Country led Situation Analysis for Mitigation of Aflatoxins in Uganda

By

Food and Nutrition Solutions (FONUS) Ltd

Submitted to

Partnership for Aflatoxin Control in Africa (PACA)

July 2015

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## Acronyms and abbreviations

|  |  |
| --- | --- |
| AF-alb | Aflatoxin Album adduct |
| AfricaAIMS | Aflatoxin Information Management System |
| AS-DSIP | Agriculture Sector Development Strategy and Investment Plan |
| ATWG | Aflatoxin Technical Working Group |
| AUC | African Union Commission |
| CGE | Computable General Equilibrium Model |
| CPI | Consumer Price Index |
| C-SAAP | Country-led aflatoxin and food safety Situation Analysis & Action Planning |
| DDA | Dairy Development Authority |
| DLGs | District Local Governments |
| EAC | East African Community |
| EU | European Union |
| FAO | Food and Agriculture Organization |
| FDA | Food and Drug Administration |
| GAP  GDP | Good Agricultural Practices  Gross Domestic Product |
| GoU | Government of Uganda |
| HBV | Hepatitis B Virus |
| HCC | Hepatocellular Carcinoma |
| HPLC | High Performance Liquid Chromatography |
| HSSP | Health Sector Strategic Plan |
| IEC  KCCA | Information, Education & Communication  Kampala Capital City Authority |
| MAAIF | Ministry of Agriculture Animal Industry and Fisheries |
| MoH | Ministry of Health |
| MT | Metric Tonnes |
| MTIC | Ministry of Trade Industry and Cooperatives |
| NAFSIP | National Agriculture and Food Security Investment Program |
| NDA | National Drug Authority |
| NEMA  NFSSP | National Environment Authority  National Food Safety Strategic Plan |
| NGOs | Non Governmental Organizations |
| PACA | Partnership for Aflatoxin Control in Africa |
| ppb | Parts Per Billion |
| PVoC | Pre-Export Verification for Conformity |
| SAM | Social Accounting Matrix |
| SPS | Sanitary and Phytosanitary |
| SPSS | Statistical Package for Social Scientists |
| UBOS | Uganda Bureau of Statistics |
| UEPB | Uganda Export Promotion Board |
| UNBS | Uganda National Bureau of Standards |
| URA | Uganda Revenue Authority |
| USAID | United States Agency for International Development |
| WFP | World Food Program |
| WHO | World Health Organization |

## Executive summary

**Introduction**

The country led situation analysis for the national food safety systems with focus on assessment and economic impact of aflatoxin contamination and control in Uganda was commissioned by the Partnership for Aflatoxin Control in Africa (PACA) with financial support from the Meridian Institute. The major aim of the study was to create empirical evidence on existing aflatoxin prevalence, existing food control systems and economic impact associated with aflatoxin contamination of three major staple foods namely; maize, groundnuts and sorghum. The specific objectives of the study were to;

1. Review the country’s food safety systems and effects of aflatoxin along the main agricultural value chains;
2. Develop and use an economic analysis framework to reveal the cost of aflatoxin to health, trade and agriculture;
3. Formulate evidence based recommendations that will form part of the input into the country’s investment strategy, as well as specific investment options required for aflatoxin mitigation in the medium term and;
4. Inform the review of the National Agriculture and Food Security Investment Program (NAFSIP – Uganda), Agriculture Sector Development Strategy and Investment Plan [AS-DSIP]) as well as development of the Africa-led Aflatoxin Information Management System (AfricaAIMS).

**Methodology**

The study adopted the methodology and guidelines provided by PACA Secretariat. The study reviewed both published and un-published literature on prevalence of aflatoxins, liver cancer, Hepatitis B Virus (HBV) as well as the policies, standards and strategies related to food safety control systems in Uganda. In addition to existing literature, the study collected primary data on levels of aflatoxins in the three target crops namely; maize, groundnuts and sorghum which were selected based on vulnerability to aflatoxin contamination, production statistics and importance with respect to caloric supply, trade and consumption levels. The levels of aflatoxins in the samples collected were quantified using the Vicam Fluorometer. More information was obtained through interviews with farmers and traders who supplied the samples, District Production Officers in the study districts, key informants from Ministry of Health (MoH), Ministry of Trade, Industry and Cooperatives (MTIC) and Ministry of Agriculture Animal Industry and Fisheries (MAAIF) as well as academicians and researchers from institutions of higher learning and major hospitals in the country. The impact of aflatoxins on the key sectors of agriculture, health, trade and the rest of the economy was assessed using the Computable General Equilibrium (CGE) Model. The data used included the 2009/10 Social Accounting Matrix (SAM), secondary micro- and macro-data, and primary data collected in different agro-ecological zones of the country. Two stakeholders meetings were also held to validate the study findings.

**Key findings**

**Status of the food safety situation in Uganda**

Results of the study indicated that at the moment, Uganda does not have a single agency responsible for food safety. Instead, there is a multi-agency system scattered in key ministries (MoH, MAAIF and MTIC). MoH has the overall responsibility of coordinating food safety related issues. In this respect, MoH mandated the food safety responsibility to the Food and Drug Authority (NDA). However, in 1993, the element of Drugs was transformed into the Drugs Act (1993) under the National Drugs Authority which weakened the food component. In order to effectively undertake the food regulation mandate, NDA established a Food Desk to oversee the transformation of NDA into a National Food & Medicines Authority (NFMA) aimed at widening the regulatory scope to include, food supplements and other substances used in public health that are not explicitly provided for under the National Drug Policy and Authority (NDP/A) Act, Cap. 206 of the Laws of Uganda (2000 Edition). The NFMA bill is currently awaiting Parliament approval into an Act.

The study also established that the Food and Drug Act of 1964 that governs food safety in Uganda has not been amended since 1993. As a result, the law does not address new developments in the food industry such as food additives and contaminants most especially mycotoxins.

**Regulation of aflatoxins in Uganda**

Uganda National Bureau of Standards (UNBS) has developed aflatoxin standards for several crops/food products including maize (US EAS 2:2013), groundnuts (US EAS 57-1), sorghum (US EAS 757:2013**)** and rice (US EAS 128) among others. The Uganda standards for aflatoxins are harmonized with the East African Community (EAC) standards. The minimum allowed levels of total aflatoxin in maize, groundnuts, sorghum and rice destined for human consumption is 10 ppb. Despite the existence of aflatoxin standards for most of the vulnerable crops, there is limited enforcement of the standards. Only foods destined for export are usually tested for aflatoxins.

**Prevalence of aflatoxins in Uganda**

The study results indicated high prevalence of aflatoxins in the three staple crops studied. Aflatoxin levels ranged between 0 ppb and 3,300 ppb. The highest level (3,300 ppb) of aflatoxins was reported in maize samples from Soroti district. However, sorghum samples generally reported the highest prevalence of aflatoxins, followed by maize samples in all the districts sampled. Based on the UNBS standard of 10 ppb, 92% of the sorghum was not suitable for human consumption. For maize, 44% of the samples were not suitable for trade and human consumption. Groundnuts reported the lowest prevalence of aflatoxins with an average rejection of 12.2%. The findings of this study were in agreement with previous studies conducted on maize and groundnuts in Uganda. It should however, be noted that this study collected samples only once. There is need to collect more samples on a regular basis to ascertain the trend over an extended period of time. Information gathered from the farmers and traders indicated that the high prevalence of aflatoxins in the staple crops could be due to use of poor agronomic and postharvest handling practices, inadequate appropriate storage structures and limited knowledge on aflatoxin management among other factors. As a result, aflatoxin contamination most likely starts in the field and keeps on accumulating along the crop value chain.

**Capacity of the existing structures to provide aflatoxin safe foods to the public**

The study revealed that generally, the food quality control systems in Uganda are very weak and control systems for aflatoxins are not an exception. The government ministries and departments charged with ensuring food safety were found to be limited in both infrastructure for analyzing aflatoxins as well as financial and human resources for enforcing the existing aflatoxin standards. In Uganda, aflatoxins are only monitored for produce that is destined for export. The UNBS also monitors aflatoxin levels of imports through monitoring at boarder entry points. Equally, the private sector (traders, processors and development partners) mainly promote use of good agricultural and postharvest handling practices but lack adequate resources to monitor and enforce aflatoxin standards. The existing structures are therefore not well facilitated to provide aflatoxin safe foods to the public.

**Level of aflatoxin awareness amongst the different value chain actors**

The study established that majority of the value chain actors including extension workers, policy makers, traders and consumers were not aware of aflatoxins and their negative effects on agriculture, health and trade. Mouldy produce was traded freely in the markets and used to prepare household meals, brewing local beer (for maize and sorghum) or used for animal feeds. Poor quality (broken and shriveled) groundnuts that could not be sold as whole kernels were either milled into flour for making sauce or roasted to make paste and peanut butter. Most of the interviewed value chain actors admitted that fungal infection was a common occurrence in the staple foods but they did not associate it with health risks.

**Economic i**m**pact associated with aflatoxin contamination in maize, groundnuts and sorghum**

The study results showed that aflatoxin contamination reduces economic growth by 0.26 percent due to deterioration in productivity as a proportion of the labour force get sick with aflatoxin-related diseases. Firms that are labour intensive reduce their demand for labour whereas those that are capital intensive like the manufacturing sector increase their employment of labour so as to compensate for the reduced efficiency (productivity) per unit of labour. In other words, the output produced by labour per hour or day reduces as a result of time lost while seeking medication and taking care of the sick relatives. Total exports deteriorate by US$ 37.56 million of which agricultural exports fall by US$ 16.34 million. Grain exports reduce by US$ 7.48 million which is approximately 45% of the reduction in total agricultural exports.

Household disposable incomes fall by 0.33 percent (US$ 79.3 million) and the respective household consumption deteriorate by US$ 59.1 million. However, consumption of grains increases by US$ 2.3 million, largely due to the fall in price and excess supply of grains resulting from the rejection of aflatoxin contaminated grains in the export market. Total trade deteriorates except for the sales of the health products that increase by US$ 1.83 million during simulation period. Household consumption for domestic health commodities increase by 0.25 percent and the consumption of imported health commodities increase by 2.83 percent.

The negative impacts of aflatoxin contamination increase through time, and these manifest through: increasing aflatoxin exposure, liver cancer and HBV prevalence, surging economic productivity, increasing medical bills in the household consumption basket, and triggering a fall in exports emanating from a continuous deterioration of competitiveness within EAC community member states and the rest of the world.

**Identified gaps/challenges**

The study identified the following gaps/challenges;

1. Limited knowledge and awareness on the effects of aflatoxins
2. Limited infrastructure for aflatoxin analysis
3. Lack of an enabling policy and law on enforcement of aflatoxin standards
4. Lack of direct budget support for aflatoxin control
5. Limited coordination among the key stakeholders
6. Limited access to appropriate postharvest technologies
7. Inadequate information/data on aflatoxin exposure

**Priority areas and interventions for management and control of aflatoxins in Uganda**

The study identified five priority areas where interventions for management and control for aflatoxins could focus. The identified priority areas include and the strategies therein include,

**1.** **Production, post-harvest handling & storage**

1. Training in good agricultural (pre-harvest) and improved post-harvest handling practices
2. Increasing access to appropriate post-harvest handling technologies
3. Increasing access to appropriate storage facilities
4. Establishment of Warehouse Receipt Systems
5. Strengthening monitoring and surveillance at district levels
6. Promoting the use of bio-control initiatives

**2. Processing and marketing**

1. Training of the processors and produce dealers in quality control and quality assurance with respect to aflatoxin
2. Promote formation of cooperative societies that will enhance the financial capacity of the processors and grain traders to acquire improved postharvest and handling technologies
3. Put in place mechanisms that will promote adherence to the existing aflatoxin standards
4. Devise cost effective alternative uses of aflatoxin contaminated produce

**3. Public health management**

1. Strengthen the capacity of research institutions in aflatoxin exposure and risk assessment as well as early detection and treatment of aflatoxin related diseases like liver cancer
2. Identify the aflatoxin hotspots and the major confounding factors to enable public health managers to design practical strategies for the affected communities
3. Carry out massive HBV vaccination to reduce the increased risk of liver cancer associated with being HBV positive
4. Promote diet diversification to reduce over reliance on aflatoxin prone foods

**4. Advocacy and awareness creation**

1. Carry out massive awareness campaigns to sensitize all the stakeholders on the economic and health effects associated with aflatoxins
2. Develop a comprehensive national communication strategy that will facilitate delivery of uniform and harmonized messages
3. Advocate for prioritization of aflatoxin activities in the key government ministries of health, trade and agriculture and district local governments
4. Develop and disseminate simple but effective information, education and communication materials in different local languages

**5. Policy and regulation**

1. Mainstream aflatoxin aspects in the National Development Plan (NDP) and related plans like the Agricultural Sector Strategic Plan (ASSP) and the Health Sector Strategic Plan (HSSP)
2. Enhance monitoring and enforcement of aflatoxin standards through district authorities
3. Strengthen the food safety control systems by fast tracking the relevant policies like the food safety policy and the grain policy and ensure that aflatoxin management and control aspects are well articulated in the policies
4. Put in place standard operating procedures and codes of practice for management and control of aflatoxins
5. Establish a multi-sectoral aflatoxin management committee to oversee the integration and implementation of aflatoxin mitigation activities in the various ministries
6. Integrate aflatoxin aspects in the education curriculum at all levels of the education system

**Conclusion**

The study has revealed that aflatoxin is a major problem in Uganda. In addition, the study showed that the food control systems are weak, thereby enhancing exposure of the populace to aflatoxin effects. Therefore, there is the need to put in place deliberate strategies to manage the devastating effects of aflatoxin contamination.

## 1.0 Introduction

## 1.1 Overview of the aflatoxin problem in Uganda

Uganda is an agricultural country with over 90% of the population depending on agriculture for their livelihoods. The major staple crops produced in Uganda include maize, groundnuts, cassava, millet, sorghum and of recent, rice (UBOS, 2013). Unfortunately, all these crops are susceptible to fungal contamination with subsequent production of mycotoxins most especially aflatoxins (Sebunya and Yourtee, 1990; Kaaya and Warren, 2005; Kaaya and Kyamuhangire, 2010; Kaaya and Eboku, 2010). The contamination of food with mycotoxins in Uganda is further enhanced by the tropical climate, inappropriate agronomic and postharvest handling practices as well the limited awareness of the problems by majority of the population (Kaaya and Kyamuhangire, 2006; Atukwase et al., 2009).

Occurrence of aflatoxins in food has a negative impact on agriculture, trade and health through reduced labour efficiency, reduction in produce quality, rejection of produce in the markets, costs of inspection, impounding and disposing off of contaminated products as well as treatment of diseases associated with consumption of aflatoxin contaminated foods (Otsuk et al., [2001](#_ENREF_11)a; Jolly et al., 2007). It is estimated that Africa alone loses more than 670 million US dollars in exports to the European Union (EU) due to aflatoxin contamination (Otsuk et al., 2001b). The losses could be higher but there is no adequate information from a number of countries. Furthermore, studies have estimated that over 5 billion people in developing countries worldwide are at risk of chronic exposure to aflatoxins through consumption of aflatoxin contaminated foods (Strosnider et al., 2006; Shephard 2008). The primary disease associated with aflatoxin intake is hepatocellular carcinoma (HCC, or liver cancer) and it is estimated that about 550,000–600,000 new cases of liver cancer each year are attributed to aflatoxins (WHO, 2008). Consumption of aflatoxin contaminated foods has also been associated with stunting in children and immune suppression (Willaims et al., 2004; Khlangwiset et al., 2011).

In Uganda, no studies had been done to document the impact of aflatoxin contamination on agriculture, health and trade. However, prevalence studies conducted by several researchers indicated that majority of the staple crops like maize, groundnuts, cassava, millet, and sorghum were prone to aflatoxin contamination with levels ranging between 0 and 55 ppb (Kitya et al., 2010) and sometimes even up to 700 ppb (Kaaya et al., 2006a). Although the above mentioned studies covered specific agro-ecological zones and a limited number of crops; the findings pointed to a possibility of a high aflatoxin exposure by the Ugandan population. The situation could be worsened by limited enforcement of the existing aflatoxin standards. While Uganda has aflatoxin standards with a limit of 10 ppb in foods destined for human consumption, there is very limited enforcement of these standards at all levels of the value chain. Only a few companies engaged in production of ready-to-use therapeutic foods and the World Food Program monitor the levels of aflatoxins. However, the produce that is rejected by these companies is left in the food chain due to weak enforcement capacity (human and infrastructure).

In a bid to address the challenges associated with aflatoxins in the country, the Government of Uganda (GoU) in collaboration with the Partnership for Aflatoxin Control in Africa (PACA) commissioned a Country-led aflatoxin and food safety Situation Analysis and Action Planning (C-SAAP) to create empirical evidence on existing aflatoxin prevalence, legislation, policy and regulation and the impact of aflatoxins on agriculture, heath and trade. The situation analysis was also aimed at catalyzing strategic actions in Uganda by identifying existing programs that can integrate aflatoxin control measures, avoid duplication of efforts and provide the necessary input to align aflatoxin control with broader food safety and Sanitary and Phytosanitary (SPS) issues within Uganda.

## 1.2 Objectives of the C-SAAP

The main objectives of the Country-led Aflatoxin and food safety Situation Analysis were to;

1. Review the country’s food safety systems and effects of aflatoxin along the main agricultural value chains;
2. Develop and use an economic analysis framework to reveal the cost of aflatoxin to health, trade and agriculture;
3. Formulate evidence based recommendations that will form part of the input into the country’s investment strategy, as well as specific investment options required for aflatoxin mitigation in the medium term and;
4. Inform the review of the National Agriculture and Food Security Investment Program (NAFSIP – Uganda), Agriculture Sector Development Strategy and Investment Plan [AS-DSIP]) as well as the development of the Africa-led Aflatoxin Information Management System (AfricaAIMS);

## 2.0 Methodology

The study adopted the methodology proposed by Lamb et al. (2013) and guidelines provided by PACA Secretariat which involved six phases namely;

## 2.1 Identifying key crops of concern (Phase 1)

The key crops were identified by the Aflatoxin Technical Working Group (ATWG) in a round table meeting. The selection focused on crops that are highly vulnerable to aflatoxin contamination, are either produced or consumed in large quantities and/or contribute significantly to Gross Domestic Product (GDP) by being exported in large volumes as well as contributing to nutrition and food security. Three crops namely: maize, groundnuts (peanuts) and sorghum; were selected as the key crops of focus. Details of the criteria used are discussed below;

**a) Vulnerability to aflatoxin contamination**

Vulnerability to aflatoxin contamination was based on studies carried in Uganda for maize (Kaaya et al., 2005; Kaaya and Kyamuhangire, 2006; Kaaya et al., 2006a) and groundnuts (Kaaya et al., 2000; Kaaya et al., 2006b). The above mentioned studies have indicated that maize and groundnuts as well as their products contained aflatoxins levels above the national (UNBS) and regional (EAC) standard of 10 ppb.

There was no information on the contamination of sorghum with aflatoxins by the time this study was conducted. However, studies in other countries like Malawi with similar environmental conditions like those experienced in Uganda have indicated that the crop is also vulnerable to aflatoxin contamination (Matumba et al., 2011). Given the increasing importance of sorghum in Uganda as food and as an ingredient in baby foods as well as being a raw material for beer making, and the lack of information on the levels of aflatoxins, it was agreed that sorghum be included as the third crop.

**b) Importance and final uses of the crops**

The second criterion for selecting maize, groundnuts and sorghum was due to their contribution to household income and food and nutrition security in the country. The three crops serve as staple foods for many households and institutions in Uganda. According to FAO, maize is the third most produced crop in Uganda after plantains and cassava (Annex 1). It is also the most produced and consumed cereal in Uganda (Annex 2). Maize is used as food for humans, mainly consumed as porridge or thick paste commonly known as *Posho.* Fresh maize is also consumed as roasted or steamed snack. The crop is also used in production of local brews. In terms of energy supply, maize provides the largest amount (344 kcal/person/day), equivalent to 17.2% of the total per capita energy intake of 2006 kcal/person/day (UBOS, 2006). Maize is also a major foreign exchange earner with an estimated value of US $ 27,277,000 and 17,096,000 for 2010 and 2011, respectively (Annex 3).

Groundnuts are the second most important legume after beans with a total production of 295 MT (Annex 1) and supplies 3.4 kcal/person/day (Annex 2). Most of the groundnuts produced in Uganda are consumed locally as snack and sauce while some are used in production of peanut butter. On average, groundnuts are included in the daily diets of almost every Ugandan. In 2011, Uganda exported approximately 150 tonnes of groundnuts equivalent to US $ 136,000 (Annex 3).

Sorghum production is well established in Uganda and has been practiced across communities for centuries. According to UBOS (2013), the Northern region is the leading sorghum producing region in the country with a total production of 177 MT. Sorghum is a staple crop for many people in the eastern and northern parts of the country. The crop is also used widely as weaning food and in the production of local brews in the eastern, southern and northern parts of Uganda. At industrial level, sorghum most especially the white variety (*Epuripur*) is currently being used by Nile Breweries Ltd in the production of beer – the Eagle Lager brand. The use of sorghum in production of commercial beer has catalysed more interest in the crop. There are also efforts to use sorghum in production of high quality products like Ice Cream cones (Kigozi et al., 2011), baby foods, bread and other related products.

After identifying the key crops, the next step was to select the regions/districts where the samples were collected. According to Ministry of Agriculture Animal Industry and Fisheries (MAAIF) (2010), Uganda is divided into 10 agro-ecological zones (Annex 4). Based on the target crops selected and crop production data (Annex 5 a -c), only three agro-ecological zones were selected (Table 1). From each agro-ecological zone, three districts were selected from which the samples were drawn. The selection of the districts was also based on production volumes and the importance of the crops (Annex 5 a-c).

Table 1: Study sites (agro-ecological zones/districts)

|  |  |  |  |
| --- | --- | --- | --- |
| Agro-ecological zone | Target crops | Target districts | Notes |
| Western Savannah Grasslands | Maize and groundnuts | Mubende  Masindi  Kamwenge | Mubende district is the second largest producer of maize in Uganda |
| Kioga plains | Maize, groundnuts and sorghum | Iganga  Soroti  Tororo | Iganga is the leading maize producing district in Uganda while Soroti District is the leading producer of sorghum and groundnuts |
| North Eastern Savannah Grasslands | Sorghum and groundnuts | Gulu  Lira  Amuria | Groundnuts and sorghum form a significant proportion of the staple foods in this region |

The location of the agro-ecological zones and the districts sampled are indicated in Figure 1.

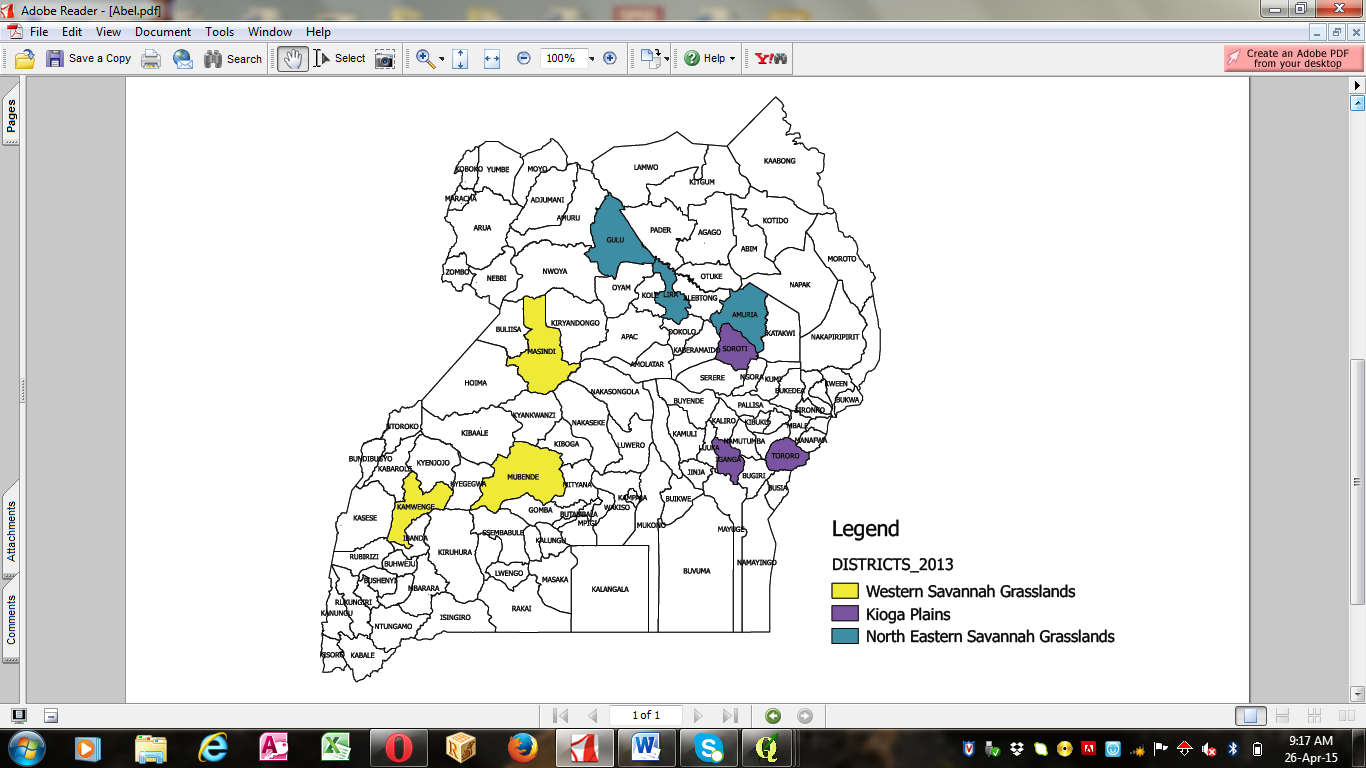


Figure 1: Agro-ecological zones and districts sampled

## 2.2 Determining the prevalence and distribution of aflatoxins (Phase 2)

After identifying the key crops, a survey was undertaken in the agro-ecological zones that were known to be the major producers of the target crops. The agro-ecological zones were selected based on production statistics obtained from the Uganda Census of Agricultural (UBOS, 2010). In each agro-ecological zone, the major producing districts were randomly selected from which samples of the target crops were drawn. This phase therefore involved four major activities namely;

1. **Sample collection:** Although some studies had been conducted on the prevalence of aflatoxins in Ugandan foods, the available information was limited in coverage and some of it had been collected several years ago. Therefore, more samples of the selected crops were obtained from the major growing agro-ecological zones. Bulk samples each of approximately 1000 g comprising of 5-10 incremental portions were randomly taken from each type of commodity using a sampling probe or scoop. The incremental samples were taken at randomly selected points in a batch/lot. The incremental portions were mixed in a large bowl and the 1000 g sample was withdrawn. Where there was less than 10 bags, incremental portions were taken from each bag, and where the number of bags was >10, incremental portions were taken from well distributed bags (where N = the number of bags). At least 100 samples per crop (a total of 300 samples) were collected from the different agro-ecological zones.

Samples were collected at both household and market levels in each agro-ecological zone. The samples obtained were packaged in paper bags and transported on the same day to the Food Chemistry Laboratory at the Department of Food Technology and Nutrition, Makerere University, Kampala Uganda. At the laboratory, the samples were kept at -18oC until analysis. The detailed sampling plan is provided in annex 6. In addition to the samples, the respondents (farmers and traders) provided information with respect to production, harvesting, handling and storage of the produce. The checklist used to collect information from farmers and traders is indicated in annex 7.

1. **Conducting interviews with District Production Staff.** In addition to the information collected from the farmers and traders, more information on levels of awareness, district capacity in terms of staff and infrastructure as well as marketing was collected from District Production staff using a check list (Annex 8).
2. **Aflatoxin analysis:** Aflatoxin analysis was done using the immunocapture fluorometeric assay (Vicam LP, Watertown, MA 02472 U.S.A, 1999). The samples were analyzed in triplicates and results reported as the mean of the three separate analyses.
3. **Data analysis:** The data obtained was entered in Microsoft Excel and SPSS version 16 for analysis. The data was analyzed to establish the number and percentage of samples with aflatoxin levels above the UNBS standard of 10 ppb.

## 2.3 Characterizing the risks of aflatoxin contamination and exposure (Phase 3)

The core risk of aflatoxin contamination was assessed by analyzing the uses of maize, groundnuts and sorghum. Risk assessment focused on the effects of exposure to aflatoxins resulting from consumption of contaminated food and the synergy between aflatoxin and Hepatitis B Virus (HBV) prevalence. The information used to characterize the risk of aflatoxin contamination was obtained from both primary and secondary sources. The primary sources were both quantitative; mainly aflatoxin prevalence obtained through analysis of samples; and qualitative data obtained through interviews with farmers, traders, district production staff and key informants from ministries especially from the Ministry of Trade, Industry and Cooperatives (MTIC), Ministry of Agriculture, Animal Industry and Fisheries (MAAIF), and Ministry of Health (MoH); UNBS, Uganda Revenue Authority (URA), Uganda Export Promotion Board (UEPB) and other relevant stakeholders. Secondary data was obtained through literature review for example, information contained in reports from various government bodies, NGOs and peer reviewed publications.

## 2.4 Estimating the economic impact of aflatoxin contamination (Phase 4)

The Computable General Equilibrium Model (CGE[[1]](#footnote-1)), which represents the state- of- the -art of empirical macro- policy analysis, was adopted to measure the dynamic impact of aflatoxin contamination on the Ugandan economy. The CGE model was adopted because of its ability to capture general equilibrium effects (direct and indirect effects) of aflatoxins and can provide reliable estimates of social costs borne by citizens of a specific country (Lamb et al., 2013). The CGE model is also useful in separating out policy effects from random disturbances, though it requires detailed information on the allocation of resources and relationships among all economic actors of the economy.

The impact of the aflatoxin contamination and related losses stimulate changes in income, prices, quantities consumed, quantities produced and exported. According to Lamb et al. (2013), these varying changes are translated into measurable deviations in the welfare of producers and consumers of aflatoxin-contaminated products that also signal the cost borne by society due to the prevailing aflatoxin problem in the country. The analysis in this section therefore assessed the economic impact of aflatoxin contamination on the performance of the health, trade and agriculture sectors, and the general macro-economy. The analysis was also extended to measure the economic implication of aflatoxins on household welfare, employment and factor productivity. Here, we used data that is based on 2009/10 Social Accounting Matrix (SAM). In this analysis, the Ugandan economy was characterized with and without aflatoxins to allow for comparison of the two scenarios.

## 2.4.1 The customized CGE model for estimating the impact of aflatoxin exposure

As earlier mentioned, the adopted model in this study is a modified CGE that is able to capture the impact of detailed accounts of trade, agriculture and health sectors. It is able to capture the transmission channels of the impact of aflatoxin contamination and exposure on the Ugandan economy. In particular, the model is composed of the behavior of investors, households, government, industries and exporters and is also based on the theoretical structure of the ORANI-G model (Dixon et al., 1982). Trade and transport are incorporated as margins in the model that are mainly used to facilitate distribution of produce from farmers to the final consumer. The combination of these margins, taxes, effectiveness of existing aflatoxin regulation and control approaches are used to account for the deviations between basic prices (farm-gate prices) and purchaser (market) prices.

The dynamic equations are extracted from ORANIGRD Model (Corong and Horridge, 2012), while frictions are from the work of Sadoulet and de Janvry (1995) to produce a Recursive Dynamic (forecasting) Model. The dynamic equations derive real wage and employment adjustment mechanisms as well as capital accumulation and investment allocation. In the model, the assumption is that households maximize utility by maximizing revenue, minimizing cost as well as optimal allocation of resources.

Enterprises are assumed to minimize costs subject to input prices. Imperfect substitution is assumed between domestic outputs and imported commodities. Households consume both imported and domestic commodities whose substitutability is captured by constant elasticity of substitution (CES). The agricultural production frontier is dependent on intermediate consumption (e.g. use of fertilizer) and factors including labour, capital and land, which are competed for with non-agricultural sectors. A portion of the agricultural produce is sold to the domestic market, while the rest is exported. The producer’s choice between the domestic and export market is captured by the Constant Elasticity of Transformation (CET). The model is extended to include the equation to capture the additional data from the Social Accounting Matrix (SAM).

## 2.4.1.1 Production and supply of aflatoxin foods

Aflatoxin contaminated agricultural commodities are produced by local firms following a CES production function. Here, we modified equations from Sadoulet and de Janvry (1995) and Devarajan et al. (1997) to generate the aflatoxin partial analysis. The problem faced by the producer of aflatoxin contaminated foods is to choose input () while minimizing the cost of producing a given output), subject to the CES production function;

with the input demand of 

Where  and 

In the above,  is aflatoxin contaminated foods produced;  is aflatoxin-free foods produced; is factor demand; is labor force that contracted aflatoxin related diseases; is the labor force free from related aflatoxin diseases; and  is capital employed in production.

The aflatoxin contaminated foods referred to above are supplied both to the domestic market

() and export market (). The reduction in export of aflatoxin foods increases their supply to the domestic market. In this analysis, we assume that all aflatoxin contaminated foods that are rejected in the foreign market, are sold on the domestic market and consumed in the economy.

The increased consumption of these commodities in the domestic market increases the risk of break-out of diseases. We use a Constant Elasticity of Transformation (CET) to capture the flow dynamics of aflatoxin contaminated foods in the domestic and international market as shown in the following algebraic form.

****

Where 

In the above equation, ****is agricultural output contaminated with aflatoxins;  is export transformation elasticity; is the share parameter of the domestic supply between domestic market and export; is the aflatoxin contaminated agricultural output sold on domestic market; is the aflatoxin contaminated agricultural output exported to foreign market.

## 2.4.1.2 Macroeconomic impacts of aflatoxins

Assuming mild substitutability () between imports and domestic goods in the consumption basket; the presence of aflatoxins in the agricultural produce reduces both the sales (volume) and price of agricultural related outputs, assuming that the domestic economy is characterized by a substantial level of awareness of aflatoxin effects and clear enforcement of aflatoxin related standards. The consecutive fall in exports results into a fall in foreign exchange which is crucial for the import bill. This generates excess demand for the foreign exchange thus causing depreciation of the local currency. The depreciation in the local currency increases the price of imports in the local currency, which ignites import substitution following the elasticity of substitution in the Armington function. Import volumes will reduce as consumption of the domestic commodities rises. The conceptualization in Figure 2 is a modification extract from [Sadoulet and de Janvry (1995](#_ENREF_27)).



Figure 2: Aflatoxin pathway through the Macro-Economy

Information in Figure 2 shows that presence of aflatoxins in agricultural produce reduces their competitiveness mainly in the international market thus leading to a fall in their respective prices from to. The consequential fall in foreign exchange earnings ignites depreciations of the local currency which makes import prices () to increase.

In the presence of the elasticity of substitution (), composite consumption will shift in favour of domestic produce thus optimal consumption mix will move from point C to C\* where consumption of imports reduce and consumption of domestic products increases.

## 2.4.1.3 Impact of aflatoxins on consumption and human health

The presence of aflatoxin related information asymmetry (imperfect information), the associated moral hazards (hidden selfish behavior) and adverse selections in the agricultural trade services has made the supply of aflatoxin contaminated food on the local market inevitable. As a result, the contaminated foods are not discriminated from the aflatoxin-free foods. The consistent consumption of aflatoxin contaminated foods bursts the aflatoxin thresholds in the consuming population, thus resulting into health complications in form of cancer and immune system dysfunctions.

The economic implications resulting from health hazards due to aflatoxin exposures in Uganda are mainly in escalating medical bills, loss of labour hours when sick, and increasing dependency burden (in case of death). We used a decomposed consumption equation to differentiate the aflatoxin contaminated commodities from other items in the consumer’s basket. The consumption function is derived from Klein-Rubin utility function for each household type as expressed by [Corong and Horridge (2012](#_ENREF_6)) and is depicted as follows:

,

The *X3SUB* and *S3LUX* are behavioral coefficients though the *S3LUX* must sum to unity. *Q* is the number of households per household category. Commodity *C* is comprised of aflatoxin affected produce and aflatoxin-free commodities.

 where depicts foods contaminated with aflatoxin and is aflatoxin-free foods.

The demand equations that arise from the above utility function are:

,



Where, linear expenditure system stipulates that expenditure on each good is a linear function of prices (*P3\_S*) and expenditure (*V3TOT*). In the above household demand functions, *X3SUB* are said to be the 'subsistence' requirements of each good: these quantities are purchased regardless of price (Erwin and Mark 2012). Furthermore, *V3LUX\_C* is what remains of the consumer budget after subsistence expenditures are deducted. This is what we call 'luxury' or 'supernumerary' expenditure. The *S3LUX* are the shares of this remnant allocated to each good, the marginal budget shares.

## 2.4.1.4 Impact of aflatoxins on trade

In the model, we included both trade and transport margins which mainly facilitate the movement of commodities (including aflatoxin contaminated foods) from the producers to consumers. We appended efficiency parameters on demand of these margins to depict constant urge to minimize costs by margins (trade and transport) of consumers. However, excluding the efficiency parameters, the margin demand is proportional to the flow of commodities associated with these margins.

The impacts of aflatoxin contamination in foods on trade are captured if and only if the following happen;

1. Some or all of the aflatoxin commodities are channeled into the domestic market;
2. There is existence of price disparity between aflatoxin contaminated foods and aflatoxin-free foods;
3. Aflatoxin foods are discriminated or rejected in the international market, and;
4. A significant share of the aflatoxin contaminated foods is produced.

However, this impact fails with perfect information asymmetry where aflatoxin contaminated foods are not discriminated from the aflatoxin free foods.

## 2.4.2 Recursive Dynamic Mechanisms in the CGE

Additional equations and variables added to the model to allow it capture the life-cycle of the shock to the economy are a modified extraction from Corong and Horridge (2012). The model used is recursive and with the simulation period of four years. The rate of growth of capital stock is linked to investment; and investment is guided by the rates of return.

## 2.4.2.1 Capital accumulation

Like any other sector, agricultural capital stock in each period grows by an amount equal to the rate of investment at the beginning of the period, less of depreciation as expressed in the equations 1 and 2 below;

…..……………………………………………….……………….. (1)

...………...……………………………………………….… (2)

Here: Y = investment

K = amount of capital

D = depreciation rate

= price of a unit of new capital

The subscript '0' denotes the initial (start-of-period) value. Thus, a change in investment in the current period affects the growth rate of capital not in the current period but in the next. We assumed that investment has a 'gestation' period of one year. Both sides have been multiplied by in order to relate and to the values which appear in the initial database.The investment allocation mechanism has two components. The first component is that investment/capital ratios are positively related to expected rates of return. From variables; unit rental price of capital, unit asset price of capital (, investment (Y) and amount of capital (K); we can postulate that;

R = Pk/actual gross rate of return ……………………………… (3)

G = Y/K gross rate of capital growth next period……………….... (4)

E = expected gross rate of return for next period

The theory that the rates of growth of capital stock depend on expected rates of return may be expressed as:

where …………………..…………………………….….…. (5)

Note: Both G and R (and by extension E) must be > 0. In the case of R, this is guaranteed by other model equations - capital always earns a positive rent. For convenience, we have expressed (6) in terms of gross rather than net rates of growth and return.

We also hypothesized that each sector has a long-run or normal rate of return (Rnormal) and that when E, the expected rate is equal to Rnormal, then G = Gtrend, where Gtrend is a normal or secular gross growth rate. That is,

Gtrend = F (Rnormal) ………………………………………………………...……….. (6)

We chose a type of logistic curve for the function F:

……………………………… (7)

If M = 1 then G = Gtrend; if M is large then G = QGtrend = Gmax , and if M is 0 then G = 0.

## 2.4.2.2 Real wage adjustment

Real wages are expected to respond to the dynamics in the labour market mainly caused by production swings emanating from disturbances in the product market for aflatoxin contaminated foods. Thus, wages adjust to employment levels that is; If end-of-period employment exceeds some trend level by x% then real wages will rise, during the period, by x%. Since employment is negatively related to real wages, this mechanism causes employment to adjust towards the trend level in the dynamic model.

## 2.4.2.3 SAM Extension

The above theoretical description of the CGE model does not capture the Social Accounting Matrix (SAM) variables. The coefficients and variables names in the SAM are based on the row and column in which they are located. Here we captured SAM accounts including; a) Gross operating surplus; b) Enterprise account; c) Labor income of households; d) Household income, consumption, savings and transfers; e) Government income and expenditure; f) Private investment expenditure, and; g) rest of the world (ROW).

Robustness check of the key CGE findings on a range of economic impacts was assessed using a partial equilibrium analysis, which is unable to capture indirect effects of the aflatoxin related shocks to the economy. This approach has the advantage of assessing the impact of aflatoxins on specific sectors separately, without accounting for feedback among households, firms, and various sectors ([Lamb et al., 2013](#_ENREF_17)). Here, we opted to employ additional primary data and to estimate annual impacts in a typical year rather than aflatoxin contamination impact over a specific policy period.

## 2.4.3 Data used in simulation

The impact of aflatoxin contamination in three main staple foods (maize, groundnuts and sorghum) and their consumption on the Ugandan economy was assessed through three channels, namely: a) impact on health through consumption of contaminated produce, b) impact on trade through rejection/discrimination of contaminated produce in the local and regional markets, and c) impact on government expenditure through the importation of medicinal products for treating aflatoxin-related diseases like liver cancer. The simulation was built in respect of the above transmission mechanisms to which a survey was conducted to derive the necessary values of shocks for use in the simulation (See data in Tables 4-6). The shocks below were treated as a onetime effect for FY 2013/14 in the factor and product markets. A recursive dynamic Computable General Equilibrium Model (CGE) was used to shock the economy with the aflatoxin shocks listed below;

Table 2: Simulation shocks used in the CGE Model

|  |  |  |
| --- | --- | --- |
|  | Shock description | Shock (%) |
| 1. | Labour efficiency loss | 0.75 |
| 2. | Maize export rejection (formal) | 2.24 |
| 3. | Groundnut export rejection (formal) | 0.24 |
| 4. | Sorghum export rejection (formal) | 0.30 |
| 5. | Maize domestic rejection (formal) | 0.36 |
| 6. | Groundnut domestic rejection (formal) | 0.00 |
| 7. | Sorghum domestic rejection (formal) | 0.056 |
| 8. | Household health shock | 1.06 |
| 9. | Government health shock | 0.16 |

**Source: Derived from field data collected by FONUS[[2]](#footnote-2) and Bank of Uganda[[3]](#footnote-3)**

Table 2 shows simulation shocks in the factor market, domestic and international product market mainly focused on the trade and health sector effects. The shocks were deduced from data compiled from the survey carried out specifically for this study with a combination of secondary data. The produce (maize, groundnut and sorghum) rejection shocks were calculated on the assumption that there was enforcement of aflatoxin standards (10 ppb) in both the domestic and international markets. The health shocks were calculated based on prevalence of liver cancer (GLOBOCAN 2012, IARC - 17.9.2014, <http://globocan.iarc.fr/Default.aspx>**)** and HBV (Bwogi et al., 2009). The other information used in simulation is summarized in Table 3.

Table 3: Other information used in simulation

|  |  |
| --- | --- |
| **Item** | **Value (Ugx)** |
| Health sector budget[[4]](#footnote-4) | 1,127.48 bn |
| Household cost for treating Cancer & HBV[[5]](#footnote-5) | 10.3 mn |
| Cancer treatment cost (Recovery)5 | 10.0 mn |
| HBV treatment cost (Recovery)5 | 0.3 mn |
| Cancer Institute Budget[[6]](#footnote-6) | 6.48 bn |
| National medical store budget6 | 219.37 bn |
| WFP food purchases per annum[[7]](#footnote-7) | 90.53 bn |

2.5 Identifying and prioritizing opportunities for aflatoxin control (Phase 5)

Opportunities for aflatoxin control were identified in a half day Stakeholder Leaders’ Workshop held on 27th February 2015. The participants were drawn from the key ministries namely, MoH, MAAIF and MTIC as well as academia and private sector.

## 2.6 Conducting stakeholder workshop to communicate and validate study findings and recommendations (Phase 6)

This was the final step of the exercise and it involved a multi-sectoral workshop with key stakeholders from key government sectors namely; agriculture, trade, health; district local governments; academia and research; the public and private sectors. The report was presented and discussed exhaustively after which breakout sessions identified priority action steps that need to be undertaken to mitigate the effects of aflatoxins.

## 3.0 Results and Discussion

## 3.1 Status of the food safety situation in Uganda

The status of the food safety situation in Uganda was mainly ascertained through review of the existing literature focusing on government policy documents and interviews with key informants in the ministries charged with the responsibility of ensuring food safety.

The findings of this study indicate that at the moment, Uganda does not have a single agency responsible for food safety. There is instead a multi-agency system scattered in different ministries and/or departments. As a result of this arrangement, the food safety, quality and infrastructure are rather fragmented being shared between several ministries, departments and agencies. Food safety issues are mainly collaborated by three key ministries namely;

1. **The Ministry of Health (MoH).** This is the lead agency and is at the forefront of coordinating all food safety issues. The Ministry gave the National Drug Authority (NDA) the mandate to regulate food. In order to effectively undertake the food regulation mandate, the NDA established a Food Desk to oversee the transformation of NDA into a National Food & Medicines Authority (NFMA). The transformation from NDA into NFMA will widen regulatory scope to include food, food supplements and other substances used in public health that are not explicitly provided for under the National Drug Policy and Authority (NDP/A) Act, Cap. 206 of the Laws of Uganda (2000 Edition). In 2014, Cabinet approved the bill to transform NDA into NFDA. The bill is currently awaiting Parliament approval into an Act.
2. **The Ministry of Agriculture Animal Industry and Fisheries (MAAIF).** The food safety roles in MAAIF are distributed amongst three departments namely;
   1. Crop Protection Department (Under the Directorate of Crop Resources). The Department is responsible for formulating and enforcing regulations related to seeds, agro-chemicals and use of pesticides and the management of phytosanitary risks. The department also issues phytosanitary certificates when they are required for exports.
   2. Department of Livestock Health and Entomology (Under the Directorate of Animal Resources). This Department is responsible for ensuring sustainable animal disease and vector control, animal food quality and safety for improved food security and household income. The Department carries out inspection at abattoirs and meat processing establishments. Some of the inspection responsibilities are delegated to city and municipal councils and district veterinary staff.
   3. Department of Fisheries Control, Regulation and Quality Assurance (Under the Directorate of Fisheries Resources). This Department is the Competent Authority (CA) legally responsible for regulating and controlling activities in the fish industry and it is among others charged with: The statutory inspection and control of fish and fishery products and related activities, Certification of fish and fishery products intended for export and local consumption and inspection of health conditions for the production and distribution of fishery products for human consumption, including the inspection of hygiene, premises, equipment, and checks in fish processing establishments.
3. Ministry of Trade Industry and Cooperatives (MTIC). The ministry hosts the Uganda National Bureau of Standards (UNBS) which sets food standards where safety issues are emphasized. UNBS sometimes carries out surveillance to ensure that the standards are followed. However, enforcement is usually very weak due to limited funding, infrastructure and human resource.

In addition to the roles played by the three key ministries (MoH, MAAIF and MTIC), there are other government ministries and agencies that are directly or indirectly regulating food and related services. Such ministries include, the Ministry of Water and Environment is responsible for ensuring water quality and proper environmental management; Ministry of Local Government which controls District Veterinary and Environmental Health Inspection; Kampala Capital City Authority (KCCA) and District Local Governments (DLGs) which are charged with enforcement of laws and regulations at district and lower government levels.

All the above ministries and departments share responsibility of food safety based on their respective institutional mandates (FAO, 2012). A plan to create the National Food and Drugs Authority to be housed in the Ministry of Health has already been endorsed by Cabinet. The proposed authority will be in charge of enforcing food standards while UNBS will be left with the mandate of developing standards.

## 3.2 Existing food safety laws and strategies

The Ministry of Health has put in place a number of strategies to address food safety issues in the country. A summary of the existing food safety laws and strategies are discussed below;

**The Food and Drug Act (1964)**

This is the main law that governs food safety in Uganda. In 1993, the element of Drugs was transformed into the Drugs Act (1993) under the National Drugs Authority. What was left is now referred to as the Food Act that has not been amended since then. It is important to note that the current Food Act does not address new developments in the food industry such as food additives and contaminants most especially the mycotoxins. During the time this study was undertaken, information from top officials in the MoH indicated that development of a modern and unified National Food Safety Law had reached advanced stages. However, there was no clear indication of when the food safety law would be finalized.

**The Public Health Act (1935)**

This is the law in force that empowers health workers to carry out inspections of public eating places to ensure health, hygiene and safety of the workers and clients. The inspections focus on the hygienic and safety standards of the premises, sanitary fittings, utensils, workers (protective war and medical fitness) in order to minimize disease transmission. Part XII of the Act focuses on protection of food stuffs but only specifies the construction and regulation of buildings used for storage of food. This section of the Act also restricts personnel from residing or sleeping in any room where food is stored.

The Act empowers the Ministry to make rules for any purpose whose objective is to preserve the health or prevent disease, make statutory orders and establish sanitary boards as deemed necessary. The Act also gives powers to Medical Officers to make orders for protection of public health if he or she reasonably considers the action necessary for the protection of the public health. This Act is still in force and is an important regulatory tool for ensuring public health mainly enforced by City, Municipal and Local Council Authorities.

**Uganda National Bureau of Standards (UNBS) Act (1983)**

The Act mandates the UNBS to formulate and enforce national standard specifications for commodities and codes of practice; promote standardization in commerce, industry, health, safety and social welfare and provide testing and calibration services to facilitate both regulatory and promotional roles. Given this mandate, the UNBS uses regulations on Imports Inspection and Certification together with the existing food standards to regulate the quality of foods manufactured locally as well as those imported into the country. In addition to the national and regional standards, the UNBS has adopted the ISO 22000 standard for food safety.

The UNBS enforces the existing food safety regulations by drawing samples of various products of interest for laboratory testing. Products that do not meet the minimum requirements for health and safety set out in the relevant standard are restricted from accessing markets or withdrawn from the market (for products already in the market) and seized for destruction or re-exportation at the importer's expense.

**Dairy Industry Act (2000)**

The Dairy Industry Act 2000 provides the legal framework for implementing the key recommendations of the Dairy Master Plan. The Act established Dairy Development Authority (DDA) whose operations started June 2000. This is a semi-autonomous, statutory body that oversees the development and regulation of the dairy industry. With respect to food safety, DDA is charged with the responsibility of ensuring that all the milk value chain actors follow the recommended practices in handling, processing and storage of milk. The Authority therefore inspects raw-milk traders, transporters, processors, importers and exporters of milk and milk products, input suppliers and equipment, issues certificates to ensure compliance and sets and monitors quality standards.

**Other supporting policies/strategies**

**The National Food Safety Strategic Plan (NFSSP) 2007-2016.**

The National Food Safety Strategic Plan aims at guiding the implementation of food safety laws, programmes, activities, and other food safety controlsystems. The plan aslo translates the food laws into a tool for an effective food-safety control system and spell out the roles and responsibilities of key stakeholders, through addressing institutional linkages,collaboration, and harmonization of activities aimed at promoting and improving the status of food safety and reduce the burden of food-borne illnesses in the country.

**The Health Sector Strategic Plan (HSSP), 2010/2011 – 2014/2015**

This is a five year strategic plan for MoH that provides strategies for the implementation of the National Health Policy. The HSSP emphasizes the promotion of proper personal and food hygiene, food safety, supply of safe water and improved sanitation.

**National Codex Committee**

Uganda established a multi–sectoral National Codex Committee in June 2000 chaired by the DHS. The Uganda National Bureau of Standards is the National Codex Contact Point. The National Codex Committee is responsible for implementing the objectives and activities of Codex Alimentarius Commission in Uganda.

**The Uganda Food and Nutrition Policy (2003)**

The overall objective of the policy is to promote the nutritional status of the people of Uganda through multi-sectoral and co-coordinated interventions that focus on food security, improved nutrition and increased incomes. The Policy therefore, provides the framework for addressing food and nutrition issues in the country. Much as the policy emphasizes provision of quality and safe food to the communities, it does not spell out the strategies to ensure the safety of food. The Policy also proposes the establishment of Food and Nutrition Act that will provide for the establishment of the Uganda Food and Nutrition Council to serve as the apex body for guidance and the co-ordination of all food and nutrition activities in the country and to guide the Government in all matters pertaining to food and nutrition. However, the Food and Nutrition Act has not been enacted to date. This has rendered the Food and Nutrition Policy inactive. Information obtained from key informants indicates that the Food and Nutrition Policy is currently under review and aflatoxins and other food safety related issues have been incorporated. For better coordination and implementation, the Policy hosting has been transferred from MAAIF to the Prime Minister’s Office (OPM). It is anticipated that the transfer of the Food and Nutrition Policy to OPM will increase commitment of resources towards implementation of the strategies outlined in the policy.

**Food Hygiene Advisory Committee**

The Food and Drugs Act empowers MoH to constitute a Food Hygiene Advisory Committee. The Committee is composed of technical experts drawn from key stakeholders in the Food Industry. Its mandate is to advise the Minister to regulate on any matters of food hygiene and safety in Uganda. This Committee is in place and the Director of Health Services (DHS) is the Chairperson and the Executive Director UNBS is the Vice Chairperson.

## 3.3 Regulation of aflatoxins in Uganda

The Government of Uganda (GoU) recorgnises the importance aflatoxins with respect to health, trade and food security. In a bid to protect the citizens against the harmeful effects of aflatoxins, the MTIC through UNBS has developed aflatoxin standards for several crops/food products including maize (US EAS 2:2013), groundnuts (US EAS 57-1), sorghum (US EAS 757:2013**),** and rice (US EAS 128) among others. The UNBS also has laboratory facilities for analysing aflatoxins in foods and provides analytical and certification services to companies that are exporting to countries where there are strict aflatoxin regulations.

The minimum allowed levels of total aflatoxin in maize, groundnuts, sorghum and rice is 10 ppb. The Uganda standard for aflatoxins is harmonized with the East African Community (EAC) standard. The aflatoxin limit in Uganda and EAC is higher than the EU limit (4 ppb) but lower than that of the Food and Drug Administration (FDA) and World Health Organization (WHO) which is at 20 ppb.

Despite the existence of aflatoxin standards for most of the vulnerable crops, there is limited enforcement of the standards. Only foods destined for export are usually tested for aflatoxins. There is no policy to support the surveillance and monitoring of procedure along the major value chains. Susceptible produce like maize and groundnuts are not routinely inspected at different points of the value chain to ensure that aflatoxin contaminated produce is removed from the food chain.

There is therefore a high possibility that the Ugandan population is exposed to high levels of aflatoxins due to weak or ineffective regulatory systems. The situation is worsened by low levels of awareness amongst the various stakeholders. Much as a lot of effort is invested in cleaning, sorting and drying of the produce at farm level, the situation is different during transportation, marketing and processing. Traders and processors usually pay more attention to profits compared to the safety of the products. It is therefore common to find traders mixing mouldy produce with good quality produce in an effort to improve the quality of the former. Groundnut traders also process broken, shriveled and mouldy kernels into peanut paste and flour. Given the weak enforcement of standards in the markets, the marketing of poor quality and possibly aflatoxin contaminated produce goes on every day with very little interventions from the regulatory authorities.

The sale of poor quality produce has however, not passed without negative effects on trade. The World Food Programme (WFP) one of the largest grain buyers in the country usually screens maize for aflatoxin contamination. All produce that is found with aflatoxin levels above 10 ppb is rejected. The actions of WFP have already sent a signal to all value chain actors that there is need to pay attention to aflatoxin contamination. The Ministry of Trade, Industry and Cooperatives is in the final stages of developing a Grain Trade Policy that will promote the production and trade of good quality grains. In this policy, the strategies for controlling aflatoxins in grains are clearly stipulated.

**3.4 Prevalence of aflatoxins in Uganda**

The detailed results of aflatoxin prevalence in the sampled districts are indicated in annex 7. In sections 3.4.1 – 3.4.3, we present and discuss the prevalence and distribution of aflatoxins per crop in each of the studied districts.

## 3.4.1 Prevalence and distribution of aflatoxins in maize from different agro-ecological zones

The results in Table 4 indicate the levels of aflatoxins in maize obtained from the major production districts in Uganda. Overall, the results indicate that majority of the samples were contaminated with aflatoxins. The highest mean total aflatoxin levels (388 ppb) were reported in maize samples obtained from Soroti district followed by those obtained from Mubende district (71.5 ppb). Basing on the UNBS standard of 10 pbb, the results of the study indicate that Iganga district would have the highest percentage (65%) of samples with aflatoxin levels above the standard followed by Soroti at 60%. Masindi (25%) and Tororo (20%) reported the lowest proportion of samples with aflatoxin levels above the UNBS standard.

Table 4: Levels of aflatoxins in maize

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Agro-ecological zone | District | Total aflatoxin levels (ppb) | | % samples  >10 ppb |
| **Range** | **Mean** |
| Western Savannah Grasslands | Mubende | 0-255 | 71.5 | 45 |
| Kamwenge | 3-110 | 25.4 | 50 |
| Masindi | 0-550 | 42.6 | 25 |
| Kioga plains | Iganga | 0-680 | 45.8 | 65 |
| Soroti | 0-3,300 | 388 | 60 |
| Tororo | 0-86 | 11.3 | 20 |

## 3.4.2 Prevalence and distribution of aflatoxins in groundnuts from different agro-ecological zones

The prevalence of aflatoxins in groundnuts is summarized in Table 5. The results indicate that as for the case of maize, the districts of Iganga (78.7 ppb) and Soroti (18.9 ppb) reported the highest levels of aflatoxin contamination in groundnuts. The results further indicate that Iganga and Soroti districts at 30 and 20% respectively; had the highest proportion of samples with aflatoxin levels above the UNBS standard. In general, it was observed that groundnuts had lower levels of aflatoxins compared to maize.

## Table 5: Levels of aflatoxins in groundnuts

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Agro-ecological zone | District | Total aflatoxin levels (ppb)  Range Mean | | % samples  > 10 ppb |
| Western Savannah Grasslands | Mubende | 0 - 15 | 1.5 | 10 |
| Kamwenge | 0-11 | 1.9 | 10 |
| Masindi | 0-179 | 16.1 | 10 |
| Kioga plains | Iganga | 0-850 | 78.7 | 30 |
| Soroti | 0-141 | 18.9 | 20 |
| Tororo | 0-12 | 1.7 | 10 |
| North Eastern Savannah Grasslands | Gulu | 0-4 | 1.0 | 0 |
| Amuria | 0-13 | 3.7 | 10 |
| Lira | 0-22 | 3.0 | 10 |

## 3.4.3 Prevalence and distribution of aflatoxins in sorghum from different agro-ecological zones

The levels of aflatoxins in sorghum are indicated in Table 6. The results indicate that sorghum samples obtained from all the districts had high level of aflatoxins. The highest mean total aflatoxin levels (170.1 ppb) were reported in Lira district while the lowest was in Amuria (11.5ppb). All samples (100%) in Soroti, Amuria and Lira districts were above the UNBS limit of 10 ppb. The situation was not very much different in the other districts where over 65% of the samples had aflatoxin levels above the minimum standard. This is the first detailed study on the prevalence of aflatoxins in sorghum in Uganda. However, information from MAAIF indicated South Korea was interested in importing sorghum from Uganda but could not go ahead due to high levels aflatoxins reported in the samples taken for analysis. The high prevalence of aflatoxins in sorghum could be attributed to the poor agronomic and postharvest handling practices used by farmers and other value chain actors. This is because sorghum has mainly remained a subsistence crop and is ranked low in terms of money value, thus limited or no substantial resources s have been invested in improving the quality of the crop.

Table 6: Levels of aflatoxins in sorghum

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Agro-ecological zone | District | Aflatoxin levels (ppb)  Range Mean | | % samples  > 10 ppb |
| Kioga plains | Soroti | 97-260 | 170.1 | 100 |
|  | Tororo | 0-240 | 55.1 | 65 |
| North Eastern Savannah Grasslands | Amuria | 25-514 | 11.5 | 100 |
|  | Gulu | 0-121 | 66.6 | 95 |
|  | Lira | 26-240 | 102.7 | 100 |

In general, the findings of the study indicate that the aflatoxin problem is wide spread amongst the staple foods in Uganda. The results are in agreement with previous studies conducted on maize and groundnuts. For example, levels as high as 700 ppb have been reported in maize (Kaaya et al., 2000) and 2,000 ppb in groundnuts (Kaaya et al., 2006a).

The results are also in agreement with the findings of a recent pilot study that evaluated population exposure to aflatoxins in rural areas in western Uganda where it was established that every adult and all but four children in the study had detectable AF-alb adduct, including five babies reported to be exclusively breastfed (Asiki et al., 2014). The AF-alblevels ranged from 0 to 237.7 pg/mg albumin and did not differ significantly between men and women, by age or by HIV serostatus. The findings of the study further revealed that adults who consumed more *Matooke* (bananas) had lower levels of AF-alb adduct than adults compared to those that consumed other staples like maize meal. It was also reported that children who consumed soya-based weaning formulae, which is not grown locally, were found to have almost two times higher AF-alb compared to those who were not fed on soya formulae. In Uganda, majority of processors blend soya with maize in order to increase the calorie content of weaning foods. The high levels of AF-alb adduct in groups consuming soya could therefore be attributed to the use of aflatoxin contaminated maize in the preparation of the composite flour.

The high levels of aflatoxin contamination in the staple foods could be attributed to several factors namely; extrinsic, intrinsic, agronomic and postharvest handling factors among others, which interact at different levels of the value chain.

The extrinsic factors mainly include the prevailing climatic conditions during the production, harvesting, postharvest handling and storage periods namely temperature, humidity, atmospheric composition. Uganda has a tropical climate with temperatures ranging between 15-35oC and two rainy seasons per year in most parts of the country with the exception of some few districts that have one rainy season (Rwabwogo, 2005). Thus, the prevailing environmental conditions mainly temperature and humidity at any particular point along the production chain play an important role in contamination of the produce. Studies have indicated that hot and dry conditions favour aflatoxin contamination when the crop is still in the field while wet and warm conditions favour postharvest contamination (Cotty and Jaime-Garcia, 2007). Information obtained from farmers indicated that dry conditions are usually experienced towards the end of the production seasons and while wet conditions are common during harvesting and drying periods. Such conditions could therefore partly explain the high incidence of aflatoxins in the staple crops.

The effect of extrinsic factors could be further enhanced by intrinsic factors like the nature of the substrate, its nutrient composition and the water activity. Crops like maize, groundnuts have been reported to be very vulnerable to aflatoxin contamination due to their nutrient composition. Thus, if such crop is grown and handled under conditions that are suitable for aflatoxin production (high moisture content and temperature), it will accumulate much higher levels of aflatoxins in a short period. Majority of farmers in Uganda do not measure the moisture content of the grains before storage. Furthermore, the storage structures commonly used by small scale farmers and grain traders do not provide protection to the crop against moisture absorption and rewetting. A case in point is the observed increasing trend of storing harvested produce inside homes characterized by humid conditions and poor ventilation. Studies conducted by Kaaya et al., (2000) have reported that use of inappropriate storage structures led to increase in aflatoxin levels.

Poor agronomic practices could also be responsible for the high incidence of aflatoxin contamination in Ugandan produce. Majority of the farmers reported that they do not remove or burn trash from the previous crop, plant home kept seeds and hardly practice crop rotation due to land scarcity. In addition, majority of the farmers harvest late in a bid to dry the crop in the field and avoid labour costs associated with drying the crop at home. Failure to remove trash of the previous crop and repeated planting of one crop on the same plot season after season have been reported to increase inoculum of mycotoxin producing fungi in the soil (Atukwase et al., 2009). Delayed harvesting exposes the crop to damage by pests and frequent re-wetting by rain which favour growth of *Aspergillu*s spp and subsequent aflatoxin contamination (Kaaya et al., 2005).

Majority of the farmers reported that drying of maize, groundnuts and sorghum was mainly done on bare ground using the natural energy from the sun (open sun drying). This technique is slow, time consuming, labour intensive and exposes the crop to rains that are normally frequent during the harvesting and drying periods making it difficult to achieve the recommended moisture level (13.5%) for safe storage (Kaaya and Kyamuhangire, 2006). In addition, the crop is persistently exposed to soil contamination which is the source of fungi. The primary processing practices used by farmers also expose the produce to aflatoxin contamination. Majority of the farmers reported that shelling and threshing are mainly done by beating with sticks or using locally fabricated motorized maize and groundnut shellers. Such technologies normally cause damage to the grains which creates an opportunity for fungal infestation. It was also noted that groundnuts are sprinkled with water prior to shelling in order to increase the efficiency of the shellers in breaking pods. Such practices result into increased moisture content of the kernels which may facilitate aflatoxin contamination during the subsequent handling steps. As already mentioned, there is little attention paid to the storage of harvested produce at all levels of the value chain. Insect and fungal infestation was a common occurrence in most of the households and produce stores visited during the study. It is therefore apparent that there is accumulation of aflatoxins while the produce is under storage.

A deeper analysis of the current situation in Uganda indicates that aflatoxin contamination most likely starts in the field and keeps on accumulating along the value chain. It was also evident that majority of the stakeholders (farmers, consumers, technocrats, traders and processors) had limited knowledge and awareness on the effects of aflatoxins with respect to food security, heath and trade. This situation therefore calls for integrated management approaches that will target all the stakeholders along the value chain.

## 3.5 Capacity of the existing structures to provide aflatoxin safe foods to the public

The capacity of both public and development partners to provide aflatoxin safe foods to the community was assessed on a number of parameters namely; ability to analyze aflatoxins (laboratory infrastructure), the methods of analysis used, availability of technical staff, funds committed to management of aflatoxins, the ability to undertake regular aflatoxin monitoring within their jurisdiction and engagement in awareness and advocacy.

## 3.5.1 Public institutions involved in management and control of aflatoxins

As already mentioned, the responsibility of ensuring food safety is shared by the three ministries namely, MoH, MAAIF, MTIC. It was noted that both the MoH and MTIC were not directly involved in management and control of aflatoxins as well as enforcement of the existing aflatoxin standards.

Much as MAAIF promotes good agricultural practices (GAP) and postharvest handling of produce which are part of the key strategies to manage aflatoxins, such efforts are not directly targeted to aflatoxins. The ministry does not have infrastructure for analysis of aflatoxins but collaborates with UNBS or the Government Chemist and Analytical Laboratory (Ministry of Internal Affairs) whenever samples are referred to them for analysis. Similarly, the Departments of Health and Agriculture at in the districts have no infrastructure for monitoring aflatoxins.

The MTIC under its regulatory body, the UNBS is the only ministry at the forefront of tackling the aflatoxin problem. The role played by UNBS could be attributed to the fact that aflatoxin has become a global challenge that affects both regional and international trade. In order to facilitate regional and international trade, the UNBS has developed aflatoxin standards for various staple crops like maize, groundnuts, sorghum, rice, baby foods, and dried cassava chips /flour among others. The UNBS has a central laboratory at its headquarters where aflatoxin analysis is conducted.

The UNBS mainly regulates aflatoxins in commodities destined for export to countries where commodities must meet the limits for aflatoxins. The UNBS also monitors aflatoxin levels of imports through presence at boarder entry points. In addition, the UNBS monitors aflatoxin through the Pre-Export Verification for Conformity (PVoC) programme, which ensures that food products are tested before shipment to Uganda. The UNBS employs third parties like Société Générale de Surveillance (SGS), Intertek the PVoC scheme to carry out analyses.

Despite the efforts championed by the UNBS, it was noted that there is no enforcement of aflatoxin standards in the local markets. Both traders and processors of the staple crops that are vulnerable to aflatoxin contamination do not monitor aflatoxins. This means that all the aflatoxin vulnerable staple foods produced and consumed internally are not monitored and no one knows their safety with respect to aflatoxins. Given the poor handling and storage systems at all levels of the value chains as well as the high prevalence of aflatoxins reported in the previous studies and those reported in the current study, it is evident that the public is exposed to high levels of aflatoxins.

The limited monitoring and surveillance of aflatoxins in locally produced products is attributed to limited capital and human resources. Information obtained from UNBS indicated that the bureau lacks adequate financial resources to undertake surveillance at all levels of the value chain and has only one High Performance Liquid Chromatography (HPLC) centrally located at the Head Quarters in Kampala. There is no aflatoxin testing centers in the districts or regions to handle samples at local level. In addition, UNBS does not have sufficient staff especially for surveillance activities. The other challenge affecting monitoring and surveillance of aflatoxins in the local markets is the lack of policy and laws to guide enforcement of the standards. Much as there are standards, there is no clear policy stipulating who should carry out monitoring and surveillance. Furthermore, there is no law stipulating the penalties for trading in products with aflatoxin levels above the UNBS limit of 10 ppb.

## 3.5.2 Private/development partners involved in aflatoxin control

There are private and/or donor agencies (development partners) that are involved in management and control of aflatoxins with the aim of facilitating trade and ensuring safety of the target consumers. Table 7 presents some of the private organizations/development partners engaged in management and control of aflatoxins.

Table 7: Private/development partners engaged in activities that contribute to reduction of aflatoxin levels in the staple crops in Uganda

|  |  |
| --- | --- |
| Organisation | Role played |
| Vredesilanden Country Office (VECO) - Uganda | Training of groundnut farmers in Eastern Uganda in agronomic and postharvest handling practices aimed at reducing aflatoxins. The organization has developed a Quality Management Systems Manual (QMS). In the manual, the Critical Control Points (CCPs) along the groundnut value chain have been identified and strategies to manage the CCPs proposed. The manual is currently used by groundnut farmers in Eastern Uganda (Iganga, Bugiri, Pallisa, Tororo, Kumi and Soroti). |
| Food and Agriculture Organization (FAO) | Supports extension services aimed at improving the quality of produce. For example, the organization has supported farmers in several districts in construction of improved storage structures like cribs and provision of maize and groundnut shellers |
| World Food Program (WFP) | Supporting farmers and maize traders in various districts with improved postharvest handling and storage technologies of maize like grain cleaners, dryers and metallic silos. WFP also offers premium prices for good quality maize whose aflatoxin levels are below 10 ppb. WFP screens maize for aflatoxins using rapid test prior to purchasing. |
| USAID | Through a number of projects, USAID is supporting farmers and grain traders in several districts in construction of improved storage facilities as well as training of value chain actors in management of quality along the value chain. USAID is also supporting the Warehouse Receipt System whose aim is to provide standard storage systems that will maintain the quality and safety of the produce during the storage period |
| Sasakawa Africa Association (SAA) | Promotes good postharvest handling practices using their extension staff and also assist farmers with dryers, improved storage structures, shellers, moisture meters |
| World Vision | Training farmers on management and control of aflatoxins in the staple crops as well as providing support in acquisition of improved postharvest handling technologies |
| Catholic Relief Services (CRS) | CRS runs a program that twins Ugandan farmers with those in the United States of America. The program focuses on agriculture, food security and nutrition thereby promoting the use of good agricultural and postharvest handling practices. |

## 3.6 Level of aflatoxin awareness amongst the different value chain actors

The study findings indicated that some value chain actors in some districts were aware of the dangers of aflatoxins due to the trainings conducted by VECO, Makerere University and other organizations. However, majority of the people were not aware of the dangers of aflatoxins. Most of the value chain actors the enumerators talked to admitted that fungal infection was a common occurrence in the staple foods but they did not know that the fungi were associated with toxic substances. Others did not believe that aflatoxins exist. The claim was that ***“if aflatoxins existed, then they would be dead by now since they have been consuming the same staples throughout their lives”.***

The respondents reported that mouldy produce is used to prepare household meals, brewing local beer (for maize and sorghum) or used for animal feeds. In areas where there are large volume buyers who are strict on quality; the farmers and produce dealers sorted out poor quality produce which was sold at low prices to local middle men. The middle men mix the rejects with good quality produce and sell it on the local markets. The rejected groundnuts are usually milled into flour which is used to make sauce or roasted to make paste or peanut butter.

## 3.7 Economic impact associated with aflatoxin contamination in maize, groundnuts and sorghum

Results of the economic impact analysis are composed of a mixture of both micro and macro interpretations mainly focusing on the following areas, a) sectoral impacts, b) impacts on household welfare and c) macroeconomic impacts.

## 3.7.1 Impact of consumption

Results in Figure 3 indicate that exposure to aflatoxin in Uganda reduces economic growth by 0.26 percent, increases household consumption of domestic health services (medical commodities) by 0.25 percent and also increases consumption of imported health services (medical commodities) increase by 2.83 percent.

The consumption of other commodities falls as health costs crowd out the other commodities in the household consumption basket. Household consumption of grains that are susceptible to aflatoxin contamination reduces more than other commodities and this avails more financing for the inevitable high health costs as shown in Figure 3.



Figure 3: Impact of aflatoxins on household consumption

Results in Figure 3 further show that import demand for health services raises more than demand for domestic health service mainly because medication for liver cancer is largely imported thus little funding is devoted to complementally domestic health products for treating the related diseases. Demand for imported grain seeds falls mainly due to their substitution with the cheap aflatoxin contaminated locally produced grains that are rejected in the formal export market.

Information asymmetry in the domestic market consumption decisions makes it easy to consume both aflatoxin contaminated and non-contaminated grains without price discrimination or rejection. This puts the whole population that consumes the affected grains at risk of contracting ailments related to aflatoxin accumulation in the body. Demand for products from other sectors falls but the demand for real estate dwellings falls even more because this sector is mainly funded by household savings which in the current state are being substituted to finance the high health costs related to treating liver cancer, HBV and other ailments associated with consumption of aflatoxin contaminated foods.

## 3.7.2 Impact on of aflatoxins on the export market and competitiveness

The export sector deteriorates with the influx of aflatoxin contaminated foods in the economy. Nominal exports deteriorate by -0.62 percent (US$ 37.56 million) more than real exports (-0.47 percent) indicating a deterioration in the price of exports (-0.15 percent). The stable import prices, accompanied with increased importation of medical supplies and falling export earnings, generate excess demand for the foreign currency thus causing a depreciation of the local currency by 0.1 percent. The positive effect of depreciation on exports is surpassed by the weight of the loss of market due to aflatoxin contamination thus causing both deterioration in the balance of trade and terms of trade (0.15 percent). The depreciation would cause Ugandan exports to be more competitive but this positive effect is eroded with deteriorating quality of exports with aflatoxin contamination. This accounts for the export loss of US$ 37.56 million despite the depreciation of the exchange rate. Thus aflatoxin makes the local produce less competitive in the export market.

Agricultural exports fall by -1.09 percent (US$ 16.34 million) as manufacturing, utilities and services fall by 0.05, 0.13 and 0.55 percent respectively. However, export products from the mining sector improve by 0.02 percent (US$ 0.013 million) mainly because this sector is largely capital intensive which is less affected by loss in labor efficiency which accounts for the positive reception to the benefits of the exchange rate depreciation. The sectoral performance of real exports is shown in Figure 4.



Figure 4: Real exports performance

Information in Figure 4 further shows that exports deteriorate across all sectors except the mining sector which experiences a mild improvement. Agricultural sector suffers the highest deterioration in exports followed by services, then utilities and manufacturing. The construction sector experiences no effect on its exports mainly because Uganda does not export construction services.

All the real individual sectoral exports deteriorate by less than 0.7 percent except exports for grain seeds that deteriorate by 1.35 percent. The fall in labour productive efficiency and reduction in demand of non-health sector products, both account for the fall in production and exports. However, grain seeds including maize, ground nuts and sorghum face additional effects from rejections in the domestic and foreign markets.

Both nominal and real imports fall by 0.29 percent mainly due to the general reduction in national income and the substitution of other imports for the more expensive medical supplies for treatment of aflatoxin related diseases. The monetary performance of the export and import sectors is shown in Table 8.

Table 8: Change in value and quantity of exports due to aflatoxin contamination

|  |  |  |  |
| --- | --- | --- | --- |
|  | Nominal export (US$ million) | Real export (percent) | Export price |
| Total export | -37.56 | -0.47 | -0.15 |
| Agriculture | -16.34 | -1.09 | -0.28 |
| Grain seeds | -7.48 | -1.35 | -1.04 |
| Health commodities | 0.00 | -0.13 | 0.00 |
| Trade profits (grains) | -1.34 | -1.35 |  |

Aflatoxin contamination in the grains produced in Uganda results into a deterioration in export earnings. Total export loss amounts to US$ 37.56 million of which US$ 16.34 is a loss in agricultural export and US$ 7.48 million is loss in export of grain seeds. The real total exports deteriorate by -0.47 percent whereas real export of grain seeds deteriorate by -1.35 percent. The aggregate export price deteriorated by - 0.15 percent against a fixed import prices thus accounting for the deterioration in the terms of trade by -0.15 percent. Following the deterioration in national income (-0.26 percent), demand for imports falls by US$ 24 million which is less than the fall in exports mainly because of the increased importation of medical supplies for treatment of ailments related to aflatoxin. The performance of expenditure on imports is shown in the Table 9.

Table 9: Change in the value and quantity of imports due to aflatoxin contamination

|  |  |  |  |
| --- | --- | --- | --- |
|  | Nominal import (US$) | Real import (percent) | Import price |
| Total import | -24.33 | -0.29 | 0.00 |
| Agriculture | -2.03 | -0.83 | 0.00 |
| Grain seeds | -5.69 | -2.51 | 0.00 |

Information in Table 9 shows that, the import of grain seeds deteriorate by US$ 5.6 million which is higher than the reduction in general agricultural imports (US$ 2.03 million). This explains the existence of substitution effect for the grain seeds, implying that more maize and groundnuts are imported to substitute their domestic counterparts that are contaminated with aflatoxins.

## 3.7.3 Impact of aflatoxins on trade (business) and transport margins

The impact on trade is mainly captured through the response of general sales of goods and services in the economy as well as the response of trade margins (markup) for the business activity. The sales are analyzed from six demand aggregates including intermediate demand, investment demand, household consumption, export, government demand and stocks. The results from the above shocks indicate a slowdown in business activity in the economy. This is shown by the general reduction in the sales of goods and services except for the sales of health sector related products as shown in Figure 5.



Figure 5: Sales of sectoral goods and services

Information in Figure 5 further shows that, sales of health sector goods and services to households and government increased in FY 2013/14 due to aflatoxin medical costs. Sales of health sector commodities for intermediate consumption reduced by 0.02 percent (US$ 0.023 million) whereas sales to households and government increased by 0.12 (US$ 0.47 million) and 0.38 percent (US$ 1.38 million) respectively thus amounting to a 0.48 percent increase in trade services in the health sector. However, the deterioration of sales of the rest of the products outweighs the improvement in health sector sales thus causing a general slowdown in trade (business) in the economy.

Export trade margins (markup) reduce more for grain seeds (-1.35 percent) amounting to short falls of US$ 1.34 million for trade margins and US$ 0.18 million for transport margins whereas export margins for the rest of commodities deteriorate by not more than 0.13 percent. Trade markups derived from sales to government deteriorate by 0.18 percent and export margins from mining sector increase by 0.02 percent. Both trade and transport margins raised by business activity from domestic sales to households deteriorate for instance grain seeds (-0.27 percent) and animal farming (-0.13). However, margins raised from import sales to households deteriorate further, for instance grain seeds face 2.7 percent reduction in trade and transport margins as animal farming face 0.42 percent reduction. The slowdown in business results into deterioration in trade and income of those households participating in this activity. This effect combined with general slowdown in production affects the household income, expenditure, savings and welfare as discussed in the subsequent sections.

## 3.7.4 Impact of aflatoxins on household welfare

Household income, consumption and savings deteriorate as composite consumer prices fall by 0.15 percent. Post-tax household incomes reduce by 0.33 percent (US$ 79.3 million) thus forcing the general real household consumption to deteriorate by 0.18 percent and the nominal household consumption to reduce by 0.33 percent (US$ 59.1 million). Household savings deteriorate by 3.44 percent (US$ 76.54 million) in FY 2013/14 due to aflatoxin contamination in agricultural produce that generates new expenditure items in the health sector. Among all the commodities in the consumer basket, only the grain seed consumption increases by 0.11 percent (US$ 2.3 million) whilst the consumption of the rest of the products reduce by an average of 0.23 percent.

Maize, groundnuts and sorghum consumption increases mainly because all rejected produce in the formal exports and domestic market is re-sold through informal means to domestic consumers and some is exported through informal arrangements. This creates excess supply of grain seeds in the domestic market thus a fall in their respective prices by 1.04 percent which accounts for 0.11 percent increase in their domestic consumption. However, the increased consumption of the contaminated produce rejected in the formal market increases the risk of disease exposure to the consuming population. The aggregate impact on consumption is shown in Figure 6.



Figure 6: Real and nominal consumption

Information in Figure 6 further illustrates that a onetime shock of aflatoxin contamination causes household consumption and the respective prices to fall. However, it takes an average of 3 years for the prices to return to their steady state levels. The deteriorating household consumption, income, and savings and more exposure to aflatoxin by consuming rejected contaminated produce, amount to the deterioration in the household welfare in the economy.

## 3.7.5 Impact of aflatoxins on the health sector (private and public)

The effect of aflatoxins on the health sector is mainly through the flow of funds and friction between the health sector and the rest of the economy. Government spends on medical imports and administrative costs through the fiscal budget which generates employment in the economy. Households also spend part of their earnings on medical expenses to treat aflatoxin-related illnesses which crowd out savings and other household consumptive and investment commodities. The ailing labor force loses time seeking medication and treating their sick family members thus increasing the opportunity cost of the medical labor time. This accounts for the fall in labor income and increased demand for health goods and services.

Aflatoxin contamination in food grains results into ailments leading to a 0.25 percent and 2.83 percent increase in household demand for domestic and imported health services respectively as shown in Figure 3. Following the increase in demand for health services in the domestic market, production of health services increased by 0.61 percent mainly due to local market effect as shown in Figure 7. Given that all domestically produced health services are consumed domestically and a larger proportion of domestic health supplies are imported; the excess demand for health services results into 0.85 percent increase in the respective price to clear the market. In response to the increase in production of health services, the sector’s demand for the factors of production increases by demand for 0.61 percent.

Aflatoxin contamination in foods raise demand for the medical supplies and technical personnel at the government funded health centers thus generating a fiscal impact. In the simulation period, government savings turns out to be US$ 0.3 million less than it would have been without aflatoxin contamination whereas government expenditure on health services increase by 0.87 percent (US$ 0.91 million). Aggregate tariff revenue deteriorate by 2.55 percent as transfers from the rest of the world to government fall by 0.24 percent, thus indicating that fiscal response to the aflatoxin related medical demand is mainly financed through expenditure switching and drawing down of savings.

## 3.7.6 Impact on production, employment and wages

The deterioration of labor efficiency across all sectors with complementary reduction in demand of products from productive sectors and increasing demand in consumptive sectors (health) results into a fall in general output level. Economic growth deteriorates by 0.26 percent in the simulation year mainly as the loss in production efficiency (-0.35 percent) crowds out the positive contribution by the increased employment demand (0.09 percent); thus the loss in output is mainly driven by the deterioration of production efficiency resulting from ailing labor force with aflatoxin related diseases The contribution of capital to GDP is less affected because capital is less flexible in the short run, thus any adjustments in output are achieved with adjustment in the levels of employment of labor.

As labour productive efficiency deteriorates due to illnesses, lost time in seeking medication and attending to the sick by family members, more labour is required to maintain the same level of economic output in the productive sectors. Thus despite the fall in output (0.26 percent), capital demand remain fixed in the short run thus more labour is required to use the existing capital to compensate for the labor productivity loss. However, demand for labour deteriorates in agricultural sector (-0.26 percent) and real estate (-0.08 percent) but increases in the mining (0.28 percent), manufacturing (0.30 percent), utilities (0.11 percent), construction (0.08 percent) and services (0.32 percent). This results into higher demand for labor which increases real wage by 0.09 percent thus yielding higher employment by 0.18 percent. This translates to a US$ 13.03 million increase in expenditure on labor in the following year by the producing firms to be able to hire more labor to compensate for the loss in labor efficiency due to aflatoxin exposure.

Aggregate real expenditure on GDP falls by 0.24 percent with deterioration in aggregate consumption (-0.15 percent), investment (-0.08 percent), exports (-0.13 percent) and an improvement in imports (0.1 percent). The sharp decrease in consumption is mainly attributed to the falling household income and substitution of consumption income to importation of medical goods and services to treat aflatoxin related diseases. Total nominal expenditure on GDP decreases by 0.34 percent that is equivalent to US$ 91.95 million reduction in expenditure on GDP mainly due to the falling income.

## 3.7.7 The impact of aflatoxins on markets and sectoral outputs

The market effect on production comprises of the responsiveness of sectoral outputs to the dynamics in the domestic market, export market and substitution of demand between imports and domestic products in the local market due to change in consumer tastes and preferences. These are summarized in the decomposition Figure 7.



Figure 7: Decomposition of market and sectoral outputs

Results in Figure 7 further show that local market effect accounts for the fall in output for all sectors except for the health sector where local market effect contributed by 0.48 percent increase in production. The fall in output of grain seed sector and hotels and restaurants is mainly attributed to the export demand effect. The low performance in the hotels and restaurant is attributed to reduced labor productivity and deteriorating quality of food supplies in the country. Among all the sectors, its only grain seeds sector where domestic products are preferred to imported related products thus import substitution. This is mainly because of the reduced prices for these products (grains) after rejection in the international market. However, this is “good news” for farmers but bad news for consumers as it exposes them to ailments and costs related to aflatoxin.

## 3.7.8 Key highlights on impacts of aflatoxin contaminations in foods

The above sections show a mix of positive and negative responses of different macro and microeconomic variables of the Ugandan in economy in FY 2013/14. These impacts have been computed both in percentage changes, as well as real and nominal discrepancy from the steady state of the economy. These impacts have been categorized with respect to their sectors as shown in Tables 10 and 11.

Table 10 shows that sales of health services in the domestic market improve as sales of products from other sectors deteriorate. This is because; with falling labor income, households’ budget constraints are forced to absorb expenditure switching to alternatives in order to accommodate consumption costs for aflatoxin related health services. However, exports sales of health services deteriorate together with their corresponding margins.

Despite the depreciation of the exchange rate and terms of trade, both real and nominal exports deteriorate in the simulation year. The aggregate losses in agricultural exports amounts to US$ 16.34 million as the mining sector registers an improvement in exports earning of US$ 0.013 million. The mining sector responds positively mainly due to the fact that the sector is capital intensive which is less flexible in the short run.

Government expenditure on supplies to health centers increase by US$ 0.91 million as her savings deteriorate by US$ 0.3 million. The increased demand for heath supplies and services escalates their respective prices by 0.85 percent. Despite the increase in the price of health supplies, the general consumer prices (CPI) decrease by 0.15 percent. A combination of falling labour income, increasing prices and expenditure switching effects; household aggregate consumption deteriorate by US$ 59.1 million and savings deteriorate by US$ 76.54 million. However, consumption of grain seeds in the economy improves by US$ 2.3 million mainly due to excess supply caused by rejections in the export market and ignorance of aflatoxin knowledge in the domestic market. Finally, economic growth deteriorates by 0.26 percent mainly due to loss in productivity efficiency. Real wages increase by 0.09 percent thus the 0.18 percent increase in employment.

Table 10: Key highlights of the impacts of aflatoxin contamination in major staple foods (FY 2013/2014)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Trade & transport margins (markup) impacts | | | Export impacts | | | Impact on health sector | | | Impact on household welfare | | | Impact on production, employment & wages | | |
|  | **%** | **US$ mn** |  | **%** | **US$ mn** |  | **%** | **US$ mn** |  | **%** | **US$ mn** |  | **%** | **US$ mn** |
| Health sales ( intermediate) | -0.02 | -0.023 | Nominal exports | -0.62 | -37.56 | Real household Demand domestic health services | 0.25 |  | Composite Price Index | -0.15 |  | Economic growth | -0.26 |  |
| Health sales ( households) | 0.12 | 0.47 | Real export | -0.47 |  | Real household Demand imported health services | 2.83 |  | Disposable household income | -0.33 | -79.3 | Production efficiency | -0.35 |  |
| Health sales ( government) | 0.38 | 1.38 | Export price | -0.15 |  | Production of health services | 0.61 |  | Nominal household consumption | -0.33 | -59.1 | Employment demand | 0.18 |  |
| Aggregate health services | 0.48 |  | Exchange rate depreciation | 0.1 |  | Real consumption of domestic health services by household | 0.25 |  | Real household consumption | -0.18 |  | Real wage | 0.09 |  |
| Export trade margins (grain seeds) | -1.35 | -1.34 | Terms of trade (TOT) | -0.15 |  | Real consumption of imported health services by households | 2.83 |  | Household savings | -3.44 | -76.54 |  |  |  |
| Export transport margins (grain seeds) | -1.35 | -0.18 | Agricultural exports | -1.09 | -16.34 | Health services price | 0.85 |  | Nominal grain seed consumption | 0.11 | 2.3 |  |  |  |
|  |  |  | Mining sector export | 0.02 | 0.013 | Government savings |  | -0.3 | Real consumption of domestic Grain seeds by households | -0.27 |  |  |  |  |
|  |  |  |  |  |  | Government expenditure on health services | 0.87 | 0.91 | Real consumption of imported Grain seeds by households | -2.7 |  |  |  |  |

Table 11: Changes in export and import values and quantity after aflatoxin shock

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Nominal export (US$ million) | Real export (percent) | Nominal import (US$ million) | Real import (percent) |
| Total export/import | -37.56 | -0.47 | -24.33 | -0.29 |
| Agriculture | -16.34 | -1.09 | -2.03 | -0.83 |
| Grain seeds | -7.48 | -1.35 | -5.69 | -2.51 |
| Health commodities | 0.00 | -0.13 |  |  |
| Trade profits (grains) | -1.34 | -1.35 |  |  |

## 4.0 Gaps, priority areas and strategies for control of aflatoxins in Uganda

This chapter summarises the gaps, priority areas and strategies for management and control of aflatoxins in Uganda. The gaps, priorities and strategies presented here are a qualitative analysis of the information obtained through interaction of the consultants with various stakeholders including farmers, traders/middlemen, district extension staff, civil society organizations, policy makers, academicians and researchers. The information was gathered through interviews, meetings, Focus Group Discussions (FGDs) and literature review.

## 4.1 Identified gaps

The following gaps were identified;

1. **Limited knowledge and awareness on the effects of aflatoxins**

Majority of the stakeholders including policy makers, technocrats, traders, processors, farmers and consumers are not aware of the negative effects of aflatoxins on health, trade and food security. As a result, limited or no attention is given to aflatoxins at all levels of the value chain. For example, the policy makers do not allocate any resources to management of aflatoxins and consequently, the extension staff does not include aflatoxins in their work plans. In addition there is limited surveillance of aflatoxins in the country.

1. **Limited infrastructure for aflatoxin analysis**

The study findings revealed that there are very few institutions with capacity to analyze aflatoxins. They include three public institutions namely, Department of Food Technology and Nutrition -Makerere University, UNBS - MTIC, Government Chemist and Analytical Laboratory - Ministry of Internal Affairs and one private laboratory - Chemipher (U) Limited. These laboratories are using High Performance Liquid Chromatography (HPLC), Fluorimeter (Vicam) and immunochemical methods like ELISA. However, none of these laboratories has capacity to assess aflatoxins in blood serum or urine. It was also noted that most of the reagents and supplies for analysis of aflatoxins are imported which makes the analysis quite costly. A combination of these factors makes it difficult to implement detailed monitoring and surveillance systems.

1. **Lack of an enabling policy and law on enforcement of aflatoxin standards**

Uganda has standards for aflatoxins for a number of food products like maize, rice, groundnuts, sorghum, and baby foods among others. However, there is no clear policy and law on the enforcement of the existing aflatoxin standards and there are no penalties for trading in aflatoxin contaminated produce. There are no standard operating procedures at all levels of the value chain to guide the stakeholders on how to reduce control aflatoxins. The situation is worsened by the limited awareness amongst the different stakeholders along the value chains.

1. **Lack of direct budget support for aflatoxin control**

The study findings revealed that there was no direct budget support for aflatoxin management and control in the key ministries of health, trade and agriculture and at district local governments. As result, both local and central governments do not have action plans for aflatoxin management. The current efforts on aflatoxin management and control of aflatoxins in the districts are mainly funded by development partners and private sector engaged in export of grains or manufacturing of baby foods. The lack of budgetary support in the key ministries could also be responsible for the inadequate infrastructure for monitoring aflatoxins in the country.

1. **Limited coordination among the key stakeholders**

The study observed that there was limited coordination in the control of aflatoxins amongst the key stakeholders. There was no platform to link the few institutions and development partners engaged in management and control of aflatoxins in the country. As a result, the study observed that in some districts, more than one organization are implementing similar activities while other districts were not covered at all.

1. **Limited access to appropriate postharvest technologies**

As already mentioned, there are no guidelines on the handling and storage of the produce susceptible to aflatoxin contamination. Majority of the farmers, traders and processors lack appropriate postharvest handling and storage facilities. There is inadequate implementation of GAP by farmers. Drying is mainly done on bare ground using natural energy from the sun while primary processing like shelling/threshing is done using rudimentary technologies like beating with sticks or use of poorly designed shelling/threshing machines that inflict damage on to the grains. The farmers mainly store their produce in their living rooms while traders and processors store in makeshift storage structures. These practices expose produce to fungal infection and subsequent contamination with aflatoxins.

1. **Inadequate information/data on aflatoxin exposure**

Uganda has not conducted extensive and regular studies to collect data for use in aflatoxin exposure assessment. The few studies conducted have been research-based focusing on specific crops and districts. The efforts undertaken by this study to quantify the impact of aflatoxins in the key sectors of agriculture, health and trade is a step in the right direction. However, more agro-ecological zones and foods need to be covered. There is also need to collect data on other variables for example; the consumption trends of the aflatoxin prone crops, levels of aflatoxins in serum of individuals consuming aflatoxin contaminated foods and the prevalence of confounding factors like liver cancer, HBV, HIV/AIDs, smoking and alcohol consumption among others. It is anticipated that a detailed analysis of all these factors will provide adequate information to enable policy makers include aflatoxin activities in the national and local budget plans.

## 4.2 Priority areas and interventions for management and control of aflatoxins in Uganda

The study identified five priority areas where interventions for management and control for aflatoxins could focus. The identified priority areas include,

1. Production, postharvest handling & storage
2. Processing and marketing
3. Public health management
4. Advocacy & awareness creation
5. Policy and regulation

The proposed specific strategies under each priority area are indicated in Table 12.

Table 12: Strategies for management and control of aflatoxins in Uganda

|  |  |
| --- | --- |
| Priority area(s) | Proposed intervention strategies |
| 1. Production, postharvest handling and storage | 1. **Training in good agricultural and improved post-harvest handling practices**   Strengthen the capacity of farmers, traders and millers in recommended agronomic and post-harvest handling practices aimed at reducing aflatoxins. This can be done through training of all value chain actors in good agricultural practices (GAP) like site selection, use of good quality seed, seed bed preparation, good crop management practices, early harvesting and improved postharvest handling practices like use of cost effective but improved crop drying technologies like using tarpaulins, cemented drying yards, raised structures as well as use of improved storage structures.   1. **Increasing access to appropriate postharvest handling technologies**   Majority of the farmers and produce dealers in Uganda are small scale in nature and do not have the financial capacity to procure improved technologies for management and control of aflatoxins during production, handling, processing and marketing of produce. In order to overcome this challenge, the different value chain actors should form respective cooperatives which can help them to take advantage of pooled resources and increase access and adoption of aflatoxins reducing technologies. Alternatively, some progressive farmers or traders can be facilitated with soft loans to acquire improved technologies like tarpaulins, shellers, mechanical driers which can be hired to the rest of the farmers and traders at a subsidized fee.   1. **Increasing access to appropriate storage facilities**   Storage is still a big challenge for majority of the farmers and produce dealers. There is need to introduce improved storage methods and materials such as hermetic storage facilities or use of super bags or cocoons to arrest growth and multiplication of aflatoxin producing molds during storage and marketing of the produce.   1. **Establishment of Warehouse Receipt Systems**   Warehouse Receipt Systems provide secure and professional storage services especially where farmer cooperative groups exist. We therefore propose that in each district, a warehouse receipt system be introduced to enhance storage and post-harvest handling   1. **Strengthen monitoring and surveillance at district level**   Strengthen the capacity of the local governments in monitoring and surveillance of aflatoxins through inclusion of aflatoxin activities in district budgets, establishment of district aflatoxin testing centers, training of extension workers and other staff on aflatoxin management and providing aflatoxin related Information Education   1. **Promote the use of bio-control initiatives**   This initiative involves the application of atoxigenic strains of *Aspergillus* spp in the fields to suppress the toxigenic ones. The practice has been found effective in West African countries and is currently in initial stages of testing in some East African countries like Kenya, Uganda and Tanzania. However, detailed environmental impact assessment is needed before full application of the strains to avoid the side effects of the strains on other crops and the environment |
| 1. Processing and marketing | 1. **Training of the processors and produce dealers in quality assurance**   Majority of the processors and produce dealers have no basic training in quality assurance. There is therefore need to train the key value chain actors in quality assurance with respect to aflatoxin contamination. This can be done through training on appropriate handling of produce, appropriate drying methods, quality monitoring and observance of good hygiene during handling, processing and storage.   1. **Promote formation of cooperatives**   As mentioned before, majority of the processors and grain traders do have sufficient capital to acquire improved postharvest handling technologies. The formation of cooperatives will enable processors and traders to pull resources together and acquire improved produce handling technologies like dryers, shellers, cleaners, moisture meters, storage facilities and aflatoxin monitoring kits.   1. **Promote adherence to the existing aflatoxin standards**   Carry out awareness campaigns on the existing aflatoxin standards and the importance of adhering to the standards. Put in place mechanisms for providing incentives for premium products (aflatoxin free products)   1. **Develop cost effective alternative uses of aflatoxin contaminated produce**   In order to reduce losses associated with condemned aflatoxin contaminated produce, there is need to develop cost effective alternative uses for produce with aflatoxins above the UNBS standard. This will also reduce the habit of mixing poor quality produce with good quality produce in a bid to avoid losses |
| 1. Advocacy and awareness creation | 1. **Awareness creation**   Majority of the stakeholders are not aware of aflatoxins and their effects. There is therefore need to carry out massive awareness campaigns to sensitize all the stakeholders on the economic and health effects of aflatoxins. This could be done through District Local Governments (Extension Workers) and NGOs as well as print and electronic media (newspapers, radio, TV, mobile phones)   1. **Develop a national communication strategy**   There is need to have a comprehensive strategy for disseminating information on aflatoxins and other food safety issues. The national communication strategy will help all the stakeholders to deliver uniform and harmonized information   1. **Advocacy**   There is need to advocate for prioritization of aflatoxin activities in the key government ministries of health, trade and agriculture and district local governments. This can need done through engagements with Legislators, Cabinet Ministers, Permanent Secretaries and Local District Councils   1. **Development and dissemination of aflatoxin management IEC materials**   There is need to develop simple but effective IEC materials in different local languages to enable easy comprehension |
| 1. Public health Management | 1. **Strengthening institutional capacity**   Strengthen the capacity of research institutions in aflatoxin exposure and risk assessment through training of human resources and establishment of a risk assessment committee. There is also need to strengthen the capacity of health facilities to detect and treat liver cancer at an early stage   1. **Identify the aflatoxin hotspots and the major confounding factors**   Identification of aflatoxin hotspots and the major confounding factors will enable the public health managers to design practical strategies for the affected communities   1. **Ensure universal HBV vaccination**   People who have HBV infection are at a higher risk of aflatoxin poisoning compared to those who are HBV negative. Universal HBV vaccination is therefore recommended to reduce the risk in HBV prone areas   1. **Promote dietary diversity**   Over reliance of aflatoxin prone crops like maize and groundnuts increases the risk of liver cancer and other aflatoxin related illness. Diet diversification to reduce consumption of such foods is therefore a good approach to reducing incidence of diseases associated with consumption of aflatoxin contaminated foods. Promotion of dietary diversity will help in boosting the health of vulnerable groups especially children, pregnant and mothers who heavily rely on aflatoxin prone crops like maize, sorghum and groundnuts. |
| 1. Policy and regulation | 1. **Mainstreaming of aflatoxin aspects**   Mainstream aflatoxin aspects in the National Development Plan (NDP) and related plans like the Agricultural Sector Strategic Plan (ASSP) and the Health Sector Strategic Plan (HSSP)   1. **Enhance monitoring and enforcement of aflatoxin standards through district authorities**   The local governments should be facilitated to test all agricultural produce for aflatoxins before it is released into the markets   1. **Fast track the relevant food safety policies**   Strengthen the food safety control systems by fast tracking the relevant policies like the food safety policy and the grain policy and ensure that aflatoxin management and control aspects are well articulated in the policies   1. **Put in place standard operating procedures and codes of practice**   Translate the existing aflatoxin standards into practical standard operating procedures and codes of practice to enable the various value chain actors integrate such SOPs and codes into their activities   1. **Put in place multi-sectoral aflatoxin management committee**   The committee will take the lead in advancing relevant authorities on policy issues related to aflatoxins. Shared responsibility amongst different government institutions weakens efforts and creates lack of clear direction   1. **Integration of aflatoxin issues in the education curriculum**   Lobby for inclusion of aflatoxin related aspects in the education curricula at different levels of education. This will increase awareness of the problem across the board |

## 5.0 Conclusion

The study has revealed that aflatoxin is a major problem in Uganda affecting the three major sectors of the economy namely; agriculture, health and trade. In addition, the study showed that the food control systems in Uganda are weak, thereby enhancing exposure of the populace to aflatoxin effects. Therefore, there is the need to put in place deliberate strategies to manage the devastating effects of aflatoxin contamination. The study has identified five strategic areas where aflatoxin management and control in the country should focus.

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## 7.0 List of annexes

## Annex 1: Production levels of selected crops in Uganda (2000-2013)

**Source: FAO, 2104.**<http://faostat3.fao.org/faostat-gateway/go/to/download/FB/CC/E>

## Annex 2: Consumption and energy supply by selected crops in Uganda

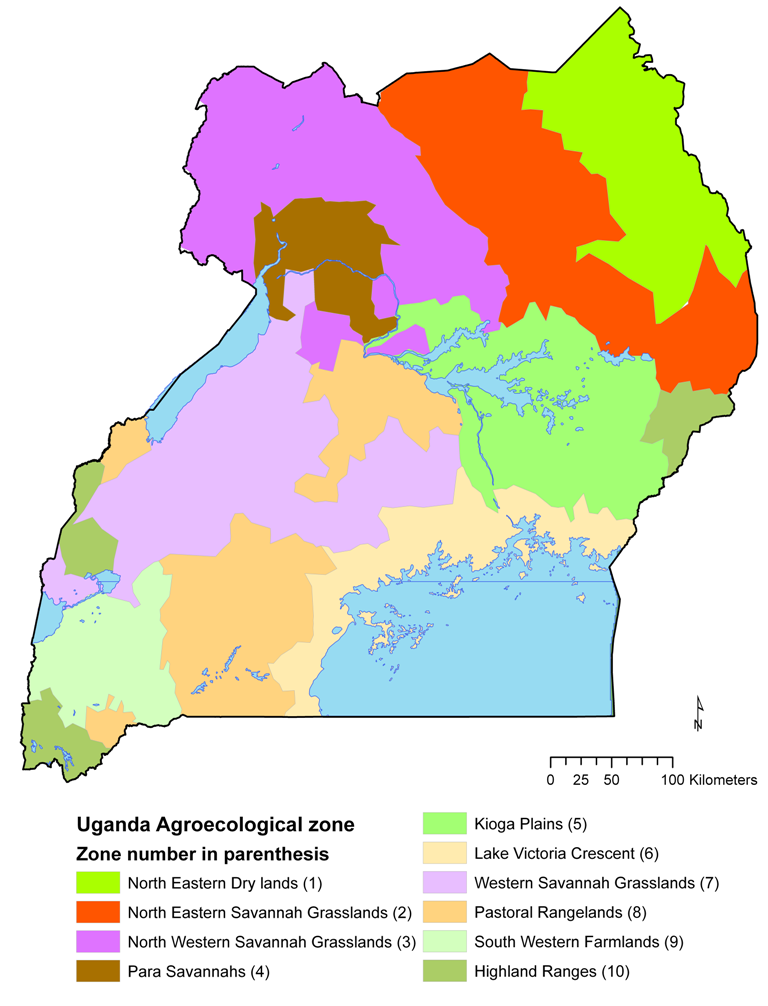
|  |  |  |  |
| --- | --- | --- | --- |
| Commodity | Amount consumed (g/person/day) | Energy supply (kcal/person/day) | % Share of caloric intake |
| Maize and products | 111 | 344 | 17.15 |
| Plantains | 357 | 318 | 15.85 |
| Cassava and products | 243 | 267 | 13.31 |
| Sweet potatoes | 169 | 162 | 8.08 |
| Beans | 27 | 91 | 4.54 |
| Groundnuts (Shelled Equivalent) | 13 | 69 | 3.44 |
| Rice (Milled Equivalent) | 15 | 54 | 2.69 |
| Millet and products | 16 | 42 | 2.09 |
| Sorghum and products | 11 | 34 | 1.69 |
| Bananas | 38 | 23 | 1.15 |
| Soyabeans | 4 | 15 | 0.75 |
| Others |  | 587 | 29.3 |
| Total |  | **2006** | **100** |

**Source: FAO, 2014, UBOS, 2006**

## Annex 3: Value of exports for selected crops in Uganda (2000-2011)

Source: **FAO, 2104.**<http://faostat3.fao.org/faostat-gateway/go/to/download/FB/CC/E>

## Annex 4: Agro-ecological zones of Uganda



## Annex 5: Production levels of targeted crops in selected districts

**A: Maize**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| District | Second season 2008 | | First season 2009 | | Total for 2008/09 | |
| ***Area (Ha)*** | ***Production (MT)*** | ***Area (Ha)*** | ***Production (MT)*** | ***Area (Ha)*** | ***Production (MT)*** |
| Iganga | 22,033 | 75,687 | 27,299 | 227,574 | 49,333 | 303,262 |
| Mubende | 21,676 | 114,277 | 19,819 | 56,811 | 41,495 | 171,089 |
| Soroti | 6,018 | 51,739 | 9,420 | 85,918 | 15,439 | 137,657 |
| Kabarole | 5,359 | 43,918 | 5,784 | 47,400 | 11,144 | 91,318 |
| Kamuli | 24,324 | 36,916 | 42,797 | 45,053 | 67,120 | 81,969 |
| Tororo | 5,303 | 31,389 | 5,855 | 44,284 | 11,158 | 75,673 |
| Masaka | 12,016 | 45,745 | 9,782 | 36,542 | 21,798 | 82,287 |
| Tororo | 5,303 | 31,389 | 5,855 | 44,284 | 11,158 | 75,673 |
| Bugiri | 26,860 | 36,182 | 32,544 | 27,421 | 59,404 | 63,603 |
| Masindi | 27,429 | 28,109 | 24,713 | 33,606 | 52,142 | 61,715 |
| Kibale | 9,466 | 30,224 | 12,002 | 30,305 | 21,468 | 60,529 |

**B: Groundnuts**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| District | Second season 2008 | | First season 2009 | | Total for 2008/09 | |
| ***Area (Ha)*** | ***Production (MT)*** | ***Area (Ha)*** | ***Production (MT)*** | ***Area (Ha)*** | ***Production (MT)*** |
| Soroti | 2,907 | 13,722 | 10,418 | 5,876 | 13,325 | 19,599 |
| Nakasongola | 2,253 | 18,975 | 2,002 | 208 | 4,255 | 19,183 |
| Amuru | 6,153 | 11,900 | 4,962 | 2,474 | 11,115 | 14,375 |
| Kibale | 3,259 | 9,876 | 3,753 | 2,597 | 7,012 | 12,473 |
| Tororo | 1,316 | 3,970 | 3,429 | 6,639 | 4,745 | 10,609 |
| Kumi | 813 | 1,260 | 10,074 | 7,377 | 10,887 | 8,636 |
| Pader | 10,013 | 4, 742 | 12,645 | 3,859 | 22,658 | 8,602 |
| Masindi | 5,480 | 4,425 | 2,856 | 3,284 | 8,336 | 7,708 |
| Gulu | 9,364 | 2,845 | 7,900 | 3,260 | 17,264 | 6,105 |
| Iganga | 4,285 | 3,059 | 5,127 | 1,977 | 9,413 | 5,036 |

**C: Sorghum**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| District | Second season 2008 | | First season 2009 | | Total for 2008/09 | |
| ***Area (Ha)*** | ***Production (MT)*** | ***Area (Ha)*** | ***Production (MT)*** | ***Area (Ha)*** | ***Production (MT)*** |
| Soroti | 12,019 | 26,036 | 6,068 | 29,509 | 18,087 | 55,544 |
| Tororo | 3,870 | 22,403 | 3,630 | 14,683 | 7,500 | 37,086 |
| Ntungamo | 6,412 | 12,316 | 5,357 | 10,790 | 11,769 | 23,106 |
| Pader | 10,267 | 9,679 | 12,137 | 12,824 | 22,404 | 22,503 |
| Kabale | 385 | 84 | 12,687 | 18,521 | 13,073 | 18,605 |
| Amuru | 4,503 | 10,318 | 4,322 | 3,472 | 8,825 | 13,790 |
| Kitgum | 11,993 | 11,721 | 12,753 | 1,545 | 24,746 | 13,266 |
| Arua | 5,998 | 7,143 | 3,096 | 5,195 | 9,094 | 12,338 |
| Kaberamiado | 6,875 | 6,759 | 4,298 | 3,173 | 11,173 | 9,932 |
| Lira | 11,613 | 11,713 | 7,835 | 2,118 | 19,448 | 13,831 |
| Moroto | 7,750 | 7,495 | 6,540 | 3,837 | 14,290 | 11,332 |
| Nakapiripirit | 32,325 | 4,304 | 34,760 | 3,063 | 67,085 | 7,368 |
| Yumbe | 3,755 | 6,400 | 3,489 | 1,107 | 7,245 | 7,507 |

**Source: UBOS 2010**

## Annex 6: Sampling plan showing the number of samples collected from each district

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Agro-ecological zone | District | Number of samples collected/crop/district | | |
| Western Savannah Grasslands | ***Maize*** | ***Groundnuts*** | ***Sorghum*** |
| Mubende | 20 | 15 | - |
| Kamwenge | 20 | 15 | - |
| Masindi | 20 | 10 | - |
| **Sub-Total** | **60** | **40** |  |
| Kioga plains | Iganga | 20 | 10 | - |
| Soroti | 10 | 10 | 20 |
| Tororo | 10 | 10 | 20 |
| **Sub-Total** | **40** | **30** | **60** |
| North Eastern Savannah Grasslands | Gulu | - | 10 | 20 |
| Lira | - | 10 | 20 |
| Amuria |  | 10 | 20 |
| **Sub-Total** |  | **30** | **40** |
| Grand Total |  | **100** | **100** | **100** |

## Annex 7: Levels of aflatoxins in maize, groundnuts and sorghum

**7.1 Aflatoxin levels in maize grains**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **District** | **Source** | **Aflatoxin Content (ppb)** | **Aflatoxin Content (ppb)** | **Mean ± SDV** |
| Iganga | Farmer | 1 | 3 | 2.0 **±** 1.4 |
| Iganga | Farmer | 6 | 7 | 6.5 **±** 0.7 |
| Iganga | Farmer | 6 | 8.3 | 7.15 **±** 1.6 |
| Iganga | Farmer | 6 | 8 | 7.0 **±** 1.4 |
| Iganga | Farmer | 0 | 0 | 0.0 **±** 0.0 |
| Iganga | Farmer | 7 | 10.1 | 8.5 **±** 2.2 |
| Iganga | Farmer | 7 | 6.3 | 6.65 **±** 0.5 |
| Iganga | Farmer | 7 | 4.9 | 5.95 **±** 1.5 |
| Iganga | Farmer | 8 | 13 | 10.5 **±** 3.5 |
| Iganga | Farmer | 17 | 19 | 18.0 **±** 1.4 |
| Iganga | Farmer | 24 | 21 | 22.5 **±** 2.1 |
| Iganga | Farmer | 57 | 65 | 61 **±** 5.7 |
| Iganga | Market | 2 | 3.5 | 2.75 **±** 1.1 |
| Iganga | Market | 4 | 5 | 4.5 **±** 0.7 |
| Iganga | Market | 22 | 25 | 23.5 **±** 2.1 |
| Iganga | Market | 37 | 33 | 35 **±** 2.8 |
| Iganga | Market | 79 | 75 | 77 **±** 2.8 |
| Iganga | Market | 680 | 330 | 505 **±** 247.5 |
| Iganga | Market | 67 | 72 | 69.5 **±** 3.5 |
| Iganga | Market | 44 | 41 | 42.5 **±** 2.1 |
| Kamwenge | Farmer | 3 | 4.3 | 3.65 **±** 0.9 |
| Kamwenge | Farmer | 4 | 6 | 5.0 **±** 1.4 |
| Kamwenge | Farmer | 7 | 5.9 | 6.45 **±** 0.8 |
| Kamwenge | Farmer | 7 | 6.1 | 6.55 **±** 0.6 |
| Kamwenge | Farmer | 7 | 8 | 7.5 **±** 0.7 |
| Kamwenge | Farmer | 12 | 10 | 11.0 **±** 1.4 |
| Kamwenge | Farmer | 76 | 71 | 73.5 **±** 3.5 |
| Kamwenge | Farmer | 110 | 98 | 104 **±** 8.5 |
| Kamwenge | Farmer | 19.5 | 17 | 18.25 **±** 1.8 |
| Kamwenge | Farmer | 25 | 28 | 26.5 **±** 2.1 |
| Kamwenge | Farmer | 29 | 26 | 27.5 **±** 2.1 |
| Kamwenge | Market | 3 | 2.8 | 2.9 **±** 0.1 |
| Kamwenge | Market | 3 | 3.5 | 3.25 **±** 0.4 |
| Kamwenge | Market | 4 | 8 | 6.0 **±**2.8 |
| Kamwenge | Market | 7 | 6 | 6.5 **±** 0.7 |
| Kamwenge | Market | 8 | 13 | 10.5 **±** 3.5 |
| Kamwenge | Market | 10 | 15 | 12.5 **±** 3.5 |
| Kamwenge | Market | 35 | 33 | 34 **±** 1.4 |
| Kamwenge | Market | 35 | 40 | 37.5 **±** 3.5 |
| Kamwenge | Market | 100 | 109 | 104.5 **±** 6.4 |
| Masindi | Farmer | 3 | 2.8 | 2.9 **±** 0.1 |
| Masindi | Farmer | 3 | 4 | 3.5 **±** 0.7 |
| Masindi | Farmer | 3.1 | 3 | 3.05 **±** 0.1 |
| Masindi | Farmer | 4 | 3 | 3.5 **±** 0.7 |
| Masindi | Farmer | 5 | 6 | 5.5 **±** 0.7 |
| Masindi | Farmer | 5 | 7 | 6.0 **±** 1.4 |
| Masindi | Farmer | 7 | 9 | 8.0 **±** 1.4 |
| Masindi | Farmer | 9 | 12 | 105.0 **±**.2.1 |
| Masindi | Farmer | 10 | 14 | 12.0 **±** 2.8 |
| Masindi | Farmer | 18 | 20 | 19.0 **±** 1.4 |
| Masindi | Farmer | 200 | 189 | 194.5 **±** 7.8 |
| Masindi | Farmer | 550 | 470 | 510 **±** 56.6 |
| Masindi | Market | 1 | 2 | 1.5 **±** 0.7 |
| Masindi | Market | 3 | 4 | 3.5 **±** 0.7 |
| Masindi | Market | 3 | 6 | 4.5 **±** 2.1 |
| Masindi | Market | 4 | 5 | 4.5 **±** 0.7 |
| Masindi | Market | 4 | 7 | 5.5 **±** 2.1 |
| Masindi | Market | 6 | 6.5 | 6.25 **±** 0.4 |
| Masindi | Market | 6 | 7 | 6.5 **±** 0.7 |
| Masindi | Market | 19 | 24 | 21.5 **±** 3.5 |
| Mubende | Farmer | 1 | 0 | 0.5. **±** 0.7 |
| Mubende | Farmer | 3 | 5 | 4.0 **±** 1.4 |
| Mubende | Farmer | 3 | 4 | 3.5 **±** 0.7 |
| Mubende | Farmer | 5 | 3 | 4.0 **±** 1.4 |
| Mubende | Farmer | 6 | 10 | 8.0 **±** 2.8 |
| Mubende | Farmer | 6 | 7 | 6.5 **±** 0.7 |
| Mubende | Farmer | 11 | 14 | 12.5 **±** 2.1 |
| Mubende | Farmer | 11 | 10 | 10.5 **±** 0.7 |
| Mubende | Farmer | 30 | 27 | 28.5 **±** 2.1 |
| Mubende | Farmer | 170 | 187 | 178.5 **±** 12 |
| Mubende | Farmer | 54 | 50 | 52.0 **±** 2.8 |
| Mubende | Farmer | 73 | 70 | 71.5 **±** 2.1 |
| Mubende | Market | 4 | 7 | 5.5 **±** 2.1 |
| Mubende | Market | 22 | 29 | 25.5 **±** 4.9 |
| Mubende | Market | 48 | 46 | 47.0 **±** 1.4 |
| Mubende | Market | 130 | 139 | 134.5 **±** 6.4 |
| Mubende | Market | 130 | 121 | 125.5 **±** 6.4 |
| Mubende | Market | 230 | 245 | 237.5 **±** 10.6 |
| Mubende | Market | 240 | 255 | 247.5 **±** 10.6 |
| Mubende | Market | 240 | 213 | 226.5 **±** 19.1 |
| Soroti | Farmer | 0 | 0 | 0.0 **±** 0.0 |
| Soroti | Farmer | 1 | 2.3 | 1.65 **±** 0.9 |
| Soroti | Farmer | 14 | 13 | 13.5 **±** 0.7 |
| Soroti | Farmer | 40 | 47 | 43.5 **±** 4.9 |
| Soroti | Farmer | 1000 | 350 | 675 **±** 459.6 |
| Soroti | Farmer | 3300 | 2400 | 2850 **±** 636.4 |
| Soroti | Farmer | 170 | 189 | 179.5 **±** 13.4 |
| Soroti | Market | 0 | 0 | 0.0 **±** 0.0 |
| Soroti | Market | 4 | 5 | 4.5 **±** 0.7 |
| Soroti | Market | 110 | 117 | 113.5 **±** 4.9 |
| Tororo | Farmer | 0 | 0 | 0.0 **±** 0.0 |
| Tororo | Farmer | 0 | 0 | 0.0 **±** 0.0 |
| Tororo | Farmer | 0 | 1 | 0.5 **±** 0.7 |
| Tororo | Farmer | 1 | 3 | 2.0 **±** 1.4 |
| Tororo | Farmer | 1 | 2 | 1.5 **±** 0.7 |
| Tororo | Farmer | 2 | 1 | 1.5 **±** 0.7 |
| Tororo | Market | 1 | 1 | 1.0 **±** 0.0 |
| Tororo | Market | 4 | 7 | 5.5 **±** 2.1 |
| Tororo | Market | 16 | 18 | 17.0 **±** 1.4 |
| Tororo | Market | 82 | 86 | 84 **±** 2.8 |
| **Overall average** |  | **86.116** | **67.463** | **76.7895±**16.4 |

**7.2 Aflatoxin levels in sorghum grains**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **District** | **Source** | **Aflatoxin Content (ppb)** | **Aflatoxin Content (ppb)** | **Mean ± SDV** |
| Amuria | Farmer | 25 | 45 | 35 **±** 14.1 |
| Amuria | Market | 30 | 27 | 28.5 **±**2.1 |
| Amuria | Market | 32 | 30 | 31 **±** 1.4 |
| Amuria | Market | 34 | 37 | 35.5 **±** 2.1 |
| Amuria | Farmer | 34 | 40 | 37 **±** 4.2 |
| Amuria | Market | 35 | 42 | 38.5 **±** 4.9 |
| Amuria | Market | 37 | 48 | 42.5 **±** 7.8 |
| Amuria | Market | 40 | 38 | 39 **±** 1.4 |
| Amuria | Market | 48 | 49 | 48.5 **±** 0.7 |
| Amuria | Farmer | 48 | 52 | 50 **±** 2.8 |
| Amuria | Farmer | 51 | 56 | 53.5 **±** 3.5 |
| Amuria | Farmer | 53 | 58 | 55.5 **±** 3.5 |
| Amuria | Farmer | 62 | 54 | 58 **±** 5.7 |
| Amuria | Farmer | 67 | 65 | 66 **±** 1.4 |
| Amuria | Farmer | 160 | 171 | 165.5 **±** 7.8 |
| Amuria | Market | 190 | 189 | 189.5 **±** 0.7 |
| Amuria | Farmer | 230 | 237 | 233.5 **±** 4.9 |
| Amuria | Farmer | 270 | 265 | 267.5 **±** 3.5 |
| Amuria | Farmer | 270 | 297 | 283.5 **±** 19.1 |
| Amuria | Farmer | 430 | 514 | 472 **±** 59.4 |
| Gulu | Farmer | 0 | 0 | 0 **±** 0.0 |
| Gulu | Market | 5 | 6 | 5.5 **±** 0.7 |
| Gulu | Market | 10 | 12 | 11 **±** 1.4 |
| Gulu | Market | 12 | 17 | 14.5 **±** 3.5 |
| Gulu | Market | 32 | 36 | 34 **±** 2.8 |
| Gulu | Farmer | 38 | 41 | 39.5 **±** 2.1 |
| Gulu | Farmer | 62 | 67 | 64.5 **±** 3.5 |
| Gulu | Market | 90 | 94 | 92 **±** 2.8 |
| Gulu | Farmer | 91 | 99 | 95 **±** 5.7 |
| Gulu | Market | 92 | 101 | 96.5 **±** 6.4 |
| Gulu | Market | 100 | 121 | 110.5 **±** 14.8 |
| Gulu | Farmer | 100 | 87 | 93.5 **±** 9.2 |
| Gulu | Farmer | 120 | 119 | 119.5 **±** 0.7 |
| Gulu | Farmer | 100 | 85 | 92.5 **±** 10.6 |
| Gulu | Farmer | 91 | 95 | 93 **±** 2.8 |
| Gulu | Farmer | 100 | 112 | 106 **±** 8.5 |
| Gulu | Farmer | 55.7 | 60 | 57.85 **±** 3.0 |
| Gulu | Farmer | 53 | 50 | 51.5 **±** 2.1 |
| Gulu | Farmer | 58 | 49 | 53.5 **±** 6.4 |
| Gulu | Farmer | 95 | 110 | 102.5 **±** 10.6 |
| Lira | Farmer | 41.8 | 38 | 39.9 **±** 2.7 |
| Lira | Farmer | 34 | 37 | 35.5 **±** 2.1 |
| Lira | Market | 26 | 29 | 27.5 **±** 2.1 |
| Lira | Market | 40 | 48 | 44 **±** 5.7 |
| Lira | Market | 42 | 45 | 43.5 **±** 2.1 |
| Lira | Market | 57 | 64 | 60.5 **±** 4.9 |
| Lira | Market | 89 | 94 | 91.5 **±** 3.5 |
| Lira | Market | 98 | 105 | 101.5 **±** 4.9 |
| Lira | Market | 120 | 132 | 126 **±** 8.5 |
| Lira | Farmer | 120 | 116 | 118 **±** 2.8 |
| Lira | Farmer | 120 | 143 | 131.5 **±** 16.3 |
| Lira | Market | 130 | 124 | 127 **±** 4.2 |
| Lira | Market | 130 | 121 | 125.5 **±** 6.4 |
| Lira | Farmer | 130 | 143 | 136.5 **±** 9.2 |
| Lira | Farmer | 150 | 161 | 155.5 **±** 7.8 |
| Lira | Market | 240 | 214 | 227 **±** 18.4 |
| Lira | Farmer | 120 | 139 | 129.5 **±** 13.4 |
| Lira | Farmer | 150 | 162 | 156 **±** 8.5 |
| Lira | Farmer | 98.5 | 78 | 88.25 **±** 14.5 |
| Lira | Farmer | 96.3 | 83 | 89.65 **±** 9.4 |
| Soroti | Farmer | 97 | 99.5 | 98.25 **±** 1.8 |
| Soroti | Farmer | 100 | 114 | 107 **±** 9.9 |
| Soroti | Market | 120 | 129 | 124.5 **±** 6.4 |
| Soroti | Market | 120 | 117 | 118.5 **±** 2.1 |
| Soroti | Farmer | 120 | 109 | 114.5 **±** 7.8 |
| Soroti | Farmer | 130 | 142 | 136 **±** 8.5 |
| Soroti | Market | 150 | 147 | 148.5 **±** 2.1 |
| Soroti | Farmer | 150 | 159 | 154.5 **±** 6.4 |
| Soroti | Farmer | 160 | 169 | 164.5 **±** 6.4 |
| Soroti | Farmer | 170 | 175 | 172.5 **±** 3.5 |
| Soroti | Farmer | 170 | 156 | 163 **±** 9.9 |
| Soroti | Market | 180 | 174 | 177 **±** 4.2 |
| Soroti | Market | 200 | 241 | 220.5 **±** 29.0 |
| Soroti | Market | 200 | 187 | 193.5 **±** 9.2 |
| Soroti | Market | 210 | 221 | 215.5 **±** 7.8 |
| Soroti | Market | 220 | 195 | 207.5 **±** 17.7 |
| Soroti | Market | 220 | 235 | 227.5 **±** 10.6 |
| Soroti | Market | 240 | 261 | 250.5 **±** 14.8 |
| Soroti | Farmer | 260 | 271 | 265.5 **±** 7.8 |
| Soroti | Farmer | 140 | 145 | 142.5 **±** 3.5 |
| Tororo | Farmer | 0 | 0 | 0.0 **±** 0.0 |
| Tororo | Farmer | 2 | 2 | 2.0 **±** 0.0 |
| Tororo | Farmer | 2.2 | 5 | 3.6 **±** 2.0 |
| Tororo | Market | 6 | 8 | 7.0 **±** 1.4 |
| Tororo | Market | 6 | 7 | 6.5 **±** 0.7 |
| Tororo | Farmer | 9 | 11 | 10 **±** 1.4 |
| Tororo | Farmer | 9 | 13 | 11.0**±** 2.8 |
| Tororo | Farmer | 23 | 21 | 22 **±** 1.4 |
| Tororo | Market | 32 | 37 | 34.5 **±** 3.5 |
| Tororo | Farmer | 35 | 45 | 40 **±** 7.1 |
| Tororo | Farmer | 39 | 29 | 34 **±** 7.1 |
| Tororo | Farmer | 44 | 51 | 47.5 **±** 4.9 |
| Tororo | Market | 50 | 57 | 53.5 **±** 4.9 |
| Tororo | Farmer | 50 | 59 | 54.5 **±** 6.4 |
| Tororo | Market | 68 | 61 | 64.5 **±** 4.9 |
| Tororo | Market | 99 | 89 | 94 **±** 7.1 |
| Tororo | Market | 150 | 164 | 157 **±** 9.9 |
| Tororo | Farmer | 160 | 151 | 155.5 **±** 6.4 |
| Tororo | Farmer | 190 | 240 | 215 **±** 35.4 |
| Tororo | Farmer | 95 | 85 | 90 **±** 7.1 |
| **Average** |  | **99.095** | **103.325** | **101.21 ± 3.0** |

**7.3 Aflatoxin levels in groundnuts**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **District** | **Source** | **Aflatoxin Content (ppb)** | **Aflatoxin Content (ppb)** | **Mean ± SDV** |
| Amuria | Farmer | 0 | 0 | 0 **±** 0.0 |
| Amuria | Farmer | 1 | 3 | 2.0 **±** 1.4 |
| Amuria | Farmer | 1 | 2 | 1.5 **±** 0.7 |
| Amuria | Farmer | 1 | 2.5 | 1.75 **±** 1.1 |
| Amuria | Market | 1 | 2.1 | 1.55 **±** 0.8 |
| Amuria | Market | 1 | 1 | 1. **±** 0.0 |
| Amuria | Market | 1 | 0 | 0.5 **±** 0.7 |
| Amuria | Farmer | 2 | 2.3 | 2.15 **±** 0.2 |
| Amuria | Market | 3 | 5 | 4.0 **±** 1.4 |
| Amuria | Farmer | 13 | 17 | 15 **±** 2.8 |
| Gulu | Farmer | 0 | 0 | 0 **±** 0.0 |
| Gulu | Farmer | 0 | 0 | 0 **±** 0.0 |
| Gulu | Market | 0 | 0 | 0 **±** 0.0 |
| Gulu | Market | 0 | 0 | 0 **±** 0.0 |
| Gulu | Market | 0 | 0 | 0 **±** 0.0 |
| Gulu | Market | 0 | 0 | 0 **±** 0.0 |
| Gulu | Market | 0 | 0 | 0 **±** 0.0 |
| Gulu | Farmer | 3 | 5 | 4.0 **±** 1.4 |
| Gulu | Farmer | 4 | 7 | 5.5 **±** 2.1 |
| Gulu | Farmer | 1 | 0 | 0.5 **±** 0.7 |
| Iganga | Farmer | 0 | 0 | 0 **±** 0.0 |
| Iganga | Farmer | 0 | 0 | 0 **±** 0.0 |
| Iganga | Farmer | 0 | 0 | 0 **±** 0.0 |
| Iganga | Market | 0 | 0 | 0 **±** 0.0 |
| Iganga | Farmer | 1 | 0 | 0.5 **±** 0.7 |
| Iganga | Farmer | 1 | 0 | 0.5 **±** 0.7 |
| Iganga | Farmer | 2 | 3 | 2.5 **±** 0.7 |
| Iganga | Market | 5 | 7 | 6.0 **±** 1.4 |
| Iganga | Market | 430 | 470 | 440 **±** 28.3 |
| Iganga | Market | 440 | 412 | 426 **±** 19.8 |
| Iganga | Market | 850 | 798 | 824 **±** 36.8 |
| Kamwenge | Farmer | 0 | 0 | 0 **±** 0.0 |
| Kamwenge | Farmer | 0 | 0 | 0 **±** 0.0 |
| Kamwenge | Farmer | 0 | 0 | 0 **±** 0.0 |
| Kamwenge | Farmer | 0 | 0 | 0 **±** 0.0 |
| Kamwenge | Farmer | 0 | 0 | 0 **±** 0.0 |
| Kamwenge | Farmer | 0 | 0 | 0 **±** 0.0 |
| Kamwenge | Farmer | 0 | 0 | 0 **±** 0.0 |
| Kamwenge | Market | 0 | 0 | 0 **±** 0.0 |
| Kamwenge | Market | 0 | 0 | 0 **±** 0.0 |
| Kamwenge | Market | 0 | 0 | 0 **±** 0.0 |
| Kamwenge | Market | 0 | 0 | 0 **±** 0.0 |
| Kamwenge | Farmer | 4 | 7 | 5.5 **±** 2.1 |
| Kamwenge | Farmer | 9 | 8.9 | 8.95 **±** 0.1 |
| Kamwenge | Farmer | 11 | 13 | 12 **±** 1.4 |
| Lira | Farmer | 0 | 0 | 0 **±** 0.0 |
| Lira | Farmer | 0 | 0 | 0 **±** 0.0 |
| Lira | Farmer | 0 | 0 | 0 **±** 0.0 |
| Lira | Market | 0 | 0 | 0 **±** 0.0 |
| Lira | Market | 0 | 0 | 0 **±** 0.0 |
| Lira | Market | 0 | 0 | 0 **±** 0.0 |
| Lira | Farmer | 2 | 4 | 3.0 **±** 1.4 |
| Lira | Farmer | 2 | 5 | 3.5 **±** 2.1 |
| Lira | Market | 2 | 3 | 2.5 **±** 0.7 |
| Lira | Farmer | 22 | 20 | 21 **±** 1.4 |
| Masindi | Farmer | 0 | 0 | 0 **±** 0.0 |
| Masindi | Farmer | 0 | 0 | 0 **±** 0.0 |
| Masindi | Farmer | 0 | 0 | 0 **±** 0.0 |
| Masindi | Farmer | 0 | 0 | 0 **±** 0.0 |
| Masindi | Farmer | 0 | 0 | 0 **±** 0.0 |
| Masindi | Farmer | 0 | 0 | 0 **±** 0.0 |
| Masindi | Market | 0 | 0 | 0 **±** 0.0 |
| Masindi | Market | 0 | 0 | 0 **±** 0.0 |
| Masindi | Market | 0 | 0 | 0 **±** 0.0 |
| Masindi | Market | 2 | 2.4 | 2.2 **±** 0.3 |
| Masindi | Market | 170 | 179 | 174.5 **±** 6.4 |
| Mubende | Farmer | 0 | 0 | 0 **±** 0.0 |
| Mubende | Farmer | 0 | 0 | 0 **±** 0.0 |
| Mubende | Farmer | 0 | 0 | 0 **±** 0.0 |
| Mubende | Farmer | 0 | 0 | 0 **±** 0.0 |
| Mubende | Farmer | 0 | 0 | 0 **±** 0.0 |
| Mubende | Farmer | 0 | 0 | 0 **±** 0.0 |
| Mubende | Market | 0 | 0 | 0 **±** 0.0 |
| Mubende | Market | 0 | 0 | 0 **±** 0.0 |
| Mubende | Market | 0 | 0 | 0 **±** 0.0 |
| Mubende | Farmer | 1 | 0 | 0.50 **±** 0.7 |
| Mubende | Farmer | 1 | 3 | 20 **±** 1.4 |
| Mubende | Market | 1 | 2 | 1.50 **±** 0.7 |
| Mubende | Market | 1 | 1 | 1.0 **±** 0.0 |
| Mubende | Market | 4 | 6 | 5.0 **±** 1.4 |
| Mubende | Market | 11 | 15 | 13 **±** 2.8 |
| Soroti | Market | 0 | 0 | 0 **±** 0.0 |
| Soroti | Market | 0 | 0 | 0 **±** 0.0 |
| Soroti | Farmer | 1 | 3 | 2.0 **±** 1.4 |
| Soroti | Farmer | 1 | 1 | 1.0 **±** 0.0 |
| Soroti | Farmer | 1 | 3 | 2.0 **±** 1.4 |
| Soroti | Farmer | 2 | 5 | 3.5 **±** 2.1 |
| Soroti | Market | 2 | 4 | 3.0 **±** 1.4 |
| Soroti | Market | 3 | 5 | 4.0 **±** 1.4 |
| Soroti | Farmer | 35 | 41 | 38.0 **±** 4.2 |
| Soroti | Farmer | 130 | 141 | 135.5 **±** 7.8 |
| Tororo | Farmer | 0 | 0 | 0 **±** 0.0 |
| Tororo | Farmer | 0 | 0 | 0 **±** 0.0 |
| Tororo | Farmer | 0 | 0 | 0 **±** 0.0 |
| Tororo | Farmer | 0 | 0 | 0 **±** 0.0 |
| Tororo | Farmer | 0 | 0 | 0 **±** 0.0 |
| Tororo | Market | 0 | 0 | 0 **±** 0.0 |
| Tororo | Market | 0 | 0 | 0 **±** 0.0 |
| Tororo | Market | 1 | 3 | 2.0 **±** 1.4 |
| Tororo | Farmer | 2 | 5 | 3.5 **±** 2.1 |
| Tororo | Farmer | 12 | 10 | 11 **±** 1.4 |
| **Average** |  | **21.7** | **22.1** | **21.88 ± 0.2** |

## Annex 8: Sample collection form for household and markets

1. **General**

Interviewer’s name: \\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_/ Date : /\_\_\_\_\_\_\_\_\_\_\_\_\_/

**District ………………………….Sub-county/Town Council………………………**

1. **Identification and socio-demographic characteristics of the respondent**

| Questions | Code | Answer |
| --- | --- | --- |
| 1. Name of respondent |  |  |
| 1. Sex of respondent | 0=Female 1= Male | /\_\_\_\_\_\_/ |
| 1. Religion of the respondent | 1=Animist ; 2=Christian ; 3=Muslim ; 4=other (be precise) | /\_\_\_\_\_\_/ |
| 1. Age of respondent | Write the number of year | /\_\_\_\_\_\_/ |
| 1. Marital status of respondent | 1=Married ; 2=Divorced ; 3=widow ; 4=single | /\_\_\_\_\_\_/ |
| 1. Instruction level | Write the number of year spent at school | /\_\_\_\_\_\_/ |
| 1. Literacy | 1=literate, 0=non literate | /\_\_\_\_\_\_/ |
| 1. Ethnic group of the respondent | 1=…………, 2=……….., 3=…………, 4= ………….., 5=………….., 6=others (be precise) | /\_\_\_\_\_\_/ |
| 1. What is your main activity? | 1=Agriculture, 2=Livestock, 3=Commerce/trade, 4=Processing, 5=others (be precise) | /\_\_\_\_\_\_/ |

1. How much of the following crops do you produce per year?

|  |  |  |  |
| --- | --- | --- | --- |
| **Crop** | **In local unit: Number** | **Name of the local unit** | **Equivalent of the local unit in kg** |
| Maize |  |  |  |
| Groundnuts |  |  |  |
| Sorgum |  |  |  |

1. Technical support: Do you receive technical suppot in the following domain?

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Operation | Support available | | Sources of support | type of support | Support enough | |
|  | Yes | No |  |  | Yes | No |
| Production/preharvest | ( ) | ( ) | \_\_\_\_\_\_\_\_\_\_\_\_\_ | \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | ( ) | ( ) |
| Postharvest | ( ) | ( ) | \_\_\_\_\_\_\_\_\_\_\_\_\_ | \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | ( ) | ( ) |
| Commercialisation | ( ) | ( ) | \_\_\_\_\_\_\_\_\_\_\_\_\_ | \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | ( ) | ( ) |

**III Type of sample (Tick as appropriate)**

|  |  |  |
| --- | --- | --- |
| **Sample** | **Tick as appropriate** | **Source (Indicate number as descrided in the list below)** |
| Maize |  |  |
| Groundnuts |  |  |
| Sorghum |  |  |
|  |  |  |

*1=Household, 2 = Market, 3 = Retailshop, 4= Bulking agent*

Comment on the state of storage and handling

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

## Annex 9: Questionnaire for MAAIF Staff and District Production Staff

**A. Background on Institutional Mandates**

1. What is the role of MAAIF in preventing/reducing aflatoxins?
2. What is MAAIF doing specifically to prevent/reduce aflatoxins?
3. Is there an aflatoxin focal point? Or are there policy champions within MAAIF or Extension Offices within the National Agricultural Research Organization that see aflatoxin prevention/mitigation and control as part of their mandate?
4. Is it MAAIF’s mandate to encourage uptake of Good Agricultural Practices (GAP)? What can be done to improve the execution of this mandate?

**B. Questions on Information Dissemination within MAAIF**

1. Does MAAIF (or do the extension offices) facilitate market/subsidized input industries to enable farmers to procure needed equipment (e.g., pesticides, wooden pallets, field implements, storage bags, and facilities) to implement GAP including good post-harvest handling practices?
2. What is the current level of knowledge of GAP? Among cooperatives? Among rural farmers?
3. What ongoing initiatives are there to communicate with farmers (at each level of operation: subsistence, mid-sized, contractor and industrial, and small and large livestock entrepreneurs?
4. How can MAAIF or other institutions work more closely with communities?
5. Do the existing communication initiatives among farmers reach out to male and female farmers equally?
6. Are the ongoing communication initiatives equally effective in reaching male and female farmers?

**C. Pre-Harvest Handling Questions** *[District: Ask the extension agents.]*

1. The IITA is currently developing a pre-harvest treatment that can be used on soil to prevent growth of the dangerous toxin that develops from *Aspergillus.* If this cost about US$15 (40,000 UGshs) per hectare, would farmers buy it? What if it was $10 (26, 000 UGshs) or $8 (20,000 UGshs)?
2. How would you recommend that it be marketed or sold?
3. What would need to be done to get farmers to use this technology?

**D. Post-Harvest Handling Questions** *[District: Ask the post-harvest management/extension staff]*

1. What types of traditional storage practices are prevalent?
2. Do the storage practices vary by region? If yes, can you describe what types of drying and storage practices used in your region/district?
3. Research in Nigeria and Guinea found that the following package could help reduce aflatoxin contamination at the post-harvest level: **hand sorting, storage in jute bags, education on improved sun drying, wooden pallets for drying, locally-made natural fiber mats, and insecticides**. Is this package of interventions appropriate for Uganda/your district? Why/why not?
4. Are these practices feasible at the farm level? Why?
5. Is the cost of the package of materials (jute bags, wooden pallets, and insecticides) affordable by farmers in your area?
6. Do male and female farmers have different storage practices?
7. Do they have different abilities to pay for inputs?

**E. Availability of Inputs for Storage and Drying in the Rural Areas** *[District: Try to talk to some input suppliers.]*

1. Are there any input suppliers in the rural areas selling wooden pallets, bags, insecticides, and storage inputs?
2. Are there local manufacturers of recommended wooden pallets, bags, insecticides, and storage inputs? If yes, who and where are they based?
3. Is there information on aflatoxin contamination by storage types (and region)?

**F. Economic and Pricing Factors of Aflatoxins in Maize and Groundnut**

1. Do farmers sort grain/commodities by quality? *[Ask separately for each commodity (e.g., maize, groundnuts).]*
2. Is there a difference in the price for grain based on quality in the local market? What about the general market? Is there any market where farmers find a higher price for better quality? What type of quality factors carries the most value? For example, grain with chaff or without chaff, sorted, disease-free, size of grain. *[Ask separately for maize, groundnuts, and any other important commodity.)*
3. If there is a price difference, what is the price difference by quality factors? Write down by types of quality factors (e.g., price for large grain, price for grain with chaff).
4. Do markets test for aflatoxins? Do you know anyone in the commodity market who does?
5. Is there a higher price for aflatoxin-free maize and groundnut? What is the price difference?

**Thank you for your attention and contribution. Your opinion is very much appreciated. Do you have any other recommendations or key action steps that you would like to share with us for promoting aflatoxin prevention or control?**

1. A CGE is a system of equations that are exactly identified, with the number of variables equal to the number of number of equations; have accounts that are all endogenous, and must be in equilibrium. The CGE also has endogenous prices (and exogenous prices). An infinite number of CGEs can satisfy the SAMstarting values. [↑](#footnote-ref-1)
2. Aflatoxin levels in maize, groundnuts and sorghum samples collected during the study [↑](#footnote-ref-2)
3. Computed by authors from Bank of Uganda statistics [↑](#footnote-ref-3)
4. From Bank of Uganda Statistics [↑](#footnote-ref-4)
5. Personal Communication with Dr. Ponsiano Ocama, Makerere University, College of Health Sciences [↑](#footnote-ref-5)
6. From Bank of Uganda Statistics [↑](#footnote-ref-6)
7. Data obtained from UN World Food Program [↑](#footnote-ref-7)