions are much more adopted than modern intervention in maize production. 24 out of the 97 farmers, equivalent to 24% who adopted ARI referred to using local, recycled and unimproved maize seeds called in their local name, *Kikamba* for planting while only 2 out of 97 farmers, equivalent to 2% who adopted ARI knew about Aflasafe KE01 and had benefitted from the demonstrations in their farms.

Small holder farmers determine the interventions to use based to their effects to crop yield as shown in the study. There was no evidence of the use of Bt Corn (Wu *et al*., 2005). Improved maize variety used in the area were developed to resist the environmental agents and plant stress unlike the developed countries (Hell and Mutegi, 2011). According to literature, both modern and traditional aflatoxin reduction interventions, generally known as good agronomic practices in maize production go hand in hand with increasing crop yields and to support plants from water and nitrogen stress which reduces aflatoxin levels by 50-90% (Hell and Mutegi, 2011; Hell *et al.*, 2005; Guo *et al.*, 2005; Cardwell and Henry, 2005 and Shier *et al.*, 2005).

Aflatoxin Reduction Interventions in Post-harvest handling

The study showed that farmers were aware that most interventions were adopted at post-harvest handling period. Modern aflatoxin reduction interventions were increasingly being used in this period more than in maize production or crop management period. Literature shows post- harvest handling period characterizes an out of farm practice; however, harvesting and drying were largely adopted at the farm. Findings show that farmers saved time by drying maize cobs while on the farm but compromised on sanitation where there was high likelihood of aflatoxin contamination when maize cobs are in contact with the soil. 38 out of 100 farmers, equivalent to 38% who used ARI when harvesting maize, placed cobs with/without husk on the ground followed by 26 out of 100 farmers, equivalent to 26% who used ARI when harvesting, placed maize cobs without husk placed directly in a sack while 21 out of 100 farmers, equivalent to 21% who used ARI when harvesting maize placed cobs with/without husks over maize stalks among others as shown in table 13 below.

Table 13: ARI used when harvesting

		Frequency	Percent	Valid Percent
	Place cobs with husks in sack	6	5.9	6.0
	Place cobs without husk in sack	26	25.7	26.0
	Place cobs with/without husk on the ground	38	37.6	38.0
	Place cobs with/without husks over maize stalks	21	20.8	21.0
	Place cobs with/without husk on a plastic sheet	9	8.9	9.0
	Total	100	99.0	100.0
	Do not know	1	1.0	
Total Cumulative		101	100.0	

Source: field data, 2017

The findings does not show whether the farmer did early or late harvesting. Literature shows that late harvesting has increased aflatoxin levels for 4 to 7 times more (Hell and Mutegi, 2011; Hell *et al.*, 2008).

Time as proposed by Fandohan *et al.* (2006) is another factor that determines which interventions are to be adopted, that is why drying is the most preferred traditional aflatoxin reduction intervention. An accumulative 20% of farmers saved time by drying maize crops while harvesting as shown in table 14. Farmer harvest late and as a result maize crops are left to dry in the field. Alternately, farmers also harvest on time then leaving the maize stalks with the cobs to dry in the field as shown in table 13 above. In addition, continuous drying ensured effectiveness in reduced moisture content. In the homestead, 78 out of 100 farmers, equivalent to 78% who used ARI when drying maize used the recommended intervention of proper drying of maize on a plastic sheet. However, these may not at all reduce contamination since the maize was previously placed on the ground while in the farm.

Table 14: Combined use of ARI adopted when harvesting and ARI adopted when drying

		ARI and/or techniques used when drying				
		Directly on the ground or on rocky outcrops	On a plastic sheet	On a raised platform or roof	Dry on the field	Total
ARI adopted when harvesting	Place cobs with husks in sack	0	6	0	0	6
	Place cobs without husk in sack	4	22	0	0	26
	Place cobs with/without husk on the ground	7	27	2	2	38
	Place cobs with/without husks over maize stalks	2	16	0	3	21
	Place cobs with/without husk on a plastic sheet	2	7	0	0	9
Total		15	78	2	5	100

Source: field data, 2017

Farmers were aware of how to properly dry their maize and used traditional indicators towards measuring dryness as shown on the table 15. Farmers' measure dryness through listening to the sound it makes when handling it, by looking at it and by squeezing and touch it. 3 out of 100 farmers, equivalent to 3% who used ARI when measuring dryness have adopted a modern intervention- moisture meter and other new traditional interventions.

The farmers who adopted the moisture meter accessed the intervention from their social networks. There were other new traditional interventions including to using a bottle with salt half full and placing your grains inside the bottle for hours to measure moisture content in the salt.[9]

Table 15: ARI used when measuring dryness

		Frequency	Percent	Valid Percent
Type	By looking at it	30	29.7	30.6
	By squeezing or touching it	18	17.8	18.4
	By using moisture meter	3	3.0	3.1
	By biting grains and testing hardness	12	11.9	12.2
	By listening to sound it makes when handling it	34	33.7	34.7
	I do not check	1	1.0	1.0
	Total	98	97.0	100.0
Missing	Other	3	3.0	
Total		101	100.0	

Source: field data, 2017

Consistency in the use of the interventions determined the success of farmers in aflatoxin control. In harvesting, integrated management and control of aflatoxin in farmers' farm is crucial. All farmers used ARI in threshing maize. A new modern intervention, mechanized thresher, had gained little popularity as shown in table 16. Proper threshing of maize was adhered to but not consistent. Farmers adopted the use of hands to thresh and alternated with using a stick as shown in table 17. Literature recommends threshing maize using hand rather than a stick to beat the crop in order to avoid entry of fungi in the grain (Wu & Khlangwiset, 2010; Bankole and Adebanjo, 2003; Hell *et al.*, 2008) which can result in 40-80% reduction in aflatoxin levels (Fandohan *et al.*, 2005).

[9] Key informant interview, July 2017. Verbatim from qualitative research.

Table 16: ARI adopted when threshing/ shelling

		By use of hands	Using a stick to beat the crop	Mechanized thresher
#of farmers adopted	For each	76	59	9
	Total	101	101	101
Median		1.00	2.00	
Mode		1	2	

Source: field data, 2017

According to empirical data, adoption of aflatoxin reduction interventions was determined by social security such as need to secure produce from theft. At storage, maize produce was at risk of contamination as farmers preferred to store the produce indoors in order secure their food from theft while their second preferred storage was a bamboo constructed granary with iron sheet roof outside the house. 21 out of 100 farmers, equivalent to 21% who were adopted ARI at storage, raised their platform from the ground to avoid moisture and 34 out of 100 farmers, , equivalent to 34% adopted ARI at storage, stored in sacks. The study showed farmers were at risk of accumulated aflatoxin producing fungi if they stored maize improperly at conducive moisture content of above 10-15 percent (Hell and Mutegi, 2011; Hell *et al.*, 2005) found from improper storage of maize indoors. In addition, aflatoxin accumulation was associated with storage facilities and stored maize (Robens & Cardwell, 2005; van Egmond & Jonker, 2005).

Determinants of choice such as accessible, re-useable interventions and visible effects in interventions increased diffusion and adoption of aflatoxin reduction interventions. Pic bags are being diffused more than the normal sacks because they are reusable for the next season. Pic bags were purchased between KES. 250 to KES. 300 which were usually expensive but locally available to the farmers. 27 out of 100 farmers, equivalent to 27% who adopted ARI for storing household food, could easily identify the benefits of pic bags. Pic bags reduced weevils in maize produce and were accessible from the local agro dealer. Only one farmer used a metal silo, a modern intervention to store maize produce. Other ways for storing household food which were not recommended due to sanitation were being adopted including an open granary outside and on the roof of the granary.

Table 17: ARI adopted at storage for household food

		Frequency	Percent	Valid Percent
Type	In sacks in the house/store	34	33.7	33.7
	In a heap in a room	3	3.0	3.0
	In a bamboo constructed granary with thatched/iron sheet roof outside the house	12	11.9	11.9
	In a metal silo	1	1.0	1.0
	On a raised platform indoors	21	20.8	20.8
	Outdoor plastered granary basket with lid and lower withdrawal point, raised off the ground	2	2.0	2.0
	In hermetic/ pic bags	27	26.7	26.7
	On a raised brick granary outdoors	1	1.0	1.0
	Total	101	100.0	100.0

Source: field data, 2017

Proper storage was recommended through maintaining dryness and sanitation to avoid accumulation of aflatoxin in maize produce. Farmers who adopted ARI during storage used acetylic to preserve maize because it was readily available in local agro dealers. Findings show farmers were also innovative in adopting other traditional interventions as shows in table below. They study shows 11 out of 101 farmers, equivalent to 11% are at greater risk as they did not adopt any intervention during storage.

Table 18: ARI adopted during storage

		Frequency	Percent	Valid Percent
Interventions	Nothing at all	11	10.9	12.8
	Ash	8	7.9	9.3
	Commercial stored grain pesticide (acetylic) or other commercial stored grain pesticide	36	35.6	41.9
	Stored untreated sealed bags to kill insects	15	14.9	17.4
	Continuous sanitation	16	15.8	18.6
	Total	86	85.1	100.0
Other	Aerated store Ash Continuous sanitation Dry maize on the sun Drying on the sun I sell stock quickly to reduce storage time Oil the granary stand Place plastic sheet on top of the granary Raised platform Smoking	15	14.9	
Total		101	100.0	

Source: field data, 2017

After storage, food safety is crucial. Farmers suggested drying maize on the sun between “two months” and “three months” during and after storage as the best option. 46% of the farmers, that is 46 out of 101 farmers interviewed, store household food in untreated pic bags while 34%, that is 36 out of 101 farmers interviewed, do not have ways to protect household food after storage period and even after exceeding storage period. This puts household vulnerable to food loss and unsafe food.

The study found that food processing such as fermentation and smoking were not practiced by farmers as suggested by Kirui *et al*. (2014) and Muthomi *et al*. (2005) which highly reduces aflatoxin concentration by up to 93% (Hell and Mutegi, 2011).

Small holder farmers did not know how to monitor effects of traditional interventions in reducing moisture content and in reduction levels of aflatoxin. The study identifies the need to introduce measurable interventions. The most common intervention, traditional drying reduced moisture content but could not guarantee less than 13% moisture content. The government extension services identified this gap and invested on modern aflatoxin reduction interventions which are leased freely to all farmers. They include indoor storage, raised with enough ventilation; a maize drier which driers maize faster; a moisture meter used to measure moisture content; and drilled boreholes on areas where aflatoxin was found to be in water sources[10] (Nzioka, 2016). The study found that government's assistance in advancing on technology would facilitate adoption of artificial/ modern drying which was practiced in industrialized countries whom have advanced in agricultural technology (Wu & Khlangwiset, 2010).

In spite of the challenges faced with traditional interventions, the most effective intervention was a combination of traditional and modern aflatoxin reduction interventions such as hand sorting in the field; use of plastic sheet when harvesting and drying; ensuring sanitation during harvesting and storage and the use of bottle with salt which "is an alternative to moisture meter whereby a farmer uses the bottle with salt and takes a handful of his grain to measure if there is moisture. An indication of moisture would be wet salt."

A combination of both modern and traditional intervention has been supported by African literature and in this case refers to an integrated approach. Aflasafe KE01 is the only modern intervention that promotes integrated approach with good agricultural practices and directly prevents aflatoxin producing fungus to produce in soil. Its integration with other interventions such as Pic bags has gained popularity Meru and Makueni Counties and National government in Kenya. Integrated approach to food safety is more than the type of interventions being adopted. It is also about the processes involved from the soil to the plate.

4.3.3 Access and application of intervention

The study showed that factors that determined access to interventions are different than factors needed in applying for the intervention. In accessing interventions, farmers preferred

[10] Key informant interviews, 2017. Verbatim from qualitative research.

interventions that were readily available and were able to understand where to locate them as shows in table 19. For instance, Pic bags have been adopted even though they were expensive because they were locally available and the manufacturer had promoted the bags in groups, *barazas* and church.

Table 19: Factors affecting access to aflatoxin reduction interventions

Factors affecting access to ARIs	Number of farmers proposed	Rank 1 being most important 2 being slightly important 3 being least important
Knowledge about how to access	79	2
Locally available intervention	83	1
Extra money to purchase	71	
Advice/ Trainings from social groups/ community/ neighbor/ extension officers	75	3
Knowledge about the effects of the intervention	69	

Source: field data, 2017

Accessing interventions before applying was important to farmers. Farmers find knowledge and trainings from social networks most important in applying after accessing the interventions.

Table 20: Factors affecting application of aflatoxin reduction interventions

Factors affecting application of ARIs	Number of farmers proposed	Rank 1 being most important 2 being slightly important 3 being least important
Knowledge about the use of the intervention	83	1
Materials available to apply/ construct	67	3
Money to apply/ construct	61	
Advice/ Trainings from social groups/ community/ neighbor/ extension officers	74	2
Knowledge about the effects of the intervention	66	

Source: field data, 2017

The study found that availability of knowledge on new technology and how aflatoxin would be identified and be controlled would directly curb aflatoxin in soils and maize. This study agrees with the proposition that complete information towards the aflatoxin problem and its interventions are the main determinants of choice in reducing uncertainty and increase adoption of aflatoxin reduction intervention as noted in Marechera and Ndigwa (2014) and Shier *et al*. (2005) findings. Knowledge and learning were the primary factors in both access and application of interventions hence noted by Cardwell and Henry (2005) literature.

Other determinants of choice, with or without complete knowledge, access, cost and time. Therefore, the study accepts the proposition that small holder farmers adopt Aflatoxin Reduction Interventions that are easily accessible and cost-effective (Shier *et al*., 2005). The study disagrees that adoption occurs only with complete information. The empirical data show that traditional interventions have increasingly been adopted due to incomplete knowledge of modern aflatoxin reduction interventions.

4.4 Role of social networks in adoption and rejection of Aflatoxin Reduction Interventions

The study found that the social networks were a source of knowledge, ideas and adoption of aflatoxin reduction interventions. This was influenced by high level of farmers' participation in a social network through leadership, trainings and constant interactions with group members. 41 out of 68 farmers who had joined one social network have benefitted from knowledge related aflatoxin reduction interventions in their groups. Only 6 out of 29 farmers who had joined two social networks transferred knowledge on aflatoxin reduction interventions while 6 out of 11 farmers with three social networks were beneficial towards adoption and 1 out of 2 farmers who had four social network benefitted towards adoption. Social networks were found to be avenues for transfer of knowledge and facilitated adoption of new and modern aflatoxin reduction intervention.

4.4.1 Avenues of knowledge sharing

The study showed that open discussions and space for trainings are the most common ways that social networks transferred knowledge to the members. Member farmers said, "Trainers trained our group on diverse knowledge on farming."[11]

Social networks acted as avenues for sharing knowledge on the nature of aflatoxin, its effects on health, as well as how to reduce it in farm and keep maize food safe. Farmers in social network gained more knowledge about the nature of aflatoxin than farmers without social networks. "I am

[11] Focus group interview 1, July 2017. Verbatim from qualitative research

aware of health problems related to aflatoxin and its occurrences in my area; aflatoxin is poisonous and has health effects such as stomach pains." Farmers in social networks shared ideas and are aware that "their maize produce are free from aflatoxin" because they "know about aflatoxin and how to control it."

In social networks, new interventions were promoted, trainings were received and there was a collective action to adopt pic bags and improved maize which were interventions that indirectly controls aflatoxin accumulation before, during and after storage. Among the farmers interviewed, they said, "I knew and received Pic bags from the group; I have pic bags for preserving food, so far I have saved 20kg maize food. In addition, "I know about improved maize varieties; where to find fertilizer in the market." Farmers gained knowledge on how to improve the practices for effective use of the interventions, "I learnt proper drying of maize and proper storage; learnt how to use chemical to control it and how to use plastic sheet for drying with proper sanitation."

The study showed farmers shared cost burden associated with modern aflatoxin reduction interventions. A farmer suggested, "People should form groups to collectively lease a moisture meter when needed, it is not affordable to buy as an individual." To transfer knowledge, "We have set field days where we share good agronomy practices among ourselves."

The study found out that social networks transfer information internally, that is from one group member to the other in the same network and externally though group members sharing information outside their social network. As a result of these trainings, farmers are confident enough to train others in their neighborhood, "Am now a trainer of trainees in promoting aflatoxin reduction interventions in other groups and can protect my children." Farmers noted social networks' interaction had become more beneficial than the individual conversations outside the group.

Social groups are avenues to empower members with not only knowledge but also on social welfare such as education for children. 75 social networks were identified by the farmers. Of these 75 social groups, 42 social groups do not transfer knowledge related to aflatoxin and aflatoxin reduction interventions.

It was noted that the group with external association was more likely to transfer new knowledge and facilitate new ideas other than the social network without any external association. One of the social network in a focus group discussion had associated with a non-governmental organization, Food Agricultural Organization while half of the members in each social network had an average of 1 more group that was not directly associated with the current group. As a result, they transferred ideas to the current group on the value of collective action in savings. Social networks which have partnered with external association such as Food Agricultural Organization (FAO) and Kenya Agricultural and Livestock Research Organization (KALRO) benefitted from receiving improved maize variety for planting; new interventions such as Aflasafe KE01[12]; learnt about good agricultural practices; sufficient drying of maize.

Other social networks in focus groups had no association with other social networks while members had an average of 1 group that had no association with the current group. The transfer of information and ideas were shared externally by the members to their family, neighbors and other group members but did not benefit the current group in the sharing of knowledge.

To conclude, social networks are the source of communal leaning and knowledge sharing. The empirical data added to Bankole & Adebanjo (2003) literature on communal learning and knowledge sharing as a facilitator of complete information for adoption of aflatoxin reduction intervention.

4.4.2 Interactive leaning

The study showed that farmers applied the knowledge given through interaction and hence led to adaptive learning. Farmers in social networks were taught about good agronomy practices as an integrated approach to control aflatoxin from planting to post-harvest handling to the plate. These practices include how to plant and harvest; how to store produce; use of chemicals; how to dry; how to use manure; the use of pic bag; and crop production and food safety practices. In crop production, 79 farmers out of 101 farmers, equivalent to 78% interviewed, received trainings in crop rotation and improved maize varieties, fertilizer and farm yard manure.

Few farmers, approximately 7, were trained on herbicide. None of the farmers were trained on Aflasafe KE01. In post- harvest handling, 82 farmers out of 101 farmers, equivalent to 81% interviewed, received training on post-harvest handling. The most trained topics in social

[12] Key informant interview, July 2017. Verbatim from qualitative research.

networks are pic bags which are improved storage bags available in local agro dealers; followed by drying of maize using a plastic sheet; use of chemical application; timing of harvest; improved storage facility by raising store from the ground and dry; sanitation during harvest; sitting bags away from walls; mechanized thresher; hand sorting; pest and disease identification; fumigation through use of ash and metal silo.

In management, 11 farmers out of 101 farmers, equivalent to 11% interviewed, received training on ensuring proper sanitation through transport of crop produce from farm to household; followed by milling of maize.

Source of trainings

In the study, the common source of trainings was the social networks. A farmer in social network adds, “We have been taught by agricultural extension officers and public health department about the causes of aflatoxin and how to manage it. We have also been shown how to use the best fertilizer for our soil.” The study shows that government extension officer works with groups where they are most likely to meet a large group of farmers than meeting individual farmers in their homestead which usually saves time.

The study adds that with time, media such as ‘Kilimo Biashara’ has gained popularity as avenues for trainings among individuals without social networks. Another source of trainings are the interactions between farmers and people who are close to him frequently such as family, friend and neighbors.

According to literature, the question on farmers’ capacity to modern agricultural intervention had brought about several debates on the right approaches for small holder farmers. The study findings encouraged a bottom up approach to learning where social networks improve farmers’ traditional values such as communal learning and livelihoods from personal relationships and external associations (Chambers, 1983).

4.4.3 Farmers’ capacity to learn and adapt

The study measured the ability and level of farmer’s participation. The social economic background of a farmer influenced their level of participation. Females participate more in social networks than males. 54 out of 72 females, equivalent to 75% interviewed and 14 out of 29 males, equivalent to 48% interviewed joined social networks. The relationship between gender and joining social network is positive (0.045). The number of 28% males and 29% females who joined the second networks have a relationship of r =0.447. The relationship between gender and social networks decreases in third to fourth social group. More male farmers joined three up to four groups.

In training, farmers were actively engaged in writing notes and where possible, observing from the trainer; other farmers gave ideas, asked questions or commented during the training. The most beneficial were field demonstrations in the farm and volunteered host.

There was a positive relationship of r = 0.296 between the level of education and how involved farmer were in social networks. 33 out of 40 farmers who gone to school, had completed secondary school participated in social networks and were more actively engaged planning and hosting the trainings than 28 out of 38 farmers who gone to school, had completed primary school education. The number of farmers who completed tertiary were few that is 13% hence less statistical significance in their participation of social networks. The study noted that the relationship between education and participation to social network was weak. It depended on other socio-economic characteristics of the farmers such as ability to carry the cost burden.

The study shows farmers' uncertainty as an inhibitor towards the adoption of interventions. 73 out of 79 farmers, equivalent to 73% applied the trainings received in crop production. Those who did not apply the training on crop production showed uncertainties; they had low ability to purchase and use interventions: such as improved maize varieties and fertilizer hence they substituted with locally improved seeds and farm yard manure. Others could not apply crop rotation because they had little acreage to plant. Uncertainties were also caused by social beliefs such that improved maize varieties were believed to have low productions and need a lot of rains which were very limited in the area. A farmer claimed that *mbuka* was caused by improved maize. 16 out of 73 farmers, equivalent to 22% who applied had high uncertainty of the interventions they had used.

79 out of 82 farmers, equivalent to 78% applied the trainings received in post- harvest training but not all interventions. 10 out of 10 farmers, equivalent to 100% who applied trainings on transport and milling in crop management. For those who did not apply trainings on post- harvest handling, they said the modern interventions were expensive, "Pic bags are expensive." Others

believe that since they produce for subsistence, then they do not need to use "acetylic." 18 out of 79 farmers, equivalent to 22% who applied had high uncertainty of the interventions they used. A number of reasons included as shown in table 21 below.

Table 21: Farmers' reasons for uncertainty

Reasons	**farmers' descriptions**
Unsatisfactory	*Acetylic does not easy wash out after its usage period*
	The pic bags being promoted do not control aflatoxin
	Improved maize seeds do not yield well with little rains
	Am too busy to do crop rotation
	Have small land hence cannot practice crop rotation
High cost	*I harvest little amount of maize so I do not use acetylic*
	Cannot afford pic bags
	Cannot afford proper sanitation during harvest
	Do not know to improve storage facility
	Cannot afford to improve my storage facility
	Cannot afford Improved maize seeds
Lack of knowledge	*Do not know the how to use mechanized thresher*
	Am not confident about the metal Silo;
	Do not know how to use the maize drier
	Do not know how to ensure sanitation during harvest
	Improved maize seeds with chemicals cause 'mbuka'
Lack of available interventions	*Maize drier is at the agricultural office which is too far to transport my maize*
	Improved maize seeds are not available

Source: field data, 2017

Both empirical and theoretical literature encourage "communal ownership" in reduction of farmers' uncertainty (Bankole & Adebanjo, 2003). The study finding added that social networks increase farmers' capacity to learn and adopt through communal ownership of cost, time, knowledge and modern interventions.

4.4.4 Avenues of a collective action

Social networks' acted as safe-nets. Farmer members used social networks to access loan for purchasing farm inputs for planting, expansion and diversifying farming. Of the 75 social networks identified, 39 had accessed loans to their members and 33 farmers benefitted from these loans. Farmers applied and received between Kshs.2000 to Kshs.120000. 28 out of 33 farmers' who got the loan, purchased improved seeds and fertilizer for an increase in food production; they started livestock keeping through buying more cows and cow feeds; purchased goats and poultry; planted trees and purchased water tank for vegetables. 31% were very satisfied with the benefits of getting a loan.

During planting, member farmers helped each other to prepare fields for planting like dig trenches; acquire knowledge on how to use manure to increase yields in their farms. They also unite by contributing money to buy farm inputs at a cheaper price and get knowledge on where to purchase improved maize variety and fertilizer. Only 1 group helped farmers' access to markets. This shows such knowledge is less in demand than the demand to increase yield.

The study concluded that social networks increased the capacity of farmers to participate within the networks for collection action; sharing knowledge and ideas. The study showed interactive learning, as earlier defined in literature by Andrew & Alvare (1982) increased farmers' capacity to build trust, decrease uncertainty and collectively adopt a new aflatoxin reduction interventions. Both empirical and theoretical data support that collective action in learning reduced farmers' uncertainty (Bankole and Adebanjo, 2003). Hence, the study accepted proposition that the higher the level of farmers' participation in social networks, the higher the interactive and adaptive learning where knowledge, ideas, trust and collective action facilitates adoption of Aflatoxin Reduction Interventions.

5.0 CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1 Introduction

This study was set to investigate the effects of social learning in the adoption of Aflatoxin Reduction Interventions (ARIs) in Makueni County, Kenya. The study was guided by the three research questions; first, how do social networks manifest among small holder farmers in Makueni County? Secondly, how do small holder farmers adopt Aflatoxin Reduction Interventions (ARIs) in Makueni County? Thirdly, how do these social networks influence small holder farmers' capacity to access and utilize aflatoxin reduction interventions in Makueni County? This chapter presents conclusion based on the analysis of the study findings. The chapter finalizes with recommendations for the research, development practitioners and innovators in agricultural technology; the national and county government and stakeholders.

5.2 Conclusion

The research findings arrived at a number of conclusions as per the objectives of the study. The analysis of the findings had shown social networks as sources of social learning. They manifested in personal and closely knit "set of relationship" among small holder farmers but not entirely true to define these networks as "unclear" or informal networks as noted in literature. Social networks formed in Makueni were *chamas*, cooperatives and societies. In addition, new members of the social networks knew the networks existed through personal relationships. The networks were formed locally within Mukuyuni sub-location which promoted high participation among members. They formed more formal structures to expand and sustain their networks hence social networks were dynamic in time and as per the multiple connections they had. The multiple connections were dependent on the socio economic background of the farmers such as gender, education, household capacity and responsibility. Two factors had lesser impact to the social learning in a network, which included geographical proximity and age of the member farmer. The study found out that there were challenges that inhibited the social networks' learning and flow of information; such was communication cost such as membership fee and money to pay for group's activities.

The study concluded that how social networks manifested in the community was a determinant of choice in learning and adaptive learning. The closer, personal social networks were, the higher the participation towards social learning, sharing of information and adaptive to the social economic challenges faced by the members.

The second objective of the study was to establish how small holder farmers adopt aflatoxin reduction interventions in Makueni County. According to the findings, farmers with or without social networks, adopted interventions depending on their understanding of the aflatoxin. The study noted a huge disconnect and mismatch between scientifically proven facts and social cultural knowledge and attitudes towards the aflatoxin problem. According to visual experimentation, all farmers who had aflatoxin contamination in their farm knew aflatoxin to be visible to human eye compared to the fact that aflatoxin is invisible to human eye even at high levels. Therefore, farmers' knowledge towards the aflatoxin problem and its interventions were incomplete. The use and adoption of unsuitable traditional interventions proves that farmers' have yet to adopt fully the recommended traditional and/or modern aflatoxin reduction interventions.

Small holder farmers adopted traditional interventions more than modern intervention. The factors that determined access and application of traditional and modern interventions were ranked differently in importance among them. In accessing interventions, availability of how to access these interventions, followed by knowledge on how to use these interventions and seeking advice and trainings from social networks were important. In applying interventions, knowledge about how to use it, followed by advice and trainings from social networks was crucial factors farmers considered in adopting Aflatoxin Reduction Interventions (ARI). It was clear that social networks were the common and crucial determinant of choice in access and application of modern and traditional interventions. It was also important for farmers to adopt Aflatoxin Reduction Interventions for food safety measures using an integrated approach due to the lack of awareness or incomplete information on modern interventions and the cost burden of adoption among others. Integrated approach entailed managing aflatoxin using modern and traditional interventions from planting to the plate.

Lastly, this study was set to find out how social networks influence small holder farmers' capacity to access and utilize Aflatoxin Reduction Interventions (ARI). Social networks in Makueni County are not only knowledge- based but also developmental. Therefore, social networks as a source of learning and adaptive learning are the most important factor in access and application of the traditional and modern interventions. Social networks and farmers' high participation in social networks played a role in the transfer of knowledge, trainings and adoption of ARIs. The study concludes that social networks act as safety nets and further reduce uncertainties through collectively adopting modern interventions and promoting trust and participation in sharing knowledge and ideas.

In general, the study findings were able to reach the three objectives of the study. The study further draws reference to literature by Marecherwa and Ndigwa, 2014; Wu *et al.,* 2008 and Hell an Mutegi, 2011 on the gaps that exist in adoption of aflatoxin reduction interventions. The study encourages further research in how best the small holder farmers can respond and identify an aflatoxin problem through complete knowledge and as a result, fast track the adoption of modern aflatoxin reduction interventions.

5.3 Recommendations

It was evident that adoption of modern aflatoxin reduction interventions was still a challenge in the promotion of farmer-centered approaches and participatory development. Building on interactive learning and increase in adoption of interventions will be dependent on the following: policy reforms; capacity building and promoting partnerships.

1. **Policy reforms**

This study informs policies on food safety and adoption of agricultural interventions in rural households. The policies should promote farmer centered approaches that emphasize on increasing availability and knowledge with reduced cost in access and adoption on the aflatoxin reduction interventions.

The policies should provide framework for setting up incentives on interactive learning towards improving adoption of Aflatoxin Reduction Interventions in communities and creating subsidies for modern interventions such as mechanized thresher, pic bags and new interventions such as Aflasafe KE01 which would otherwise be costly to apply to small holder farmers. There is need for subsidized farm inputs like fertilizer, chemical and maize seeds and farm services such as soil tests and trainings from non-governmental organization and individual trainers.

The policies should promote preventive, integrated approach rather than control measures when promoting food safety and agricultural technologies. Although farmers use integrated approach, there is a need to prevent aflatoxin being produced from the aflatoxin- producing fungus in the soil and further adopting improved post-harvest handling measures. Control measures of aflatoxin are not a hundred percent (100%) viable since human being cannot visibly identify the contamination hence lack the knowledge on the best intervention to use under such circumstances.

2. **Capacity building**

The transfer and use of knowledge is crucial in the adoption of agricultural intervention among small holder farmers. There should be trainings on aflatoxin and how to identify aflatoxins in maize and soils. The nature of aflatoxin and the fact that it is invisible to human eye even on high levels is still confusing for most farmers as shown in chapter 4, section 4.3. Without visible identification of the problem, farmers should be trained on general facts of fungal contaminations and maize diseases and how to identify aflatoxin in their farms.

The objective of the training should help farmers improve their confidence levels and thereon adopt modern aflatoxin reduction interventions that are much more effective and easy to measure. There is a need to show how to dry maize faster, to understand the purpose of using interventions such as pic bags, how to use chemicals, how to ensure proper sanitation and improved storage facility. In addition, farmers are looking for new technologies that would help control aflatoxin, including better drying of maize, better storage facility and how to dispose the affected maize. The use of chemicals and sacks are not enough to reduce pests and aflatoxin contamination.

There was also a need to access training to every household. Social networks showed potential to reach more small-holder farmers at a given time. Field visits and use of demonstrations are a complimentary option in transferring information even to those in the interior areas. Farmers recommend these trainings on specific periods such as planting and harvesting so as to learn how to measure moisture content and identify fungal contamination earlier.

Finally, this research should help in generating knowledge on aflatoxin management. Small holder farmers were keen to learn and satisfied with their interviews.

3. Promoting Partnership

In Kenya, we have had opportunities for partnership in facilitation aflatoxin prevention and control measures. The first being the Partnership for Aflatoxin Control in Africa (PACA) and the first conference in 2017 on post-harvest handling in Africa held in Nairobi, Kenya. These partnerships have culminated future partnerships on Aflatoxin Reduction Interventions.

There are currently new partnerships in Aflasafe KE01 which is the only preventive integrated and modern aflatoxin reduction intervention in Kenya. Aflasafe KE01 is produced by the International Institute of Tropical Agriculture (IITA) registered under Kenya Agricultural and Livestock Research Organization (KALRO) and the Government of Kenya in the buying and distribution of Aflasafe KE01 as well as other external partners such as Agricultural Research Service (ARS) of USDA, Melinda and Gates Foundation, African Agricultural Technology Foundation and Partnership for Aflatoxin Control in Africa.

County Governments of Kenya, particularly those Counties most affected with aflatoxin such as Makueni and Meru Counties should promote public and private partnerships with National Government of Kenya, research and learning institutions. Currently, IITA and University of

Nairobi have partnered with Makueni County in the promotion of Aflatoxin Reduction Interventions and research. So far, University of Nairobi through agricultural and livestock extension officers, Mukuyuni have trained social networks in promoting Trainers of Trainees within the community who would transfer knowledge on aflatoxin and its interventions. In addition, IITA introduced efficacy trials of Aflasafe KE01 in Makueni County where small holder farmers volunteered their lands for demonstrations.

4. Recommended areas for further research

There was one concern emerging from the study that would need further research: How to promote interactive and adaptive learning in stakeholder partnerships for the adoption of modern aflatoxin reduction interventions?

REFERENCES

Abdulai, A. & Huffman, W., 2005. The diffusion of New Agricultural Technologies: The case of cross-bred cow technology in Tanzania. *American Journal of Agricultural Economics*, 87(3), pp. 645-659.

Allen, J., Dawson, S., Madsen, G. & Chang, C., 2008. A Social Relationship Response to a Proposed Coal-Fired Power Plant: Network Theory and Community Change. *Community Development*, 39(1), pp. 35-49.

Andrew, C. & Alvare, J., 1982. Adoption of Agricultural Technology: Development in Agro-socio-economic Thought. *Social and Economic Studies*, pp. 171-189.

Anon.,2001.*www.promedmail.org*.[Online]Availableat:http://www.promedmail.org//[Accessed 14 June 2015].

Ballard, T., Coates, J., Swindale, A. & Deitchler, M., 2011. *Household Hunger Scale:Indicator Definition and Measurement Guide*, Washington DC: Food and Nutrition Technical Assistance II Project, FHI 360.

Bankole, S. & Adebanjo, A., 2003. Mycotoxins in food in West Africa: current situation and possibilities of controlling it. *African Journal of Biotechnology*, September, 2(9), pp. 254-263.

Bhattacherjee, A., 2012. *Social Science Research: Principles, Methods, and*. Florida: USF Tampa Library Open Access Collections.

Browning, G., Halcli, A. & Webster, F., 2000. Understanding Contemporary Society: Theories of the present. In: *Rational Choice Theory*. London: Sage Publications Ltd., pp. 126-138.

Bryman, A., 2012. *Social Research Methods*. 4 ed. New York: Oxford University Press.

Cardwell, K. & Henry, S., 2005. Risk of Exposure to and Mitigation of Effects of Aflatoxin on Human Health: A West African Example. In: K. H. Abbas, ed. *Aflatoxin and Food Safety*. 6000 Broken Sound Parkway NW, Suite 300: Taylor and Francis Group, LLC, pp. 213-235.

CAST, 2003. *Mycotoxins: Risks in Plant, Animal, and Human Systems*. USA: Council for Agricultural Science and Technology.

Chambers, R., 1983. *Rural Development: Putting the Last First*. New York: Longman.

Clark, H., 1998. *Formal Knowledge Network: A study of Canadian Experiences*. Manitoba, Canada: International Institute for Sustainable Development.

Crean, D., 2013. *Managing Mycotoxin Risks in the Food Industry: The Global Food Security Link.* Washington DC, International Food Policy Research Institute (IFFRI), pp. 20-21.

David, G. & Sukhatm, V., 2006. The "Efficient but Poor" Hypothesis. *Review of Agricultural Economics,* 6–8 January, 28(2), p. 338–343.

Emmott, A., 2013. *Market-led Aflatoxin Interventions: Smallholder Groundnut Value Chain in Malawi.* Washington DC, International Food Policy Research Institute (IFPRI), pp. 24-25.

Fandohan, P. et al., 2006. Impact of mechanical shelling and dehulling on Fusarium infection and fumonisin contamination in maize. *Food Additives & Contaminants,* 23(4), pp. 415-421.

Fandohan, P. et al., 2005. Impact of indigenous storage systems and insect infestation on the contamination of maize with fumonisins. *African Journal of Biotechnology,* 3 April, 5(7), pp. 546-552.

Feder, G., Just, R. & Zibberman, D., 1985. Adoption of Agricultural Innovation in Developing Countries: A Survey. *Economic development and cultural change*, 33(2), pp. 255-298.

GoK, 2013. *Makueni County Development Profile,* Nairobi: Government Printers.

Green, D., 2000. Small holder household at the cutting edge: appropriate technology and sustainable rural development. *Transformation,* 1 April/ June, 17(2), pp. 70-74.

Guo, B. et al., 2005. Prevention of Preharvest Aflatoxin Contamination: Integration of Crop Management and Genetics in Corn. In: H. Abbas, ed. *Aflatoxin and Food Safety.* 6000 Broken Sound Parkway NW, Suite 300: Taylor & Francis Group LLC, pp. 437-457.

Hall, A., 2009. Challenges to stregnthening agricultural innovation systems: where do we go from here?. In: *FARMER FIRST REVISITED: Innovation for Agricultural Research and Development.* Warwickshire: Practical Action Publishing Ltd, pp. 30-38.

Havnevik, K., Negash, T. & Beyene, A., 2006. Introduction to rural livelihood and governance issues. In: *Of Global Concern: Rural livelihood dynamics and natural resource governance.* s.l.:Sida Studies, pp. 11-25.

Hell, K. & Mutegi, C., 2011. Aflatoxin control and prevention strategies in key crops of Sub-Saharan Africa. *African Journal of Microbiology Research,* 4 March, 5(5), pp. 459-466.

IFPRI, T. I. F. P. R. I., 2013. *A policy brief on importance of diagnostics to aflatoxin control,* Washington DC: BecA-ILRI Hub.

International Society for Infectious Diseases,2001.*www.promedmail.org.*[Online] Availableat:http://www.promedmail.org//[Accessed 14 June 2015].

International Society for Infectious Diseases,2001.*Pro-Med.*[Online]Available at: http://www.promedmail.org [Accessed 4 Jan 2016].

International Society for Infectious Diseases, 2004. *www.promedmail.org.* [Online] Available at: http://promedmail.org/post/20040903.2460 [Accessed 14 June 2015].

James, C., 2003. *Global Review of Commercial Transgenic Crops: 2002 Feature: Bt Maize.* Ithaca, New York, ISAAA.

Jiang, Y. et al., 2008. Aflatoxin-Related Immune Dsyfunction in Health and in Human Immunodeficiency Virus Disease. *Clinical and Developmental Immunology*, 18 March, 2008(790309), p. 12.

Kadushin, C., 2004. [Online] [Accessed 29 August 2016].

KALRO & IFPRI, 2010. *THE AFLACONTROL PROJECT: REDUCING THE SPREAD OF AFLATOXINS IN KENYA*, Kenya: Kenya Agricultural and Livestock Research Organization, The International Food Policy Research Institute.

Kenya National Bureau of Statistics (KNBS); United Nations Children's Fund (UNICEF). , 2009. *Makueni District Multiple Indicator Cluster Survey 2008*, Nairobi: KNBS and UNICEF.

Kiswii, T. et al., 2014. Efficacy of selected medicinal plants from Eastern Kenya against Aspergillus flavus. *Journal of Plant Sciences*, 30 October, 2(5), pp. 226-231.

KNBS, 2013. *Statistical Abstract 2013*, Nairobi: Kenya National Bureau of Statistics.

Kumar, G. & Popat, M., 2010. Assessment of Adoption Gaps in Management of Aflatoxin Contamination of Groundnut (Arachis Hypogaea L.). *The Journal of Agricultural Education and Extension*, 3(16), pp. 309-319.

Legesse, B., 2006. Risk perceptions, risk minimizing and coping strategies of small holder farmers in the eastern highlands of Ethiopia. In: *Of Global Concern: Rural Livelihood Dynamics and Natural Resource Governance.* s.l.:Sida Studies, pp. 47-79.

Lubulwa, A. & Davis, J., 1994. *Estimating the social costs of the impacts of fungi and aflatoxins in maize and peanuts.* Australia, Proceedings of the International Working Conference, pp. 1017-1042.

Marechera, G. & Ndwiga, J., 2014. Farmer perceptions of aflatoxin management strategies in lower Eastern Kenya. *Agricultural Extension and Rural development*, December.6(12).

Marwel, G. & Oliver, P., 1988. Social Networks and Collective Action: A theory of critical mass. *American Journal of Sociology*, November, 94(3), pp. 502-534.

Mugenda, O. & Mugenda, A., 1999. *RESEARCH METHODS: Quantitative and Qualitative Approaches.* Nairobi: African Centre for Technology Studies (ACTS).

Muthomi, J., Njenga, J., Gathumbi, J. & Chemining'wa, G., 2009. The occurence of aflatoxin in maize and distribution of mycotoxin in maize distribution of mycotoxin production in Eastern Kenya. *Plant Pathology Journal (Faisalagad),* 8(3), pp. 113-119.

Ndiritu, C., Lynam, J. & Mbabu, A. eds., 2004. *Transformation of Agricultural Research Systems in Africa: Lessons from Kenya.* Nairobi: Michigan State University Press.

Ngindu, A. et al., 1982. Outbreak of acute hepatitis caused by aflatoxin poisoning in Kenya. *Lancet,* 1(8285), pp. 1346-1348.

Nzioki, S., 2016. *Existence of aflatoxin and aflatoxin reduction interventions in Makueni County* [Interview] (4 April 2016).

Obura, A., 2013. *Aflatoxicosis: Evidence from Kenya.* Washington DC, International Food Policy Reasearch Institute (IFPRI), pp. 10-11.

Plasencia, J., 2005. Aflatoxin in Maize: A Mexican Perspective. In: K. H. Abbas, ed. *Aflatoxin and Food Safety.* 6000 Broken Sound Parkway NW, Suite 300: Taylor and Francis, LLC., pp. 59-75.

Robens, J. & Cardwell, K., 2005. The costs of Mycotoxin Management in the United States. In: K. H. Abbas, ed. *Aflatoxin and Food Safety.* 6000 Broken Sound Parkway NW, Suite 300: Taylor & Francis, LLC, pp. 1,10.

Rogers, E., 1983. *Diffusion of Innovations.* 866 Third Avenue, New York,: The Free Press: A Division of Macmillan Publishing Co., Inc..

Science Africa, 2010. Aflatoxin: Kenya's Pending Health Disaster. *Africa's leading publication on Science, Innovation and Development,* July-August, Volume 11, pp. 1-2.

Scott, J., 1988. TREND REPORT SOCIAL NETWORK ANALYSIS. *Sociology,* Februrary, 22(1), pp. 109-127.

Shepherd, G., 2005. Aflatoxin and Food Safety: Recent African Perspective. In: K. Abbasa, ed. *Aflatoxin and Food safety.* 6000 Broken Sound Parkway NW, Suite 300: Taylor & Francis Group, LLC, p. 23.

Shier, T., Abbas, K., Weaver, M. & Horn, B., 2005. The Case for Monitoring Aspergillus flavus Aflatoxigenicity for Food Safety Assessment in Developing countries in developing countries. In: K. Abbas, ed. *Aflatoxin and Food Safety.* 6000 Broken Sound Parkway, NW: Taylor & Francis LLC, pp. 291-311.

Straub, E., 2009. Understand Technology Adoption: Theory and Future Directions for Informal Learning. *Review of Educational Research,* 79(2), pp. 625-649.

The International Food Policy Research Institute, 2013. *A policy brief on importance of diagnostics to aflatoxin control,* Washington DC: BecA-ILRI Hub.

Thompson, J. & Scoones, I., 2009. *Farmer First Revisited: innovation for agricultural research and development.* Warwickshire: Practical Action Publishing Ltd.

Thuo, M. et al., 2013. Social Network Structures among Groundnut Farmers. *The Journal of Agricultural Education and Extension,* 19(4), pp. 339-359 .

Turner, P. et al., 2005. Reduction in exposure to carcinogenic aflatoxins by postharvest intervention measures in west Africa: a community-based intervention study. *The Fancet,* 4 June, 365 (9475), p. 1950–1956.

van Egmond, H. & Jonker, M., 2005. Worldwide Regulations on Aflatoxin. In: *Aflatoxin and Food Safety.* 6000 Broken Sound Parkway NW, Suite 300: Taylor & Francis LLC, p. 78.

Walker, S. & Davies, B., 2013. *Farmer Perceptions of Aflatoxins: Implications for Interventions in Kenya.* Washington DC, International Food Policy Research Institute, pp. 22-23.

Windham, G. et al., 2005. Techniques Used to Identify Aflatoxin-Resistant Corn. In: *Aflatoxin and Food Safety.* 6000 Broken Sound Parkway NW, Suite 300: Taylor & Francis Group, p. 407.

World Bank, 2007. *World Development Report 2008: Agriculture for Development.* Washington DC 20433: The World Bank.

Wua, F. & Khlangwiset, P., 2010. Health economic impacts and cost-effectiveness of aflatoxin reducing strategies in Africa: Case studies in biocontrol and post harvest interventions. *National Institute of Health,* April, 27(4), p. 496–509.

Wu, F. & Khlangwiset, P., 2010. Costs and efficacy of public health interventions to reduce aflatoxin–induced human disease. *National Institute of Health,* July, 27(7), p. 998–1014.

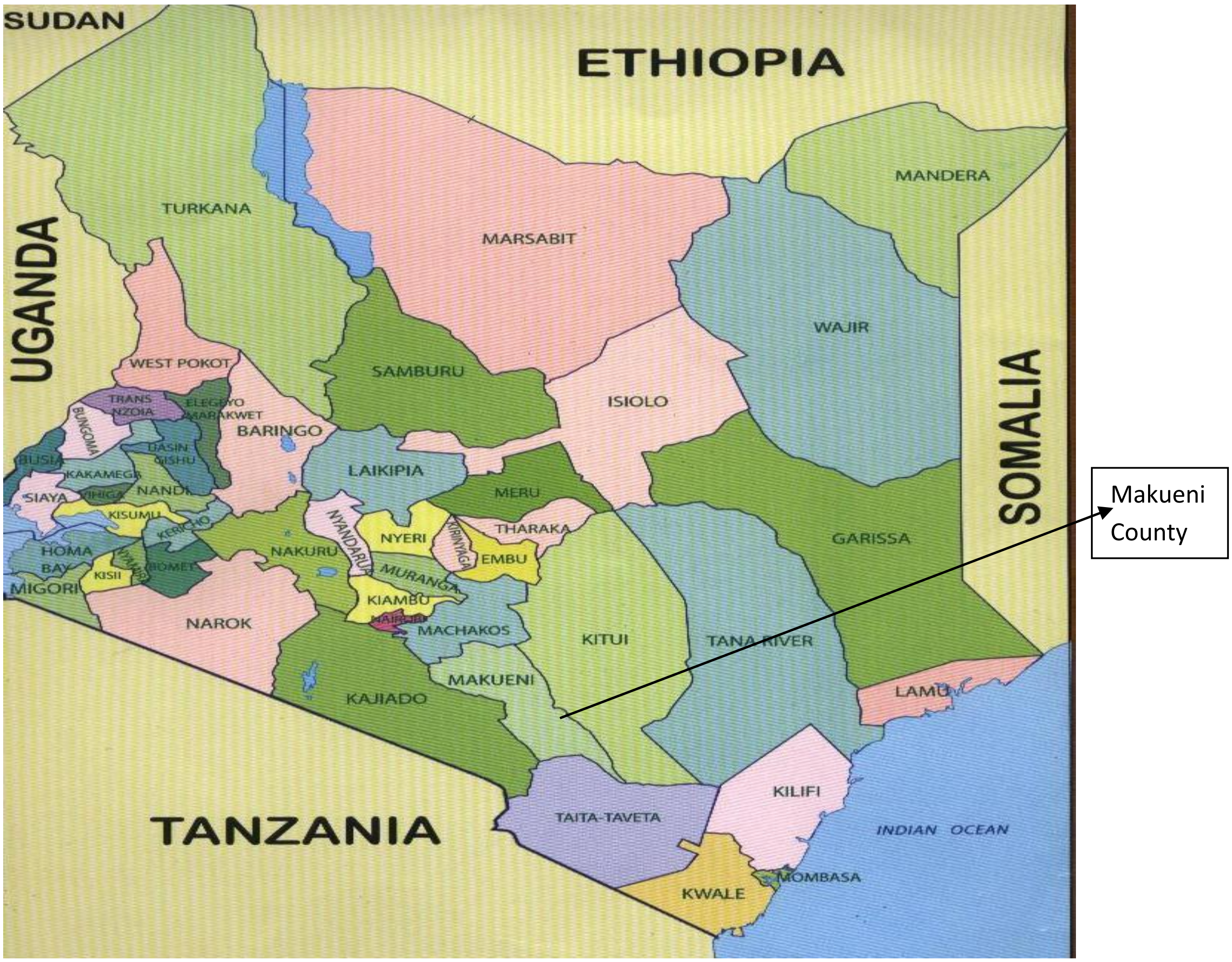
Wu, F. & Khlangwiset, P., 2010. Evaluating the technical feasibility of aflatoxin risk reduction strategies in Africa. *Food Additives & Contaminants: Part A,* 27(5), pp. 658-676.

Wu, F., Liu, Y. & Bhatnagar, D., 2008. COST-EFFECTIVENESS OF AFLATOXIN CONTROL METHODS: ECONOMIC INCENTIVES. *Toxin Reviews,* Volume 27, p. 203–225.

Wu, F., Miller, D. & Casman, E., 2005. Bt Corn and Mycotoxin Reduction: An Economic Perspective. In: H. Abbas, ed. *Aflatoxin and Food Safety.* 6000 Broken Sound Parkway NW, Suite 300: Taylor & Francis Group LLC, pp. 459-482.

Appendix 1: Map of Kenya

Figure 2: Map of Kenya showing location of Makueni County (Source: Census 2009)



RESEARCH INSTRUMENTS

Appendix 2: Semi-structured Questionnaire

FARMER/INDIVIDUAL QUESTIONNAIRE
PARTICIPANT'S CONSENT Hello. My name is Elizabeth Ngotho; a student at the Institute for Development Studies in University of Nairobi. I am carrying out a study on the role of social networks in adoption of Aflatoxin Reduction Interventions. The findings of this study will be used for academic purposes. I would appreciate if you spare a 25 minutes to answer questions. All information collected will be treated as confidential. Do you agree to participate in the survey? Thank you (*If interviewee accepts continue, if not repeat the same random selection until you find the 5th household*)

Survey No._____Date of the Interview:__/____/_ **1. STUDY SITE INFORMATION** *(to be completed by interviewer)* 1.1 County: _______ 1.2 Sub-County: _______ 1.3 Sub- Location: _____ 1.4 Village: _____	**Let's Begin by recording some information about you?** *(to be completed by interviewee)* **2. BACKGROUND INFORMATION** 2.1 Name of Farmer: _______ 2.2 Gender: (*circle as appropriate*) _______ Male Female 2.3 Age : *(circle as appropriate)* _______ <=25 26-35 36-45 46-65 >=66 2.4 Proportion of land planted maize _____acre

2.6 Level of Education of respondent (Highest education level attained) _________________

1= Primary 2=Secondary 3=Tertiary 4=Adult literacy classes 5= none

2.7 Household head Sex F= **F** [ ] M= M [ ]

	Male	Female	Total
2.8 Number of household members?			

SECTION A: NATURE OF SOCIAL NETWORKS

3.1) Which social networks are you a member of? (*includes individual and group-if individual-name relations; if group-write name*)	3.2. Which year did you join this social network?	3.3. How did you know the existence of this social networks? 1. from a non-member friend 2.from member friend 3. In church 4.from chief's meetings 5. My neighbor joined 6. observed the benefits by others 99. Others 9999.Not applicable	3.4. How often does the social network meet? 1. Daily 2. weekly 3. Monthly 9999.N/A	3.5. What were the requirements for joining the3se social networks 1. Membership age limit 2. Membership fee 3. Attend meetings 4. Pay money to start group's activity 5. Be a farmer 6. Education (specify) 99. Others (specify) 9999.N/A	
1.				i)	ii)
2.				i)	ii)
3.				i)	ii)
4.				i)	ii)
5.				i)	ii)

4.1. What is the distance between the meetings of each social networks to your house as indicated above in 3.1? ***Approx. distance to this facility*** ***(km)***		4.2. How often do you attend these meetings? 1=always 2=missed one or more meeting(s) 9999.N/A	4.3. If missed in 4.2, give reasons? 1=facility too far 2=Did not have fare to attend meeting(s) 99=Other (specify) 9999.N/A	4.4 How satisfied are you with the group meetings? 1= not satisfied 2= moderately satisfied satisfied 3= very satisfied 9999.N/A
1				
2				
3				
4				
5				

SECTION B

We have been having cases of contamination of maize harvest, farmers getting sick and even die from aflatoxin (local name…***mbuka***) poisoning in the previous years here.

5.1) Have you heard of any cases of aflatoxin contamination on crops, sickness and death in your area?

YES ____NO ____

5.2) If yes, please tell me, what occurred in your area?

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………..

6) Has the aflatoxin exposure occurred in your farm (field/during drying/shelling/ storage)?

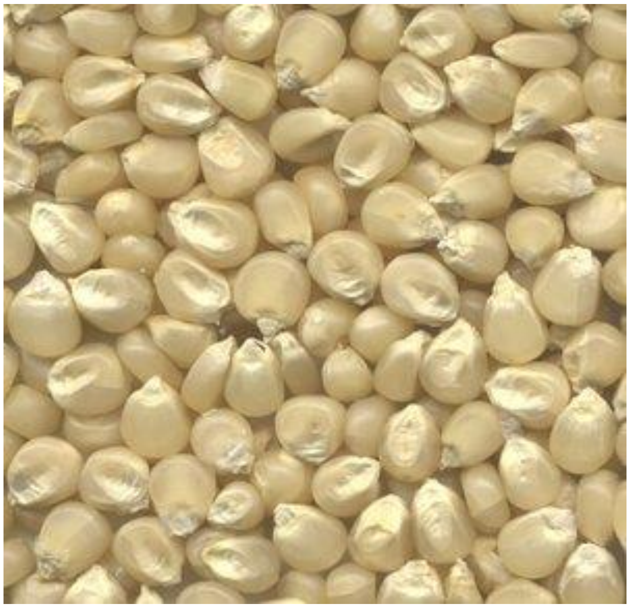
YES ____NO ____

6.1) If YES;

6.1) Which picture of MAIZE grain as provided in the *four photo grid* appear like the following photo provided in the *tool photo sheet? (Photo sheet of maize cob with possible contamination of the fungus producing aflatoxin in appendix 5)* Photo credit: Karanja, KARI		Record letter from sheet ____
6.2) (***Use the four photo grid of maize grain provided and show it to the farmer)*** Which picture of MAIZE grain looks most like the maize you placed in your store at the BEGINNING of the storage season in <u>2016</u>?		____
6.3) (***Use the four photo grid of maize grain provided and show it to the farmer)*** Which picture of MAIZE grain looks most like the maize you had in your store at the END of your <u>2016</u> storage season?		____
6.4) What could be the CAUSE of the change of this maize grain? ***(make reference to the above questions 6.2 and 6.3)***		________________
6.5) (***Use the four photo grid of maize grain provided and show it to the farmer)*** Think back to the MAIZE crop you had in store at the end of the 2015 storage season. Which picture of MAIZE grain looks most like the maize you had in your store at the END of your <u>2015</u> storage season?		____
6.6) What could be the CAUSE of the change of this maize grain? ***(make reference to the above questions 6.3 and 6.5)***		________________

Four Photo Grid Sheet 1: Maize seeds with with/ without visible contamination of the fungus producing aflatoxin

A



B

C

D

7) Are you aware of any interventions (either traditional or modern) that can be adopted to prevent or manage such cases of contamination from happening? YES ____ NO ____

8) *Looking at the use of interventions from the beginning of your planting season to post harvest handling of maize;*

Practice → CROP ↓	**8.1) What farm inputs do you usually use when planting maize?** 1=Improved maize seeds (specify) 2= Fertilizer 3= Lime and/or farm yard manure and/or cereal crop residues 4 =Herbicide 5=Aflasafe 99=Other	**8.2) How do you harvest?** 1=place cobs with husk in sack 2=place cobs without husk in sack 3=place cobs with/ without husk on the ground 4=place cobs with/without over maize stalks 5=place cobs with/without husk on a plastic sheet 99= other (specify)	**8.3) How do you dry the crop?** 1=directly on the ground or on rocky outcrops 2=on a plastic sheet 3=on a raised platform or roof 4=Dry on the field 5=Maize driers 99=other (specify)	**8.4) How do you check if your crop is sufficiently dry and quality enough to put into storage?** 1=by looking at it 2=by squeezing or touching it 3= by using a moisture meter 4= by biting grains and testing hardness 5=by listening to sound it makes when handling it 6=hand sorting 7= I do not check 99=Other (specify)	**8.5) How do you thresh/ shell your crop?** 1=by hand 2=using a stick to beat the crop 3=using a hired mechanised thresher/sheller 99= other (specify)	**8.6) How do you store the portion of your maize meant for household food? *(Let the farmer show you)*** 1=in sacks in the house/store 2=in a heap in a room 3=in bamboo constructed granary with thatched roof outside 4= in a metal silo 5=on raised platform indoors 6=outdoor plastered granary basket with lid & lower withdrawal point, raised off ground 7= in hermetic/ pic bags 8=in a raised brick-granary outdoors 99=other (specify)	**8.7) What protectant do you use to protect your crop from aflatoxin accumulation during storage?** 1=Nothing at all 2=Ash 3= Commercial stored grain pesticide (acetylic) 4=Other commercial stored grain pesticide (record product name) 5=Plant materials 6=Stored untreated in hermetically sealed bags to kill insects 7= continuous sanitation 99=Other (specify)	**8.8) How do you protect your household food from aflatoxin accumulation AFTER storage?** 1=Nothing at all **2=** Stored untreated in hermetically sealed bags to kill insects 3=Fermentation 4=Milling 99= Other (Specify)
Maize								

9.1) What is the main intervention you use/ heard to reduce aflatoxin in your maize? (*Refer to question 8 on interventions*) ………………………………….

9.2) Do you need the following factors in **ACCESSING** this interventions (*refer to 9 interventions*)?			
(tick one for each row of the table; PLEASE PROBE)	1) YES	2) NO	9.2.1) If YES, Which of these factors are the most important? Rank the 3 with 1 being most important, 2 being slightly important and 3 being least important.
1=Knowledge about the how to access	☐	☐	_______
2=Locally available intervention	☐	☐	_______
3=Extra money to purchase	☐	☐	_______
4=Advice/ Trainings from social groups/ community/ neighbour/ extension officers	☐	☐	_______
5=Knowledge about the effects of the intervention	☐	☐	_______
99=Other factors: *state here* ________________________	☐	☐	_______

9.3) Do you need the following factors in **USING** this interventions (*refer to 9 interventions*)?			
(tick one for each row of the table; PROBE)	1) YES	2) NO	9.3.1) If YES, Which of these factors are the most important? Rank the 3 with 1 being most important, 2 being slightly important and 3 being least important.
1=Knowledge about the use of the intervention	☐	☐	_______
2=Materials available to apply/ construct	☐	☐	_______
3=Money to apply/construct	☐	☐	_______
4=Advice/ Trainings from social groups/ community/ neighbour/ extension officers	☐	☐	_______
5= Knowledge about the effects of the intervention	☐	☐	_______
99= Other factors: *state here* ________________________	☐	☐	_______

SECTION C: ROLE OF SOCIAL NETWORKS IN REGARDS TO ADOPTION/ REJECTION OF AFLATOXIN REDUCTION TECHNOLOGIES

10.1) Name all the social groups (as described in 3.1)	10.2) Did you expect to receive knowledge or technologies related to reduction of aflatoxin in these social networks?	10.3) If YES, which benefits did you receive?
1)	YES ____ NO ____	1) 2) 3)
2)	YES ____ NO ____	1) 2) 3)
3)	YES ____ NO ____	1) 2) 3)
4)	YES ____ NO ____	1) 2) 3)
5)	YES ____ NO ____	1) 2) 3)

11.1) Have you received any training in crop production and post-harvest management? Yes = Y; No=N

Training topic	11.2) If YES in 13.1, which topics have you been trained on? ***Tick***	11.3) Who provided training (*see codes below)*	11.4) Year of training	11.5) How were you involved in each training given? (*see codes below)*	11.6)Satisfaction with training 3=Very satisfactory 2=Fairly Satisfactory 1=Not satisfactory	11.7) Have you applied the knowledge? yes=Y, No=N	11.8) If not applying knowledge, why not? 1=Don't know the technology well 2=Not confident to use it 3=Cannot afford it 4=Inputs not available 5=Cultural reasons 99= Other (specify)
CROP PRODUCTION							
Crop rotation							
Improved maize varieties							
Fertilizer placement							
Lime / farm yard manure and/or cereal crop residues							
Herbicide							
Aflasafe K01							
POST HARVEST HANDLING							
Timing of harvest							
Sanitation during harvest							
Drying – raised platform/mat/ local moisture assessment/ Moisture meter							
Siting of bags – raised, away from walls							
Improved storage facilities – no leakage, aerated, raised, clean							
Mechanized thresher							
Pest/disease identification							
Fumigation – local materials (ash, neem, tephrosia, tobacco, smoke)							
Chemical application – (Acetylic)							
Hand sorting/traditional dehulling/							
Improved storage bags- hermetic/pic bags							
Metal Silo							
MANAGEMENT							
Transportation practice							
Natural Fermentation							
Milling							

Information provider		Involved
1=Farmer – Group member 2=Farmer - Family/friend/neighbour 3= Local leaders in group 4=Local leaders outside group 5=Seed company in group 6=Seed/Fertilizer company outside group.	7=Brochures/pamphlets in group 8= Brochures/pamphlets outside group 9=University/Research institution in group 10=see code 9 but outside group 11=NGO/Faith based Groups in group 12=See code 11 but outside group 13= Government/Agricultural/Livestock Extension Officer in group 14= Government/Agricultural/Livestock Extension Officer outside group 99= Other (Specify)_________________	1=Requested training 2=Requested trainer 3=Planned venue/host 4=wrote minutes/notes 5=Gave ideas/Ask questions/Comments during training 99=Other (Specify)

12) Would you say you actively involved with the activities of the groups you have joined?

YES ____NO ____

12.1) If YES, How do you participate? ……………………………………………………….

13) Do you hold any leadership positions? Yes = Y; No = N 3 years ago [ ] this year [ ]

14.1) Did you **try to get any <u>agricultural</u> cash credit in your social network**? Y=Yes; N=No [ ]

14.2) From which network was the credit sought? ***(if individual-name relations; if group-write name)***	14.3) Amount applied for	14.4) Intended use of the credit 1= Input purchases 2=Inputs on post- harvest handling 99=Other (specify)	14.5) Did he/she **receive** the credit? Y=Yes N=No	14.6) If he/she **received** the credit, how much was received?	14.7) Are you satisfied with the credit facility? 3=very satisfied 2=fairly satisfied 1=not satisfied	14.8) If you have been denied credit what was the main reason? 1= no guarantor; 2=no savings in group; 3= lack of records; 4= lack of business proposal; 5= still had debt to pay off; 8 = income is low and unable to repay; 9 = project was too risky; 99=Other; 999= I don't know reason

(Interviewer) We have finally reached the end of the interview. We would like feedback about the questions asked and the study in general.

I) Did you find any question difficult to answer/ uncomfortable to answer? YES NO

II) If Yes, Why did you find it difficult to answer/ uncomfortable to answer?

___

III) Any other question or comments or recommendation?

___

THANK YOU FOR YOUR TIME AND PARTICIPATION.

Appendix 3: Focus Group Interview Guide

INTERVIEW GUIDE
INTRODUCTION Hi. My name is Elizabeth Ngotho; a student at the Institute for Development Studies in University of Nairobi. I am carrying out a study on the role of social networks in adoption of Aflatoxin Reduction Interventions. The findings of this study will be used for academic purposes. I would appreciate if you spare a one hour to discuss. All information collected will be treated as confidential.

Guide No._____Date of the Interview:__/___/_____

1. STUDY SITE INFORMATION

(To be completed by interviewer; Ask and use note book for discussion notes)

1.1 County: _______

1.2 Sub-County: _______

1.3 Sub- Location: _____

1.4 Village: _____

2. GROUP'S BACKGROUND

Let's start by understanding the origin of this group…

2.1 Name of the group:

2.2 Number of participants in the discussion?

2.3 a) What year was the group formed?

b) Why was the group formed then (year formed as per 2.1)? *Give me at most 3 reasons*

c) Are they the same reasons you have this year (2017)? 1=Yes 2=No [__]

d) If No, What are the reasons to form the group this year (2017)?

2.4 a) How many members does the group have currently?

b) Are you more or less members?

c) What is the reason for the change?

d) What is the requirement for a person to join?

d1) who brought up the idea of requirement?

d2) how did they come up with the requirement?

2.5 How many among you (by a show of hands) joined because: your neighbor joined? __ Out of __

b) Your family joined? __ Out of __

c) From observing group's benefit as a non-member? __ Out of __

2.6 a) how many times does the group hold meeting annually?

b) Where do you hold the meetings?

b1) generally, do you hold meetings within the village, ward or location?

3. AFLATOXIN PROBLEM

There have been cases of aflatoxin (local name…..) in this ward; affecting maize (such as this-show photo of maize affected by aflatoxin) and resulting to death from poisonous foods.

3.1 a) Have you heard of any cases of aflatoxin exposure in your group, either by a group member or someone outside your group?

b) What were the factors that caused aflatoxin exposure in those cases?

c) What were the effects of the exposure with the member/ farmer/ household? (Probe and note down effects of aflatoxin on households, food consumption and general well-being)

3.2 a) how many times have this cases occurred?

3.2b) what did you do as group to assist in these cases? (Describe how they access and how they applied)

3.3 What factors facilitates access and application of group interventions to curb aflatoxin problem?

3.4 What factors hinders access and application of group interventions to curb aflatoxin problem?

4. GROUP'S CONTRIBUTION TO KNOWLEDGE AND SKILL

4.1 a) Does the group hold any association with any other group/ individual/ institution/ NGO/ government initiative? Y=Yes N=No [__]

b 1) if yes, which ones (namely)?

b 2) who had the idea to join each (b1) association?

b 3) what are the contributions of each association in this group?

4.2 a) Does any member of the group hold any association with any other group/ institution/ NGO/ government initiative? 1=Yes 2=No [__]

b 1) if yes, which ones (namely)?

b 2) What did you learn from each association?

b 3) How did you personally contribute to curb aflatoxin problem in this group from each association?

b 4) At what point (time/ during aflatoxin exposure) did you share the idea learnt?

4.3 a 1) Has anyone else in this group shared any knowledge of aflatoxin problem? *(Include name of the person)*

a 2) And Aflatoxin Reduction Interventions?

a 3) how did you do about sharing knowledge with your group members?

a 4) what did it take for you to share knowledge with your group members?

5. RECOMMENDATIONS

We have reached the end of the interview.

THANK YOU FOR YOUR PARTICIPATION

Appendix 4: Key Informant Interview Guide

INTRODUCTION
Hi. My name is Elizabeth Ngotho; a student at the Institute for Development Studies in University of Nairobi. I am carrying out a study on the role of social networks in adoption of Aflatoxin Reduction Interventions. The findings of this study will be used for academic purposes. I would appreciate if you spare a 20 minutes to answer questions. All information collected will be treated as confidential.

Guide No.___Date of the Interview:__/___/

1. BACKGROUND INFORMATION

(To be completed by interviewer)

1.1 County:

1.2 Sub-County:

1.3 Name of the expert:

1.4 Occupation:

1.5 Location of occupation:

1.6 Years of expertise in agriculture:

1.7 Years of experience in aflatoxin management:

2. IDENTIFY SOCIAL NETWORKS

2.1 How many networks exist in Ukia ward, Kaiti sub-location?

2.2 What is the nature of these interactions? *(Formal/ informal and characteristics for one given)*

2.3 What are the most likely requirements for joining*?*

2.4 Who are the likely members to join a social network? (*women/men, age, occupation, average income, social status, close family/friends, members within villages*)

3. AFLATOXIN REDUCTION INTERVENTION

3.1 When the last occurrence of aflatoxin in this area?

3.2 a) Which was the most affected ward?

3.2 b) How was the area affected compared to the rest of the County?

3.3 What interventions have been introduced in the area?

3.3 b) What is the purpose of each intervention?

3.3 c) How do farmers adopt the interventions?

4 a) Generally speaking, what factors affect adoption or rejection of Aflatoxin Reduction Interventions?

4b) How do the factors (at stated) affect?

4 c) How do social network affect?

5 Moving forward, do you find social networks having a key role in improving food safety in foods?

5 b) and specifically, their role in adopting current interventions?

5 c) And specifically, their role in adopting new interventions?

6. What would be your recommendations on the adoption of aflatoxin reduction interventions?

Appendix 5: Photo sheet of maize cob with possible contamination of the fungus producing aflatoxin