Preface

This conceptual framework for country and economic assessment was commissioned by Meridian Institute, which is supporting the Africa-led Partnership for Aflatoxin Control in Africa (PACA) with funding from the Bill & Melinda Gates Foundation and the UK Department for International Development (DFID).

The framework suggests a new approach to assessing a country’s situation and outlook for aflatoxin prevention and mitigation, to estimating the economic impacts of aflatoxin contamination, and to identifying priority areas for aflatoxin control using a country-led approach. The framework includes a review of the existing literature, provides guidelines for in-country engagement and interviews, and proposes a practical method for estimating economic impacts from aflatoxin contamination despite the usual data and resource constraints that developing countries face.

This document is intended to have broad application for all developing countries, especially in Sub-Saharan Africa under PACA. It has already served as an initial guide for the work requested by the Meridian Institute on pilot country and economic assessments in Nigeria and Tanzania. Implementation of the approach requires a multi-disciplinary team of national technical consultants who are already working on aflatoxins as researchers or regulators and can be potential champions of the work. Ideally, the team should include an economist with economic impact assessment experience, an epidemiologist, a risk assessor, and a GIS specialist.
Estimating Economic Impact of Aflatoxin Contamination – A Conceptual Framework

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<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIDS</td>
<td>Acquired Immune Deficiency Syndrome</td>
</tr>
<tr>
<td>BTC</td>
<td>Bridge-to-cross</td>
</tr>
<tr>
<td>COI</td>
<td>Cost of Illness</td>
</tr>
<tr>
<td>DALY</td>
<td>Disability Adjusted Life Year</td>
</tr>
<tr>
<td>EAC</td>
<td>East African Community</td>
</tr>
<tr>
<td>ECOWAS</td>
<td>Economic Community of West African States</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>FAO</td>
<td>Food and Agricultural Organization of the United Nations</td>
</tr>
<tr>
<td>FDA</td>
<td>U.S. Food and Drug Administration</td>
</tr>
<tr>
<td>GAP</td>
<td>Good agricultural practices</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross domestic product</td>
</tr>
<tr>
<td>GEMS/Food</td>
<td>WHO Global Environment Monitoring System - Food Monitoring and Assessment Program</td>
</tr>
<tr>
<td>GI</td>
<td>Gastrointestinal</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographic information systems</td>
</tr>
<tr>
<td>GMP</td>
<td>Good management practices</td>
</tr>
<tr>
<td>GNP</td>
<td>Gross national product</td>
</tr>
<tr>
<td>HACCP</td>
<td>Hazard Analysis and Critical Control Points</td>
</tr>
<tr>
<td>HAZ</td>
<td>Height for age Z scores</td>
</tr>
<tr>
<td>HBV</td>
<td>Hepatitis B virus</td>
</tr>
<tr>
<td>HCC</td>
<td>Hepatocellular carcinoma</td>
</tr>
<tr>
<td>HCV</td>
<td>Hepatitis C virus</td>
</tr>
<tr>
<td>HIV</td>
<td>Human immunodeficiency virus</td>
</tr>
<tr>
<td>LSMS-ISA</td>
<td>Living Standards Measurement Survey – Integrated Surveys in Agriculture</td>
</tr>
<tr>
<td>PCR</td>
<td>Polymerase chain reaction</td>
</tr>
<tr>
<td>MOA</td>
<td>Ministry of Agriculture</td>
</tr>
<tr>
<td>NARO</td>
<td>National Agricultural Research Organization</td>
</tr>
<tr>
<td>ORCI</td>
<td>Ocean Road Cancer Institute</td>
</tr>
<tr>
<td>TB</td>
<td>Tuberculosis</td>
</tr>
<tr>
<td>TBS</td>
<td>Tanzania Bureau of Standards</td>
</tr>
<tr>
<td>TFDA</td>
<td>Tanzania Food and Drugs Authority</td>
</tr>
<tr>
<td>UNComtrade</td>
<td>United Nations Commodity Trade Statistics Database</td>
</tr>
<tr>
<td>USDA ERS</td>
<td>United States Department of Agriculture’s Economic Research Service</td>
</tr>
<tr>
<td>WAZ</td>
<td>Weight for age Z scores</td>
</tr>
<tr>
<td>WB</td>
<td>The World Bank</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
</tr>
<tr>
<td>WTP</td>
<td>Willingness To Pay</td>
</tr>
<tr>
<td>YLD</td>
<td>Years Lived with Disability</td>
</tr>
<tr>
<td>YLL</td>
<td>Years of Life Lost</td>
</tr>
</tbody>
</table>
Appendix A – Bibliography of Studies with Aflatoxin Prevalence Data on Maize, Groundnuts, and Sorghum for Africa
Appendix A: Bibliography

This bibliography includes articles that assess prevalence of aflatoxins in either maize, groundnuts, or sorghum in Africa. Only studies published from 1990 onwards are included. Unpublished work is not included in this list.

Maize:


Johnni H. Daniel,1 Lauren W. Lewis,1 Yanique A. Redwood,1 Stephanie Kieszak,1 Robert F. Breiman,2 W. Dana Flanders,1 Carlos Bell, Comprehensive Assessment of Maize Aflatoxin Levels in Eastern Kenya, 2005–2007

Appendix A: Bibliography


Monyo, Emmanuel S. (No date.) "Assessing Occurrence and Distribution of Aflatoxins in Malawi." Supported by The McKnight Foundation, USA. Project Final Report (Grant No. 08-598).


Groundnuts:


Appendix A: Bibliography


Monyo, Emmanuel S. (No date.) "Assessing Occurrence and Distribution of Aflatoxins in Malawi." Supported by The McKnight Foundation, USA. Project Final Report (Grant No. 08-598).


Sorghum:


Appendix B – Literature Review to Inform the Aflatoxin Country Assessments: Tanzania and Nigeria
Literature Review to Inform the Aflatoxin Country Assessments: Tanzania and Nigeria

May 29, 2012

Prepared for: Meridian Institute
1920 L Street, NW #500
Washington, D.C. 20036

In support of: Partnership for Aflatoxin Control in Africa

Submitted by: Abt Associates Inc.
4550 Montgomery Avenue
Suite 800 North
Bethesda, MD 20814
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<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUC</td>
<td>African Union Commission</td>
</tr>
<tr>
<td>CAADP</td>
<td>Comprehensive Africa Agriculture Development Program</td>
</tr>
<tr>
<td>CAC</td>
<td>Codex Alimentarius Commission</td>
</tr>
<tr>
<td>CFSVA</td>
<td>Comprehensive Food Security Vulnerability Analysis</td>
</tr>
<tr>
<td>Codex</td>
<td>Codex Alimentarius Commission</td>
</tr>
<tr>
<td>COMESA</td>
<td>Common Market for Eastern and Southern Africa</td>
</tr>
<tr>
<td>DALY</td>
<td>Disability Adjusted Life Year</td>
</tr>
<tr>
<td>EAC</td>
<td>East African Community</td>
</tr>
<tr>
<td>ECCAS</td>
<td>Economic Community of Central African States</td>
</tr>
<tr>
<td>EACOWAS</td>
<td>Economic Community of West African States</td>
</tr>
<tr>
<td>ELISA</td>
<td>Enzyme-linked immunosorbent assay</td>
</tr>
<tr>
<td>FAO</td>
<td>Food and Agriculture Organization of the United Nations</td>
</tr>
<tr>
<td>GAP</td>
<td>Good Agricultural Practices</td>
</tr>
<tr>
<td>GMP</td>
<td>Good Manufacturing Practices</td>
</tr>
<tr>
<td>HACCP</td>
<td>Hazard Analysis and Critical Control Point</td>
</tr>
<tr>
<td>HBV</td>
<td>Hepatitis B</td>
</tr>
<tr>
<td>HCC</td>
<td>hepatocellular carcinoma</td>
</tr>
<tr>
<td>HPLC</td>
<td>High-performance liquid chromatography</td>
</tr>
<tr>
<td>HPTLC</td>
<td>high-performance thin layer chromatography</td>
</tr>
<tr>
<td>IAEA</td>
<td>International Atomic Energy Agency</td>
</tr>
<tr>
<td>IBAR</td>
<td>Inter-African Bureau for Animal Resources</td>
</tr>
<tr>
<td>IFPRI</td>
<td>International Food Policy Research Institute</td>
</tr>
<tr>
<td>IITA</td>
<td>International Institute for Tropical Agriculture</td>
</tr>
<tr>
<td>IUAPC</td>
<td>International Union of Pure and Applied Chemistry</td>
</tr>
</tbody>
</table>
Literature review to Inform the Aflatoxin Country Assessments: Tanzania and Nigeria

NAFDAC  Nigeria Agency for Food and Drug Control
ng  Nanogram
OIE  World Organization of Animal Health
PANSPSO  Participation of African Nations in Sanitary and Phytosanitary Standard-setting Organizations
PLWHA  People Living with HIV/AIDS
SON  Standards Organization of Nigeria
TBS  Tanzania Bureau of Standards
TFDA  Tanzania Food and Drug Authority
USAID  United States Agency for International Development
Introduction

Aflatoxins are one of many natural occurring mycotoxins that are found in soils, foods, humans, and animals. Derived from the *Aspergillus flavus* fungus, the toxigenic strains of aflatoxins are among the most harmful mycotoxins. Aflatoxins are found in the soil as well as in grains, nuts, dairy products, tea, spices and cocoa, as well as animal and fish feeds (Waliyar et al. 2008). Aflatoxins are especially problematic in hot, dry climates (+/- 30 to 40 degrees latitude), and their prevalence is exacerbated by drought, pests, delayed harvest, insufficient drying and poor post-harvest handling. Exposure to foods contaminated with high levels of aflatoxins can cause immediate death to humans and animals. Chronic high levels lead to a gradual deterioration of health through liver damage and immunosuppression. Linkages with child stunting are suspected but not proven. Malaria and HIV/AIDS may also be affected by aflatoxin levels, though to date the evidence is inconclusive.

There are six forms of aflatoxin: B1, B2, G1, and G2 are found in plant-based food, while M1 (metabolite of B1) and M2 are found in foods of animal origin. B1 is the most harmful form due to its direct link to human liver cancer (Leslie et al., 2008; USAID 2012). Though aflatoxins are difficult to detect visually and also to contain, there are documented methods to prevent and mitigate the development and spread of aflatoxins.

Much of Sub-Saharan Africa is at risk of unsafe levels of aflatoxin exposure that can negatively affect human health, food security and economic trade (Williams et al., 2004). The present literature search is designed to contribute to ongoing efforts supported by the Partnership for Aflatoxin Control in Africa, which was established in 2011 under the auspices of the African Union Commission (AUC) and Comprehensive Africa Agriculture Development Program (CAADP). This rapid review is designed to inform the development of a conceptual framework that will be used to conduct aflatoxin country assessments in two key African countries: Tanzania and Nigeria. Assessments in those countries are intended as pilot efforts to assist policy-makers to rapidly assess current attitudes, practices and prospective opportunities for country-led aflatoxin action plans.

Nigeria and Tanzania have been selected because of the diversity of experience and history dealing with the issue. Nigeria has experienced high recorded aflatoxin exposure levels in humans, and has also reported the highest estimated number of cases of hepatocellular carcinoma (HCC—liver cancer) attributable to aflatoxins. Tanzania’s estimated aflatoxin exposure among humans (and its HCC prevalence) is much lower than Nigeria’s, but it is still elevated; the same is true for much of Sub-Saharan Africa (Liu and Wu 2010). Nigeria is developing multiple strategies to address the problem, and may offer important lessons to countries working to address aflatoxin contamination. Tanzania’s Food and Drug Authority is also addressing aflatoxins and is weaving the control processes into its new initiatives to fortify maize, wheat and edible oils. However, both Nigeria and Tanzania have a long road ahead in forming a national response. The country assessments will therefore attempt to assess stakeholders’ views on the need for and desired content of an aflatoxin control plan that reflects the state of global knowledge and best practices, adjusted to match national or sub-national circumstances.
This review first gives a general overview and then includes (where possible) Tanzania- and Nigeria-specific examples pertaining to:

- The regulatory environment related to aflatoxins
- Risk and vulnerability factors affecting aflatoxin contamination
- Value chains or commodities presenting greatest risk to humans and animals
- Promising technologies and practices for aflatoxin mitigation
- Ongoing communication initiatives addressing aflatoxin mitigation
- Gaps in the research for investigation during the country assessment
Methodology

This review relies primarily on web-based sources available from institutions such as the Codex Alimentarius Commission (“Codex”), Danya International (“Danya”), the Food and Agricultural Organization (“FAO”), the International Food Policy Research Institute (“IFPRI”), the International Institute for Tropical Agriculture (“IITA”), and the United States Agency for International Development (“USAID”). Google Scholar and personal communication with leaders in Nigeria and Tanzania’s aflatoxin response were also central to the research. As the aflatoxin causes and mitigation practices are complex and multi-faceted, this review only scratches the surface of the available scientific literature. The literature often speaks to mycotoxins broadly rather than aflatoxins in isolation.

Many of the sections related to Tanzania benefited from the personal correspondence and review from Martin Kimanya of the Tanzania Food and Drug Authority. This initial draft has not yet received the same level of review in Nigeria, and will require input from the Nigeria Agency for Food and Drug Administration and Control input prior to finalization. Throughout this review the comprehensive book entitled *Mycotoxins: Detection Methods, Management, Public Health and Agricultural Trade* (Leslie et al. 2008) was extremely informative. Readers wishing to understand the issues in more depth are encouraged to visit these authoritative sources and the websites of the institutions above.
1. The Regulatory Environment Pertaining to Aflatoxins

1.1 International Regulatory Environment for Mycotoxins

The Codex Alimentarius Commission (CAC), a joint body managed by FAO and WHO, is a recognized global standard-setting body established to protect human, animal and plant life. The Codex Committee on Contaminants in Foods (formally the Codex Standards for Food Additives and Contaminants) sets standards for contaminants in food based on scientific evidence and risk analysis (FAO 2003). Global aflatoxin limits are specified by Codex Alimentarius in: CODEX STAN 193-1995; General Standard for Contaminants and Toxins in Food and Feed.

The Codex Commission has established codes of practice for preventing mycotoxins in cereals (CAC/RCP 51-2003), peanuts (CAC/RCP 55-2004), feedstuffs (CAC/RCP 45-1997), and tree nuts (CAC/RCP 6-1972. These codes include comprehensive pre-harvest, post-harvest, storage, and sorting recommendations to prevent and control mycotoxins. They are based on Good Agricultural Practices (GAP) and Good Manufacturing Practices (GMP), and often employ the Hazard Analysis and Critical Control Point (HACCP) approach (FAO 2003). Many scientists assert that the surest way to prevent economic and health losses from aflatoxins is to shore up implementation of GAP and GMP based practices such as oil testing and selection irrigation where possible, spacing, weeding, pest control, timely harvesting, removal of moldy/shriveled grains and peanuts, proper drying, dry storage etc. (Waliyar et.al. 2008).

Codex empower countries to ask for justification of standards that exceed those set by the CAC. One such contested case is documented on the EAC website. Codex for example recommends that maize be dried to a moisture content of 15% (Codex 1995). Yet in 2005, the East African Community revised that standard to a maximum moisture content of 13.0%. In February of 2010, business and farmers groups brought forward a public request for scientific justification for these stringent standards which diverged from the CODEX standards, making it impossible for small farm holders to meet (EAC, 2011).

The European Union has the strictest limits on aflatoxin levels in food, which along with other issues of quality control may have contributed to significant trade losses to African countries that do not have the means or resources to test or control for the toxin. Yet many countries lack standards and enforcement mechanisms that can detect and prevent aflatoxins from entering the food chain. As a result, economic losses due to aflatoxins are difficult to measure, but no doubt significant.

One World Bank study estimated that trade losses with the EU alone cost Africa $670 million dollars annually in the export of cereals, nuts and foodstuffs (Fapuhunda, 2011). Another study estimated that if all countries were to adopt EU standards on aflatoxins then global trade would decline by $3 billion (Dohlman 2008). The Joint FAO/WHO Expert Committee on Food Additives estimated that reducing maximum aflatoxin limits of B1 from 20 ppb to 10 ppb would reduce cancer by 2 deaths per 1 billion people. (Dohlman, 2008).

Despite a global effort underway to harmonize mycotoxin and aflatoxin standards there is still plenty of variation in regulatory regimes across countries and continents. Maximum accepted levels of aflatoxins
in foods and products for human consumption range from 0.5 ppb in milk to 20 ppb for processed foods (USAID, 2012). Countries also differ in terms of methods for controlling for aflatoxins. In Nigeria all food and drug imports are sampled by the Port Inspectorate Division under NAFDAC, while export inspection is highly encouraged but voluntary. In Tanzania aflatoxin testing among exports is rarely done and in the United States, aflatoxin testing is not mandatory aside from maize exports (Dohlman, 2008).

In an effort to increase African participation in sanitary and phytosanitary standard setting, the EU initiated a 3-year initiative in May 2008 with 3.85 million Euros. This initiative called “Participation of African Nations in Sanitary and Phytosanitary Standard-setting Organizations” or (“PANSPSO) engages regional economic groups including the Economic Community of West African States (ECOWAS) and the East African Community (EAC) to which Nigeria and Tanzania are member states. The initiative empowers African regional economic forums to share information and establish a uniform position based on scientific evidence during the formulation of international standards on animal (terrestrial and aquatic) and plant health, and food safety.

A participation meeting took place in Nairobi April 23-25th, 2012 (Inter-African Bureau for Animal Resources IBAR with 39 African representatives from many African states and representatives from the the Common Market for Eastern and Southern Africa (COMESA), Economic Community of Central African States (ECCAS) and the East African Community (EAC). The members reviewed and agreed on proposed changes to the OIE Terrestrial and Aquatic Codes to be submitted for adoption during the General Session of the World Organization of Animal Health (OIE) which will take place in Paris, France from 20th to 25th May 2012 (IBAR 2010).

There is also an initiative of the United States Food and Drug Agency which builds Nigeria’s skilled capacity to address sanitary and phytosanitary issues. This initiative is organized annual in collaboration with USAID and the Nigeria Agricultural Quarantine Services. Under this initiative several people have been trained both locally and internationally.

1.2 Regulatory Framework for Aflatoxins in Tanzania and Nigeria

The level of contamination of aflatoxins is measured in parts per billion or microgram per kilogram. This is often denoted as ppb or µg/kg. The weight of one microgram per kilogram is proportional to the weight of one grain of rice in a 50 kg bag. Small measurements must be used to detect aflatoxins because of its high level of toxicity. The aflatoxin B₁ form (named this because of its blue color under fluorescence) is recognized by the International Agency for Research on Cancer as one of the most naturally occurring toxic and carcinogenic substances found in nature (Anthony, 2012).

---

1 The aim of this project was to increase African representation in standard setting established at the World Organization for Animal Health, the International Plant Protection Convention and the Codex Alimentarius Commission.

2 IBAR keeps a regularly updated website, which documents the forums and activities of PANSP.

3 Personal Communication with Mrs. Folasade, Head of the NAFDAC Mycotoxin Laboratory in Lagos, May 15, 2012.
A snapshot of aflatoxin standards around the world can be drawn from literature available on the web through Google Scholar searches. The most comprehensive document found during this literature review included a 2003 FAO reference and the recent Tanzania regulations for food fortification, which reference the aflatoxin limits. Yet additional follow-up will be required in Nigeria during the country assessment to investigate any updates to the standards.

**Exhibit 1: Aflatoxin Limits by Commodity**

<table>
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<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Milk</td>
<td>0.5 ug/kg</td>
<td>0.05 ug/kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food for human consumption: cereals and nuts</td>
<td>20 ppb</td>
<td>The limit for aflatoxin is 4 ppb; only 2 of which can be B1</td>
<td>4 ug/kg (AATF Project 6 (PI006)**</td>
<td>10 μg/kg for afla B1, B2, G1, G2 5 μg/kg for B1</td>
</tr>
<tr>
<td>Raw peanuts for human consumption*</td>
<td>4 ppb; only 2 of which can be B1</td>
<td>10 ug/kg</td>
<td>5 μg/kg for B1</td>
<td>10 μg/kg (total aflatoxin for cashews)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>15 μg/kg (total aflatoxin for groundnuts)</td>
</tr>
<tr>
<td>Unprocessed Maize</td>
<td>As above</td>
<td>5 ug (B1)</td>
<td>10 ug/kg</td>
<td>20 ug/kg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 ug (B1, B2, G1, G2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nuts (to be further processed)</td>
<td></td>
<td>Groundnuts to be processed further: 15; Afla B1 limit: 8 ppb.</td>
<td>10 ug/kg</td>
<td></td>
</tr>
<tr>
<td>Animal Feed</td>
<td>100–300 ppb for mature, non-milk producing animals, depending on feed type and the animal species.</td>
<td>Maize intended for feed 20 ppb for aflatoxin B1. Complete feed stuffs for dairy animals should have no more than 5 ug/kg.</td>
<td>50 ug/kg (finished feed)</td>
<td>10 μg/kg for afla B1, B2, G1, G2 5 μg/kg for B1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Calves and lambs: 10 ug/kg (B1)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**The only standard adopted by CODEX includes 15 ug/kg for raw peanuts for consumption.**


***(the FAO regulatory paper in 2003 refers to Nigerian limits on B1 aflatoxin. However, searches on the www.NAFDAC.orgwebsite, do not have references to these limits.***

****NAFDAC, Personal Communication, Mrs. Oluwabamiwo Folasade, Head of the Mycotoxin Laboratory, NAFDAC, Lagos, May 21, 2012.
1.2.1 Tanzania’s Institutional Mandates and Capacity for Aflatoxin Control

The Tanzania Food and Drug Authority (TFDA), which is an executive agency under the Ministry of Health and Social Welfare, is responsible for “regulating the quality and safety of food, drugs, cosmetics and medical devices.” The TFDA is established under section 4 of the Tanzania Food, Drug and Cosmetic Act. The Act also empowers TFDA to recognize and enforce mandatory standards sets under the Tanzania Bureau of Standards (TBS) which is a government institution under the Ministry of Industry and Trade.

Among the mandatory standards are limits for B1 of 5 μg/kg in rice, cashews, barley, sorghum flour and pearl millet grains, as well as total aflatoxin limits set at 10µg/kg and 15µg/kg for cashews and groundnuts (TFDA). A Tanzanian commodities trader must obtain approvals for manufacture, import or export for any of these foods, and is required to have a sample of the food tested for aflatoxin contamination.

The TFDA has zonal offices that are responsible for certifying food processors within their jurisdictions. Yet staff, transportation, budgets and human resources are scarce, especially outside of Dar es Salaam (Stene et al. 2011). Medium and large scale processors must get premises/products registration by TFDA to operate within the country, and industries bear the costs of this regulatory oversight.

Starting later this year, enforcement of recently formulated regulations on mandatory fortification of maize, wheat and edible cooking oils by these registered agro-processors will commence. As part of this enforcement, the fortified food must adhere to the country’s aflatoxin standards (TFDA 2011). Notably however, the majority of the population grows their own food, or purchases it from micro-processors (“posho millers”) who are too small and numerous to be regulated (Shephard 2004, Stene et al. 2011). More investigation will be required in Nigeria to determine if this is also the case.

1.2.2 Nigeria’s Institutional Mandates and Capacity for Aflatoxin Control

Nigeria uses the Hazard Analysis Critical Control Point (HACCP) approach to identify and control hazards within the food production and processing system.4 NAFDAC has the authority to enforce standards for maximum contaminants and toxins in food set by the Standard Organization of Nigeria (SON). NAFDAC’s published Good Manufacturing Guidelines note that “raw materials and other ingredients susceptible to contamination with aflatoxins or other natural toxins shall comply with regulations and guidelines...before these materials or ingredients are incorporated into finished food.” To determine what the current standards are on the various aflatoxin strains by product, more investigation will be needed.

On a promising note, NAFDAC has been lauded for its efforts and progress in controlling counterfeit medicines. Through a combination of partnership with the pharmaceutical industry to enhance inspection at ports and among traders and pharmacies, NAFDAC has made some improvements in combating this serious problem (CBS News, 2011). Though the natural occurrence of aflatoxins makes

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4 Personal Communication with Kerri Hauwa, Director of Laboratory Services, NAFDAC, March 24, 2012.
them a much more complex threat—there may be lessons learned from this example of regulatory cooperation that could be useful and applicable to addressing aflatoxin contamination.

### 1.2.3 Procedures and Capacity for Surveillance, Inspection, Testing, Sampling, Withdrawal, and Certification

To measure the effectiveness of Tanzania and Nigeria's aflatoxin control capacity, stakeholders will be interviewed to assess inspection, sampling and control. The country-specific literature on these areas was difficult to find, though there were helpful references which outlined some of the basic approaches and technologies needed.

There are several testing technologies to detect aflatoxins. These include high-performance liquid chromatography (HPLC), gas chromatography, and flame-ionization chromatography. HPLC is described as the most promising and accurate technology, although the accuracy comes at a high cost and requires highly trained scientists (Leslie et al. 2008). The equipment for an HPLC test for example costs $30,000 while each test costs $50 (Waliyar et al. 2008). The Enzyme Linked Immunosorbant Assays (ELISA) test is much less expensive ($5) per test, but requires confirmation by a more expensive method (Waliyar et al., 2008 and USAID 2012).

Accurate mycotoxin testing procedures have three components. These include sound sampling procedures, extraction and cleanup procedures and testing technologies and equipment (Pascale and Visconti, 2008). Sampling, and cleanup and extraction can be done through different methods and equipment; all of which have their own set of advantages and disadvantages. Annex A includes an excerpt from Pascale and Visconti (2008) that lists the advantages and disadvantages of testing technologies.

The variability of aflatoxin contamination makes it extremely difficult to accurately detect. One ear of corn for example may present highly contaminated kernels interspersed with low levels or non-contaminated kernels (IITA presentation, WB 2011). Due to variability, sampling methods are critical to accurate testing. There is however no commonly accepted sampling protocol, and a wide variety of stakeholders require different types of data.

Industrial processors need information on raw product, while regulators may need information about the end product. Each sampling protocol must consider where to extract the sample (this could be at the field, in storage, during transport, at a port of entry, processing or point of retail). The timing of the sample is also critical, and is usually noted relative to a particular benchmark such as harvest. Sampling plans must consider the size of sample needed based on the objectives of the test. As of 2008, Codex was beginning to make recommendations for sampling plans for groundnuts and tree nuts. Notably however, sampling plans vary widely by country, based on the available infrastructure and expertise and resources. The EU, which has some of the most well documented and rigorous sampling protocols, requires different sampling plans based on the volume to be tested, the type of product (baby formula and milk have the highest sampling rigor) and the product packaging that will be used (Miraglia et al., 2008).
Laboratory Capacity in Tanzania: Since 2005 TFDA has been monitoring aflatoxin contamination in home grown maize using an HPLC method recognized by the International Union of Pure and Applied Chemistry (IUAPC). Maize sampling was based on the EU sampling plan for maize and maize meal. From July 2008 to March 2012, TFDA tested 58 samples of food products for aflatoxin. Most of the samples were of locally manufactured maize meal and cashew nuts for export. Two of the maize samples contained aflatoxins at levels that exceeded standards.

The TFDA validated the sampling method for measuring aflatoxins in maize grains and flours. The method is being used for all cereal and nut samples received by the TFDA laboratory for aflatoxin testing. Kimanya notes however that suitability of this method for determining aflatoxins in cashew nuts and groundnuts (food with high fat content) needs further verification.

Tanzania also uses the high-performance thin layer chromatography (HPTLC) testing method. In an upcoming surveillance of aflatoxins in maize and cassava (carried out April 2012), TFDA the IITA, Sokoine University of Agriculture, the Ministry of Agriculture and food security cooperatives will explore the possibility of using the HPTLC facility at TFDA to screen aflatoxin samples. Despite the presence of both HPTLC and HPLC methods, an organized infrastructure for inspection, sampling and analysis that accounts for Tanzania’s vastness is still needed.

Laboratory Capacity in Nigeria: A 2008 case study indicated that Nigeria had the most “well-equipped mycotoxin laboratories on the continent” (Waliyar et al. 2008). This experience in Nigeria in structuring laboratories may be useful for other countries, donors and commercial sector stakeholders.

The development of Nigeria’s mycotoxin detection laboratory began in 2000 with funding and technical assistance from the International Atomic Energy Agency (IAEA). In 2002, the IAEA flew six Nigerian NAFDAC staff to Austria to be trained for six months in regulatory methods and mycotoxin testing procedures. As of 2008, the laboratory was using a combination of the expensive HPLC, HPTLC methods and the cheaper ELISA methods to test for mytoxin in cereals, milk, soil seeds, nuts and spices. At that point the lab was also expanding its capacity to additional sites throughout the country.

Initially, electricity irregularities, lack of effective communication systems and lack of trained personnel impeded the lab’s performance. Equipment maintenance was also a challenge, as breakdowns often require international engineering specialists to repair the systems. In the face of these challenges, the IAEA helped Nigeria procure generators, communications systems and establish a local engineering unit to handle some of the maintenance issues. A local quality assurance/quality control unit was created (which is essential for international accreditation) and bulk procurement of the expensive equipment.

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5 Personal Communication with Martin Kimanya, TFDA Representative, April 5, 2012.
6 Martin Kimanya, ibid.
7 Martin Kimanya, ibid.
8 Martin Kimanya, ibid.
reagents, reference materials, and consumables was completed on a quarterly basis (Waliyar et al. 2008).

The establishment of this laboratory is a promising case study in institutional development, but the reach and resources of the testing facility remains limited. Another source notes that though Nigeria is one of the West African countries with systems to test, certify and enforce quality control, these efforts are often cost–prohibitive and may only cover processed and packaged foods (CABI, 2008). In an effort to identify priority crops and geographic areas, the Mycotoxicology Society of Nigeria wishes to generate a database and aflatoxin map to enhance surveillance and detection and prioritize interventions.\(^9\)

Ultimately, determining the ability of TFDA and NAFDAC to carry out adequate testing that accommodates' both countries' vast needs will require further stakeholder engagement during the Aflatoxin Country Assessments.

\(^9\) Personal communication with Dr. Atanda, President of the Mycotoxicology Society of Nigeria, April 2, 2012.
2. Risk and Vulnerability Factors Affecting Aflatoxin Contamination

Several papers discuss the health economic impacts of aflatoxins in humans (Wu and Khlangwiset, 2010; Liu and Wu, 2010; Khlangwiset, 2011). These health economics studies include: risk assessment, valuation, and, occasionally, exploration of control strategies. No studies estimating health economic impacts for livestock were found to date.10 Below we briefly review the key methods used for these components.

2.1 Methods to Assess and Quantify Risk Associated with Aflatoxins

Risk assessment involves several steps: hazard identification, construction of the dose-response relationship, exposure assessment, and risk characterization. Although there are many health hazards associated with aflatoxin exposure (aflatoxicosis, liver cancer, immune suppression and nutritional interference (Williams et al., 2004)), most of the existing risk assessments have focused on liver cancer (Wu and Khlangwiset, 2010; Liu and Wu, 2010) and stunting (Khlangwiset, 2011). For liver cancer, the dose-response relationship reflects higher susceptibility of chronic Hepatitis B (HBV) infection carriers (JECFA, 1998). Therefore, the studies that focus on liver cancer impacts of aflatoxin exposure also characterize chronic HBV infection prevalence.

There are two ways to assess chronic exposure to aflatoxins: food sample analysis and biomarker analysis (Williams et al., 2004). All economic health impact studies thus far have relied on the food sample analysis to estimate chronic exposure to aflatoxins, although the dose-response relationship for stunting used by Khlangwiset (2011) required making conversions from estimated average intakes to aflatoxin-albumin adduct levels.

To aggregate morbidity and mortality effects of aflatoxin exposure, most studies use the Disability Adjusted Life Year (DALY) methodology, which was developed and applied by the World Health Organization and the World Bank (Havelaar 2007). DALY measures the physical burden of disease by assigning severity weights to a life year (with 0 indicating perfect health and 1 corresponding to death). DALY life year weights are disease-specific. After weighting, life years spent with a specific disease are added up to result in an estimate of the total number of healthy life years lost due to a new disease case. DALY’s occurring in the future is discounted at 3%.

10 Note that a study estimating the economic impacts that arise from animal exposure are distinct from the toxicological studies. The toxicological studies rely on controlled experiments to determine health effects of aflatoxin exposure in animal models. They are sometimes used as the basis for hazard identification in humans. However, the health economic impacts studies would be concerned with estimating the magnitudes of impacts based on the established exposure-response relationships and relevant population characteristics. No such studies were found for animals.
2.2 Synergies between Aflatoxin Exposure, Hepatitis B and Liver Cancer

A recent study estimated that aflatoxin exposure in Tanzania’s population ranged from 0.02 and 50 ng/kgBW/day. In Nigeria, the exposure was 139-227 ng/kgBW/day (Liu and Wu, 2010).\(^{11}\) There are several factors that may elevate the health risks associated with aflatoxin exposure as discussed below.

Of interest are the excess health risk estimates – the risk that can be attributed to aflatoxins – for Nigeria and Tanzania. Excess annual liver cancer incidence estimates for Nigeria were 1.39–2.27 cases per 100,000 in HBV- populations and 41.7–68.1 cases per 100,000 in HBV+ populations (Liu and Wu, 2010). Excess annual liver cancer incidence estimates for Tanzania were 0.0002–0.50 cases per 100,000 in HBV- populations and 0.06–15.0 cases per 100,000 in HBV+ populations (Liu and Wu, 2010).

**Exhibit 2: Excess Health Risk Estimates**

<table>
<thead>
<tr>
<th></th>
<th>HBV prevalence per 100,000</th>
<th>GDP per capita (Khlangwiset 2011)</th>
<th>% living below National Poverty Line (Khlangwiset 2011)</th>
<th>Aflatoxin exposure ng/kgBW/day. (Khangwiset 2011)</th>
<th>% children who are stunted (WHO 2004)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nigeria</td>
<td>Africa: 1.64</td>
<td>2357</td>
<td>34%</td>
<td>139-227</td>
<td>43%</td>
</tr>
<tr>
<td>Tanzania</td>
<td></td>
<td>1484</td>
<td>36%</td>
<td>0.02 and 50</td>
<td>44%</td>
</tr>
<tr>
<td>Kenya</td>
<td>Kenya: 0.50</td>
<td>1783</td>
<td>52%</td>
<td>3.5 to 133</td>
<td>36%</td>
</tr>
<tr>
<td>USA</td>
<td>Americas: 0.57</td>
<td>47,702</td>
<td>12%</td>
<td>0.26</td>
<td>4%</td>
</tr>
</tbody>
</table>

Source: (Khangwiset 2011 and WHO 2004).

HBV infection and aflatoxins together lead to a “30-fold higher liver cancer risk ...as compared to HBV-negative persons” Wu et al. 2011). Also of concern is the effect of aflatoxins on People Living with HIV/AIDS (PLWHA). Approximately 1.2 million adults in Tanzania and 3 million adults in Nigeria live with the virus. HIV infection may reduce the body’s ability to protect itself from aflatoxins and the common HBV/HIV co-infection may increase biological effects. There is also concern that aflatoxins may increase risk of developing TB in People Living with HIV/AIDS (USAID pp. 18).

2.3 Aflatoxin Exposure in Pregnant Women and Infants

Infants exposed to aflatoxin-contaminated foods may be more susceptible to stunting, and malnutrition. Yet exposure to aflatoxins can also incur in utero as evidenced by studies that measured blood albumin –AFB\(_1\) (biomarkers) in pregnant African women (Turner et al. 2007). A study from Ghana suggested that there may be a correlation between aflatoxins and anemia in pregnant women, which is associated with increased risk of maternal mortality and low birth weight in pregnant women (Shuaib et al. 2010).\(^{12}\)

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\(^{11}\) This measurement denotes nanogram per kilogram of body weight per day. A nanogram is 1/1000 of a microgram. This measurement is used when discussing daily intake of aflatoxins.

\(^{12}\) Women with iron deficiency anemia were excluded from the sample.
Turner al. al also found that the presence of AFB₁ in the cord blood of newborns was correlated with jaundice, low birthweight and effects on the immune system.

Studies have also found aflatoxins in the form of AFM₁ in the breastmilk of women from several African countries (Coulter et al. 1984 and Zarba et al. 1992). This can have toxic and carcinogenic properties, but also must be communicated and weighed carefully since exclusive breastfeeding for the first 6 months is still considered an essential nutrition action, and is key for child survival, particularly in poor resource settings where hygiene and sanitation are inadequate (WHO).

A study in West Africa found that “weaned children had approximately twofold higher mean AF-alb adduct [aflatoxin biomarkers] than those receiving a mixture of breast milk and solid foods...and children who were underweight and stunted had 30–40% higher mean AF-alb levels than the remainder of the children” (Gong 2003). The burden of stunting in Nigeria from consuming maize and groundnuts contaminated with aflatoxins to be 0–18.5 percent of all stunted children under age five in 2010 (Klangwiset 2011).

Though the WHO recommends that infants up to 6 months of age be exclusively breastfed, premature introduction to complementary foods is common in Tanzania and Nigeria. More than half of Tanzanian infants are introduced to complementary foods prior to the recommended 6 months of age (Kimanya, 2008). Kimanya cites studies on Tanzania stating “in most parts of the country, maize forms the main part of cereals used in complementary foods. Children are given maize-based porridge or other cereals with water (Mamiro et al., 2005; Nyarabucha et al. 2006).” In Nigeria, as well as throughout many parts of West Africa, weaning foods are commonly maize based but may also contain “groundnuts, sorghum, millet, and guinea corn (Onofiok and Nnanyelugo, 1998).
3. Value Chains or Commodities Presenting Greatest Risk to Humans and Animals

Cropping patterns and availability are the main determinants of dietary trends. In Africa it is common for adults on a maize-based diet to consume 400 g/person/day, whereas in the developed world, maize intakes are commonly less than 10 g/person/day (Shephard et al., 2002).

3.1 Cropping Patterns in Tanzania

The importance of maize is also revealed in this FAO diagram which demonstrates that throughout most of Tanzania, maize is the major crop grown (FAO 2012).

Exhibit 3: Cropping Patterns in Tanzania (FAQ 2012)


3.2 Consumption Patterns in Tanzania

In Tanzania, 44 percent of people are energy deficient. Nationally, of the food energy consumed, 70.6 percent is derived from a staple source (IFPRI, 2007). Subsistence farmers, households reliant on daily work and food aid have the least diverse diets. Across all income groups, cereal consumption comprises the majority of the diet. Wealthier income groups however also consume greater amounts of maize, even as their dietary diversity increases (Smith and Subandoro, 2007 and CFSVA, 2012).

Though dietary diversity increases with wealth, dependence on cereals as a main staple is high across all income groups, with cereals eaten an average of more than 5 days per week (CFSVA, 2010 and Smith...
and Subandoro, 2007). Dietary diversity also varies by region with Manyara, Dodoma and Mtwara being less diverse than the other regions (CSVA, 2010).

Exhibit 4: Consumption of Maize, Rice, Sorghum, and Cassava in Tanzania

![Graph showing consumption of maize, rice, sorghum, and cassava in Tanzania by income quintile, 2000.]

Source: Smith and Subandoro (2007).

Exhibit 5: Food Item Consumption by Livelihoods and Wealth

![Bar chart showing mean days food item consumed by livelihood profile and wealth quintile.]

**Fig 29:** Food item consumption by livelihoods and wealth

a) Mean days food item consumed by livelihood profile; b) Mean days food item consumed by wealth quintile (Source: 2009/2010 CF5VA)
Exhibit 6: Nigeria Cropping Patterns


The Nigerian Food Consumption Survey 2001-2003 reveals crop growing patterns throughout the country with the principal food crop map generated from IITA (2000) shown in the exhibit below. Notably maize production in Sub-Saharan Africa doubled from the 1960s to the 1990s due to increased productivity, production and an increase in land used for farming. In Nigeria during that time, maize production increased even more due to increases in production (385%), productivity (46%) and area under cultivation (231%) (Hell 2008). Maize is one of the most frequently consumed staples throughout Nigeria, though the majority of maize purchased in the markets (for both human and animal consumption) throughout the country, originates from the North.13

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3.3 Consumption Patterns in Nigeria

Throughout Nigeria’s dry savannah (where 15% of the population is underweight), humid forest, urban and rural locations), maize is the most commonly consumed staple with approximately 20% of the population consuming it at least once per week (Akinyele, 2008, Maziya-Dixon et al., 2004). Cassava, rice, groundnut and cowpea are also widely consumed (Maziya-Dixon et al., 2004).

Peanuts are an extremely important cash crop to Nigeria. Nigeria’s Ministry of Export has indicated that Nigeria has faced a large but unknown value of losses due to rejections of commodities from the EU (Waliyar et al. 2008). Given the high economic and nutritional contributions of groundnuts in Nigeria, this literature review recommends that maize and groundnuts (for Nigeria) be the main focal crops investigated during the country assessment.
3.4 Aflatoxin in Animal Feed

There are six common mycotoxins that affect animals: aflatoxins, fumonisins, ochratoxins (which like aflatoxins affect liver function), trichothecenes, and zearalenone. Diagnosis of aflatoxin exposure in animals is difficult, especially in large farms that use mixed feed, which may contain highly varied combinations of feedstuffs.

As in humans, animals exposed to high levels of aflatoxin-contaminated feed have been known to exhibit the severe form of “intoxication,” which can lead to death. Usually, however, exposure in animals is of a “sub-clinical” level, which leads to liver damage, reduced weight gain and lost productivity (declines in egg and milk production) resulting in economic losses to the industry. Aflatoxins affect livestock growth, reproduction, immune functioning and ability to metabolize vaccines (Anthony 2012). Poultry and fish are most affected, but there is also a lot of concern about B1 contamination in milk, given that it is often fed to infants and young children (Fink-Gremmels, 2008).

In Nigeria, the animal feed industry is becoming increasingly important for domestic use. SON standards set animal feed limits at 20 ppb, and some large commercial farms test animal feed to ensure that these limits are maintained. This too is important for the EU, which has reportedly rejected animal feed from some exporters. It is not clear, however, that Nigeria and Tanzania have been affected by trade losses in these EU rejections of animal feed.

Though Nigeria has many commercial farms with great awareness and demand for aflatoxin-safe feed, complete with aflatoxin binders and enzymes (which prevent the body’s absorption of the contaminant), the prevalence of aflatoxins above the regulated 20 ppb is still common among commercial producers of feed. A recent study of poultry feed found aflatoxin levels above 20 ppb in 62% of samples among commercial producers in 17 states (Ezekial, n/d). Less awareness exists, however, among subsistence farmers, who may still blend highly contaminated feed with less contaminated feed in an effort to conserve the harvest (Anthony et al. 2012).

Several studies from Nigeria reveal very high levels of contamination in finished feed that do not meet SON guidelines for human or animal consumption. This can be a challenge given that many of the preferred products that are used for animal feed due to their high energy and/or protein presence (e.g., maize and groundnut cake) are also susceptible to aflatoxin contamination.

Experts in Nigeria estimated for example that for most poultry feed, maize comprised nearly half the raw material. A study of 55 maize samples collected from 11 districts of three agro-ecological zones of Nigeria showed that in 10 of the 11 districts, samples were found with aflatoxin levels of 30.9-507.9 ug/kg (Atehnkeng et al. 2008). Another study from Nigeria found aflatoxins in “alarming concentrations above 20 ppb in 62% of samples among commercial producers in 17 states (Ezekial, n/d). Less awareness exists, however, among subsistence farmers, who may still blend highly contaminated feed with less contaminated feed in an effort to conserve the harvest (Anthony et al. 2012).

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14 Personal Communication with Dr. Dotun Oladele, Principal Manager, Lab Services Animal Care Representative, May 19, 2012.

15 Personal communication with Dr. Dotun Oladele, Principal Manager, Lab Services, Animal Care Services Konsult (Nig)Ltd on May 19, 2012 and Mrs. Omotoso, President, Animal Science Association of Nigeria, May 16, 2012.
of between 3,000 to 138,000 ug/kg in pre-harvest maize samples” (Maxwell et al. 2000). A third investigation of 13 samples of poultry feed in Nigeria found a mean concentration of 15.5 ppb with a range of 0 to 67.9 ppb (Adebayo and Etta, 2010). Groundnut cake, which is a preferred ingredient in animal feed due to its relatively cheap protein source, is very susceptible to high levels of aflatoxin contamination. A recent study found that 90% of groundnut cake samples from five states in Nigeria had aflatoxin levels that exceeded 20 ppb (Ezekial 2011). Another study of groundnut cake destined for animal feed in the Ibadan market contained between 20 ug/ppb and 455 ug/ppb of aflatoxin B₁ (Akonda and Atanda 1990).

The effects of animal feed on meat and other byproducts: Consumption of aflatoxin-contaminated animal feeds varies with preparation and the type of product. Anthony et al. reviewed studies in which the prevalence of aflatoxins was compared across beef and edible organs that were either fresh or sundried. Consistently, organ meats (especially kidney) were more contaminated than beef, while fresh products (as opposed to sundried products) maintained higher aflatoxin contamination levels.

<table>
<thead>
<tr>
<th>Cattle Product</th>
<th>Aflatoxin B₁ in Fresh samples (ng/kg)</th>
<th>Aflatoxin B₁ Sundried ng/kg in sundried samples (ng/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muscle tissue/beef</td>
<td>21.7</td>
<td>2.9</td>
</tr>
<tr>
<td>Liver</td>
<td>33.9</td>
<td>3.1</td>
</tr>
<tr>
<td>Heart</td>
<td>55.9</td>
<td>27.9</td>
</tr>
<tr>
<td>Kidney</td>
<td>85.2</td>
<td>75.8</td>
</tr>
</tbody>
</table>

Source: Oyero and Oyefolu (2010).

Of further importance to the health and economic implications of animal feed is the “carry-over” of aflatoxin contamination from feed to by-products. In milk, this “carry-over” effect is of great concern, as within 12 hours of ingesting AFB₁, cattle may excrete AFB₂ into milk, which is almost as carcinogenic as AFB₁ (Udom et al., 2011). A study of dairy cattle feed and milk residuals in Northern Nigeria (Jos) found that “92% of the feed samples for dairy cattle had AFB₁ concentrations exceeding the stipulated 5 μg/kg maximum limit set by the European Union (EU) for dairy cattle. AFB₁ concentrations in all samples of the maintenance feed concentrate were within the EU maximum acceptable limits of 20 μg/kg” (Udom et al., 2011).

In other products (eggs, muscle tissue), the carry-over effect has been found to be quite low, though it varies with the product. The Anthony et al. literature review of aflatoxins in animal feeds revealed very low transfer ratios in feeding trials as summarized below:
Despite this low carry-over level of aflatoxins to livestock products, egg samples from Cameroon, for example, found up to 7.86 ppb contamination levels in eggs, suggesting that feed may contain extremely high levels of aflatoxin contamination (Speijers and Speijers 2004).

Additional public health considerations of aflatoxins in animal feed: Concentration of mycotoxin in meat, eggs and milk is generally low, and some researchers believe that the increased use of anti-microbials in animals (to offset mycotoxin-induced immunosuppression) may actually pose a greater threat to human health. Poultry in particular may be more prone to viral outbreaks and microbial resistance with the increasing use of anti-microbials (Fink-Gremmels, 2008).

Ultimately, animal feed is very important to the control of aflatoxins, particularly since some people may view animal feeds as an appropriate “alternative use” for highly contaminated feed.16

The United States Department of Agriculture, for example, allows for aflatoxin contamination of up to 300 ppb for corn destined for finishing feed (feed used for up to 2 weeks before slaughter) for cattle, <200 ppb for finishing feed for swine, <100 ppb for breeding cattle, swine, and mature poultry, and <20 ppb for dairy cows and young animals.

In the initial visit to Nigeria, a large animal feed processor, Animal Care Konsult of Nigeria, confirmed that it may buy groundnuts with contamination levels as high as 100 ppb, if it plans on using the groundnuts only as 10-15% of a raw material in animal blends. Managing the composition is one way to utilize a cheap supply of crude protein while ensuring that the finished feed does not contain more than 20 ppb of aflatoxins.17

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16 Further, though some experts state that use of aflatoxin contaminated foods in biofuel may be plausible, there was no literature discussing a viable market for biofuel in Tanzania or Nigeria.

17 Personal Communication with Dr. Dotun Oladele, Principal Manager, Lab Services, Animal Care, May 19, 2012.
4. Promising Technologies and Practices for Aflatoxin Mitigation

Many of the technologies for aflatoxin mitigation have been well documented in the recently released Synthesis of the Research on Aflatoxin in Health, Agriculture and Trade (USAID 2012). This section also draws heavily from the analysis of Liu Y. and Wu, F. (2010) and Khlangwiset (2011). What follows discusses the literature as it pertains to the potential feasibility of these solutions in Tanzania and Nigeria.

4.1 Pre-Harvest Solutions

As noted above, many of the pre-harvest solutions currently available to Tanzania and Nigeria are based on Good Agricultural Practices, which typically include use of insect resistant crops, good tillage and weeding practices, appropriate use of fertilizers, irrigation, and crop rotation (Kimanya, 2008). In addition to GAP, practices such as treating soil with lime and farmyard manure have proven successful at reducing aflatoxin contamination levels (Waliyar et al., 2008).

Bio-controls: The USAID desk review notes that “biocontrols are used in place of traditional chemical pesticides, are environmentally safe and derived from natural means and may include beneficial insects, plant extracts, or the introduction of other natural organisms. Use of bio-controls is promising with reductions of B1 aflatoxins by as much as 83%” (USAID 2012, p. 43). Plants sprayed with the atoxigenic strain were 97% free of the aflatoxins at follow-up, and inoculation of soil (which may be more feasible for smaller farmers) has also proven to be a highly effective method to prevent aflatoxins pre-harvest (USAID 2012).

IITA is currently exploring options for possible bio-control development that could be adopted by Mali, Ghana and Tanzania (IITA Presentation, March 2012). IITA and its partners seek to develop a scalable, natural scientific solution for aflatoxin contamination in the form of a biological control that naturally is both adapted to and native to local environments.

In a 2011 World Bank Forum, the IITA presented findings from trials of bio-controls in Nigeria revealing that aflatoxin reductions on average reduced by 79% across trials in four locations of Nigeria’s Kaduna district. Slides from this presentation, showed the 79% mean reduction of maize treated with Aflasafe, four months of poor storage.

As shown above, crops treated with aflatoxins continued to show a dramatic reduction in aflatoxin levels, even one year after the application of the bio-control on the test fields, even in environments where storage is poor.
4.2 Post-Harvest Stage

During the post-harvest stage, thorough drying, prompt storage and transport using clean, dry containers are the basic elements of aflatoxin prevention and control. Timely harvest is also critical for aflatoxin prevention. One study found that aflatoxins in maize increased 4-7 fold after a 3-4 week delay in harvest after maturity (Hell 2008). IITA has made recommendations for aflatoxin mitigation in maize for subsistence farmers, who often lack the resources or access to drying and storage equipment. It based its recommendations on surveys with subsistence farmers throughout in Nigeria and other parts of Sub-Saharan Africa. Through these interviews, IITA identified some practices that were already being put to use which affected the levels of aflatoxin follow up tests.

The key elements of these recommendations include sorting, cleaning, drying, packaging, adherence to hygiene and sanitary conditions in storage and transport, as well as through raising farmers’ awareness about these practices (Hell et al. 2008). The recommended practices are documented below.

Exhibit 10: Farming Practices Associates with High and Low Aflatoxin Levels in Stored Maize in Benin

Table 1. Farming practices associated with high and low aflatoxin levels in stored maize in Benin.

<table>
<thead>
<tr>
<th>Production Practices</th>
<th>Higher Aflatoxin Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop rotation</td>
<td>Maize mono cropping</td>
</tr>
<tr>
<td>Local variety in South</td>
<td>Improved variety in South</td>
</tr>
<tr>
<td>Improved variety in North</td>
<td>Local variety in North</td>
</tr>
<tr>
<td>Maize in mixed cropping</td>
<td>Cowpea, peanut or cassava intercrop</td>
</tr>
<tr>
<td>Diammonium phosphate fertilizer</td>
<td>No fertilizer</td>
</tr>
<tr>
<td>Farmers aware of incomplete husk cover</td>
<td>Maize is damaged in the field</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Harvest Practices</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvest at crop maturity</td>
<td>Delayed harvest</td>
</tr>
<tr>
<td>Harvest of maize with the husk</td>
<td>Harvest maize in heaps, cobs shelled later</td>
</tr>
<tr>
<td>Sun drying on platform</td>
<td>“Field” drying on the plant</td>
</tr>
<tr>
<td>Drying of maize without the husk</td>
<td>Delayed drying</td>
</tr>
<tr>
<td>Immediate removal of damaged cobs</td>
<td>No sorting at harvest</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Storage Practices</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleaning of the storage structure</td>
<td>No preparation of the storage structure</td>
</tr>
<tr>
<td>Maize stored for 3-5 months</td>
<td>Maize stored for 8-10 months</td>
</tr>
<tr>
<td>Smoke or insecticide use</td>
<td>No insect control</td>
</tr>
<tr>
<td>Maize stored in aerated stores</td>
<td>Maize stored in poorly aerated stores</td>
</tr>
</tbody>
</table>

Source: (Hell et al. 2008)
Exhibit 11: Occurrence (%) of Some Toxigenic Fungal Species in Maize Grains Following 7 Days of Drying with the Indicated Drying Method

Table 2. Occurrence (%) of some toxigenic fungal species in maize grains following seven days of drying with the indicated drying method.

<table>
<thead>
<tr>
<th>Drying method</th>
<th>Aspergillus</th>
<th>Fusarium</th>
<th>Penicillium</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cobs on stalk in the field</td>
<td>4.7 ab</td>
<td>99 a</td>
<td>41.7 a</td>
<td>5.3 a</td>
</tr>
<tr>
<td>Sun drying; cobs on the ground</td>
<td>21 a</td>
<td>95 a</td>
<td>44 a</td>
<td>10 a</td>
</tr>
<tr>
<td>Sun drying; cobs on a platform</td>
<td>2.0 b</td>
<td>86 b</td>
<td>4.7 b</td>
<td>2.7 a</td>
</tr>
<tr>
<td>Sun drying; cobs on a plastic sheet</td>
<td>18 a</td>
<td>33 c</td>
<td>9.7 b</td>
<td>4.7 a</td>
</tr>
</tbody>
</table>

Source: (Hell et al. 2008)

Different drying methods were also analyzed by Hell et al which suggested that for maize, drying on a platform may be the most effective way to reduce aflatoxins. The World Bank publication also notes that while tarps and wooden cribs for maize drying can be effective for aflatoxin reduction, the wooden cribs may attract termites, while both come at a high financial cost to small farm holders. Flatbed dryers were promising for drying rice, though the cost of $100/MT of rice was deemed as fitting only for larger contract farmers (World Bank, 2011).

4.3 Storage

Clean, dry, insect and rodent free storage conditions are critical to prevent aflatoxin growth as noted by the USAID desk review. Making storage options inexpensive and accessible is of paramount importance for consistent, long term utilization. The USAID synthesis outlines broadly the various pre harvest and post-harvest methods (USAID, 2012).

Turner et al also investigated low-technology post- harvest handling options for groundnut in an aflatoxin susceptible zone in Guinea. The package of interventions investigated included: hand sorting, storage in jute bags, education on improved sun drying, wooden pallets for drying, locally-made natural fiber mats and insecticides. The estimated cost of this intervention package was $50 (including $10 for the wooden pallet); a sizeable but potentially manageable cost where the GNP per capita is $1100.

Five months after harvest, this combination of storage methods led to a 50% reduction of aflatoxin biomarkers among the households in the intervention group as compared to the control group.
Exhibit 12: Storage Systems and Agro-Ecological Zone with Reported Rates of Insects and Fungus in Benin

<table>
<thead>
<tr>
<th>ZONE</th>
<th>STORAGE SYSTEM</th>
<th>PROBLEM</th>
<th>FUNGI</th>
<th>INSECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Humid Forest</strong> (high humidity)</td>
<td>Platform</td>
<td>29</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bag</td>
<td>61</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fireplace</td>
<td>50</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pot</td>
<td>0</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bottle</td>
<td>0</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td><strong>Mid-Altitude</strong> (cool climate)</td>
<td>Platform</td>
<td>0</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bag</td>
<td>50</td>
<td>49</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rhumbu</td>
<td>0</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Floor</td>
<td>0</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tree</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Southern Guinea Savannah</strong> (annual rainfall 100cm–150cm)</td>
<td>Bag</td>
<td>0</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Crib</td>
<td>40</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fireplace</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rhumbu</td>
<td>0</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oba</td>
<td>0</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td><strong>Northern Guinea Savannah</strong> (wet season lasts 4–6 months)</td>
<td>Bag</td>
<td>0</td>
<td>84</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rhumbu</td>
<td>0</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Floor</td>
<td>0</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Basket</td>
<td>0</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td><strong>Sudan Savanna</strong> (dry season lasts 6–8 months)</td>
<td>Bag</td>
<td>0</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rhumbu</td>
<td>0</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Floor</td>
<td>0</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Basket</td>
<td>0</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

Source: (USAID, 2012 citing Hell et al. 2008).

### 4.4 Processing Stage

Even in resource-constrained communities, there are several processing methods that can reduce aflatoxins in maize. The most promising processes reviewed included cleaning the cereal/groundnut by sorting, washing the food before processing and dehulling grain mechanically. Cleaning and dehulling were also noted to be safer as these methods are unlikely to produce other toxins that would be harmful to human health. Roasting also had some promising reductions in aflatoxins, up to an 85% reduction in B1 aflatoxin in one quoted study. While cooking reduced aflatoxins, it was noted that generally temperatures that are not achieved during home cooking (195 degrees Celsius for aflatoxin reduction) would be needed to sufficiently effect aflatoxin levels (Fandohan 2008).
Literature review to Inform the Aflatoxin Country Assessments: Tanzania and Nigeria

Other promising practices include: wet and dry milling, grain cleaning, canning, roasting, baking, frying, and extrusion cooking. Studies referenced in the USAID synthesis found that 23% of aflatoxin may be reduced by home preparation of a maize porridge. Caution however should be exercised, as even these reductions in aflatoxin levels may not bring the contaminants down to safe levels (USAID, 2012). More research needs to be done for specific recommendations in these practices and other practices including fermentation require further investigation (Hell et al. 2008).

It is also worth mentioning that unsafe household processing practices may exacerbate human exposure to aflatoxin contamination. These include using leftover water after maize steeping for cooking (the steeped water may contain a high level of aflatoxin contaminants). Further, though grounding aflatoxin-contaminated oil seeds would produce aflatoxin-free oils, the remaining ‘cake’ which is often fed to children and adults could be highly contaminated (Fandohan et al.).

Industrial processing: Industrial detoxification processes include using “inorganic salts and organic acids, and ammoniation which can eliminate the aflatoxin producing fungus with ammonia vapor [as well as] natural acids, salts and plant extracts. The USAID synthesis also notes that “though there is no widespread government acceptance of any decontamination treatment intended to reduce aflatoxin B₁ levels in contaminated animal feeding stuffs….Ammoniation appears to have the most practical application for the decontamination of agricultural commodities.” In animal feed, an anticaking(binding agent like "hydrated sodium calcium aluminosilicate" may reduce AFM₁ residues in milk, depending on the initial concentration of AFB₁ in the feed. (USAID, 2012)

4.5 Public Health Interventions

The WHO gauges whether a public health intervention is cost effective by estimating the number of life years that would be saved by an intervention. To evaluate and prioritize public health interventions, WHO uses a cost effectiveness ratio to determine whether an intervention is deemed ‘very cost effective, cost effective or not-cost effective.’ Typically, an intervention that costs less than three times the Gross Domestic Product per capita per life year saved is considered cost effective. Using this criterion Khlangswiset concluded that the Hepatitis B vaccine in Nigeria would be a highly effective, cost effective public health intervention to reduce aflatoxin induced liver cancer.

Khlangswiset notes that 100% Hepatitis B vaccination in Nigeria could reduce by half (49-53%) the total number of liver cancer cases (43,000) in Nigeria. Novasil, which is not widely regarded as a viable option for human consumption would be less effective, reducing 3%–10% (1,403–4,709) cases. Khlangswiset calculated that the cost of saving one disability adjusted life year (DALY) in Nigeria using the Hepatitis B Vaccine would range from $1,073 to $1,146. The cost of bio-control where DALY saved would be $26,467 to $69,110. According to the WHO criteria of cost-effectiveness ratio, the Hepatitis B vaccine

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18 Extrusion cooking is often an industrial process that involves mixing the food content (e.g. peanuts) with a reagent at very high temperatures. A Food Navigator article cites a study in which aflatoxins in peanuts were reduced by 97% by an extrusion cooking process that mixed calcium chloride, lycene and methylamine (Gray, 2011).
would be cost-effective, while the bio-control is likely to be cost-effective, especially given its preventive efficacy.

### 4.6 Gender Considerations of Aflatoxin Management

Though there is scant literature on the gender implications of aflatoxin management, there is a wealth of available resources on gender roles in agriculture. There are several Gender Analysis Frameworks that can be used to evaluate constraints and opportunities of both women’s and men’s ability to adapt the package of interventions that comprise a comprehensive aflatoxin control and prevention strategy. These frameworks provide a structure for considering how aflatoxin recommendations and mitigation interventions will be accessed by men and women, as gender may influence access to and adoption of agricultural technologies, information, inputs, finance and decision making authority with regard to planting, marketing and harvesting.

The Women’s Empowerment Framework (Hlupekile Longwe), investigates women’s control over decision making factors related to production, participation in decision making, access to agricultural inputs, awareness raising about gender roles and division of labor, and women’s welfare (Gate Project 2009). This framework can guide the investigation of gender considerations of aflatoxin prevention and control strategies, particularly at the community and household level.

In rural areas of Nigeria, women make up 60-80% of the agricultural labor force. In Tanzania, women in rural areas are responsible for 87% of the labor used for growing food consumed by households (Ogunlela and Mukhtar, 2009). Though women are larger contributors to rural food production, they often have less decision making authority and control over farming decisions than men.

A gender in decision making study conducted in Nigeria’s northern state of Kaduna (a major maize producing state), found that among 10 major farming decisions, women were consulted for less than 20% of them, aside from decisions about whether to access credit. Only 1 to 2.5% of women in the study sample made final decisions about farm operations. Notably, however, women did make final decisions about storage and marketing practices of their rural farm produce, as noted in the table excerpted from the authors’ paper. Women’s decision making power increased with age, education and income (Ogunlela and Mukhtar, 2009).
Exhibit 13: Women’s Role in Farming Operations (Kaduna State, Northern Nigeria)

<table>
<thead>
<tr>
<th>Decision-making area</th>
<th>Nil</th>
<th>Only consulted</th>
<th>Opinion considered</th>
<th>Final decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land preparation</td>
<td>176 (84.0)</td>
<td>21 (10.5)</td>
<td>3 (1.5)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Time of sowing</td>
<td>156 (78.0)</td>
<td>34 (17.0)</td>
<td>8 (40.0)</td>
<td>2 (1.0)</td>
</tr>
<tr>
<td>Manure/Fertilizer types and time of application</td>
<td>162 (81.0)</td>
<td>19 (9.5)</td>
<td>15 (7.5)</td>
<td>4 (2.0)</td>
</tr>
<tr>
<td>Time of weeding</td>
<td>189 (94.5)</td>
<td>9 (4.5)</td>
<td>2 (1.0)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Number of hired labourers and wages to be paid</td>
<td>135 (67.5)</td>
<td>39 (19.5)</td>
<td>17 (18.5)</td>
<td>9 (4.5)</td>
</tr>
<tr>
<td>Time of harvesting</td>
<td>111 (55.5)</td>
<td>37 (18.5)</td>
<td>49 (45.5)</td>
<td>3 (1.5)</td>
</tr>
<tr>
<td>Storage and marketing of farm produce</td>
<td>28 (11.5)</td>
<td>37 (18.5)</td>
<td>92 (46.0)</td>
<td>48 (24.0)</td>
</tr>
<tr>
<td>Purchase and sale of farming implements</td>
<td>156 (73.0)</td>
<td>29 (14.5)</td>
<td>13 (6.5)</td>
<td>2 (1.0)</td>
</tr>
<tr>
<td>Purchase and sale of farm lands</td>
<td>161 (80.5)</td>
<td>23 (11.5)</td>
<td>11 (5.5)</td>
<td>5 (2.5)</td>
</tr>
<tr>
<td>Farm credit</td>
<td>117 (58.5)</td>
<td>57 (28.5)</td>
<td>26 (13.0)</td>
<td>0 (0.0)</td>
</tr>
</tbody>
</table>

Source: (Ogunlela and Muktar, 2009; Damisa and Yohanna, 2007).

Two articles written about gender considerations for aflatoxin management in Uganda and Nigeria revealed how gender must be incorporated into any analysis of local remedies for aflatoxin mitigation. In Uganda, USAID supported a gender assessment of women’s roles in groundnut production and trading, which was carried out in Uganda by Virginia Tech and the Department of Food Science and Technology of Makerere University, Kampala. This study, conducted in the three districts of Uganda found that women farmers predominantly managed the pre- and post-harvest production of groundnuts. They also managed the household process of making groundnuts into flour paste for a peanut sauce that was consumed by their families on average 3-4 times per week.

The analysis also revealed gender differences in production and marketing/use of groundnuts. Women produce them on a smaller scale (e.g., household plots/gardens) than men, and are more likely to use local seed varieties, use traditional methods to chop and plant and produce mainly for household consumption. They will however sell their supply of groundnuts when they have a need for cash. Men by contrast are more likely to produce groundnuts for commercial purposes and are more likely to use improved traditional practices (e.g., row planting) or more advanced methods and technologies such as hybrid seeds. Women reported that they relied on groundnuts as their sole source of income, but also reported that they controlled the revenue only from groundnuts grown in their gardens (Kaaya, 2007). Kaaya’s study revealed several perceptions about tasks that were seen to be women’s (weeding and planting) vs. men’s responsibilities (planting and spraying). To date, it is unclear whether these gender constraints are present in Tanzania and Nigeria based on the available literature, and a gender analysis on the division of labor, decision making authority, access to finance, inputs, and information for aflatoxin mitigation will need to be further investigated during the country assessment.

The study on gender and storage in Nigeria, which investigated Nigerian gender differences in agricultural storage technologies, found no marked differences in storage technologies or aflatoxin levels in crops produced by men and women. The study did however find that when husbands received agricultural training and advice from extension workers, they rarely passed on this information to their
wives; thus, the need for separate aflatoxin trainings geared toward women is recommended (Udoh et al. 2000).  

In addition to information flows, gender roles, flows of income and divisions of labor, women’s access to inputs (insecticides, storage equipment, bio-controls), and finance (loans, credit and savings schemes) as well as time are key factors affecting their ability to effectively prevent and control aflatoxin contamination at the household and community level. Further, local customs or regulations affecting land tenure, mandates for extension services and education for women and girls also determine women’s access and adoption of new technologies and practices. Customs, norms and laws that affect women’s access to resources, assets and inputs affect their standing in the household, community and market. Women’s standing in turn affects their autonomy to make household health and consumption decisions such as diversifying the household’s diet, spending household resources on vaccinations, or using agricultural revenue to invest in promising technologies such as bio-controls, storage cribs or wooden pallets (World Bank, FAO, IFAD 2009).

19  www.caes.uga.edu/commodities/fieldcrops/peanuts/pins/peanutcrspprojects/vt54.html#top.
5. Ongoing Aflatoxin Communication Initiatives Addressing Aflatoxin Mitigation

Raising public awareness and disseminating currently available practices and technologies to growers, processors, and traders is essential for mitigation of aflatoxin contamination. As demonstrated in the studies above, many of the viable prevention solutions currently exist within the GAP, GMP and SPS recommendations. Finding ways to disseminate a complete package of technologies, equipment and knowledge to growers, while raising consumer demand for safe, high quality foods, will be essential elements of any action plan.

Aflatoxin risk communication however remains highly sensitive given that presenting the dangers without viable solutions is counterproductive. Withdrawing contaminated crops without alternative uses and compensation may heighten economic losses and affect food security among the poor.

Tanzania (TFDA and TBS) and Nigeria (NAFDAC and SON) appear very open about communicating the causes of aflatoxin (and mycotoxin) exposure. In August 2010 for example, the TFDA educated 29 policy makers and 11 journalists from nine public and private radio, newspaper and television sources about mycotoxins. The media houses present at the training are listed below. Those with documented reporting evidence on the issue are starred.

Exhibit 14: TFDA Engages Journalists and Policy Makers to Raise Awareness of Mycotoxins

<table>
<thead>
<tr>
<th>TV sources</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>*Independent television,</td>
<td>Three of four television stations</td>
<td>Three of four television stations</td>
</tr>
<tr>
<td>*Tanzania Broadcasting</td>
<td>reported on mycotoxin.</td>
<td>reported on mycotoxin.</td>
</tr>
<tr>
<td>corporation (public source),</td>
<td>Nature of content unclear</td>
<td>Nature of content unclear</td>
</tr>
<tr>
<td>*Capital Television</td>
<td></td>
<td></td>
</tr>
<tr>
<td>East Africa television</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radio</td>
<td>No documented evidence of reporting, but this would have required</td>
<td>No documented evidence of reporting, but this would have required</td>
</tr>
<tr>
<td></td>
<td>in-depth transcript review.</td>
<td>in-depth transcript review.</td>
</tr>
<tr>
<td></td>
<td>(transcript review would be needed)</td>
<td>(transcript review would be needed)</td>
</tr>
<tr>
<td>Newspapers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>*Daily Newspaper (Public</td>
<td></td>
<td></td>
</tr>
<tr>
<td>source),</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Business Times Newspaper</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Majira News.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Email correspondence: Martin Kimanya of TFDA (April 5, 2012).

Nigeria has an established body of professionals who created the Mycotoxicology Society of Nigeria to raise awareness and promote good agricultural practices to reduce mycotoxins in general. The Society has produced op-eds in national papers and holds annual mycotoxin conferences that are announced on national radio. In June, 2011 the Society and representatives from NAFDAC and the SON provided a one-
day training to farmers to raise awareness about aflatoxins.\textsuperscript{20} To raise the attention of the governor’s office they noted that the WHO had placed aflatoxin B\textsubscript{1} on a list of human carcinogens, and then the Mycotoxin Society provided a one day workshop on aflatoxin mitigation for farmers and traders of livestock, and crops including: beans, maize, cassava, groundnuts, and yam flour in the Kwara State.

The current president of Mycotoxicology Society of Nigeria would like to make further progress in terms of mycotoxin communication and control. He wishes to create a national mapping of tested samples, and create a database system for nation-wide collaboration and information sharing\textsuperscript{21}.

\textsuperscript{20} Personal communication with Mrs. Folasade, Mycotoxicology Society Member and head of the Mycotoxin Laboratory in NAFDAC, May 21, 2012.

\textsuperscript{21} Personal Communication with Dr. Atanda, President of the Nigeria Mycotoxicology Society, May 4, 2012.
6. Gaps in Research to Be Addressed by the Aflatoxin Country Assessments

Based on the literature above, it seems that maize in both Nigeria and Tanzania, and groundnuts in Nigeria, are key commodities that would make primary focus crops for the aflatoxin country assessments. These choices, however, will need to be vetted however with local stakeholders and officials such as TFDA and NAFDAC.

There are several gaps in the literature that will be informed by the Country Assessment primary investigation. The sections on Nigeria will need to be updated and reviewed by local authorities. Much of the literature was two or more years old, so some of the local capacities and practices may have been revised. The case study on the laboratory capacity in Nigeria for example was written in 2008, so this will require updated interviews with experts within NAFDAC.

In both Nigeria and Tanzania testing of raw (unpackaged) agricultural products consumed locally is rare. In Nigeria however a new directorate of food safety had just been created in NAFDAC, which may yield further information and regulation of aflatoxin levels in agricultural products destined for local consumption.22

The availability of technologies and equipment for aflatoxin prevention and control, as well as knowledge and ability to implement the recommended GAP and GMP recommendations will also require further discussion. In both countries, interviews with laboratory and regulatory officials will need to be done to develop a better understanding of surveillance, inspection, sampling, testing, withdrawal, and certification procedures.

The bio-control trials from Nigeria will yield more results over the course of this year, and progress of bio-control commercialization in Nigeria will be made. Alternative uses for contaminated crops and incentive mechanisms for improving production, post-harvest and transport quality will be sought during the Tanzania and Nigeria country assessments.

Much more information on gender and aflatoxin management is needed. As noted above, the literature on aflatoxin specific management is scarce, though there are plenty of available resources on assessing and empowerment women in agriculture generally. These resources recommend on conducting gender analysis to ensure that recommendations and interventions are equitably access to men and women. This entails an assessment to understand what additional barriers women (or men) may have in adopting new technologies, access inputs, hearing and receiving extension messages, or accessing finance and equipment. Likewise, recommendations to shore up Good Agricultural Practices, should consider the extra time burdens this may have for women, who may already be disproportionately overburdened with agricultural, house and child care.

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22 Personal communication pertaining to Nigeria, conducted with Mrs. Folasade, May 15, 212, and regarding Tanzania with Dr. Kimanya, April 5, 212.
Public and private solutions for storage and drying, fertilizer and pest management require further investigation, as will existing opportunities for farmers to access finance to employ the recommended practices. A draft conceptual framework will be established and vetted with local authorities and members of the PACA. This will inform the methodology and framework for the aflatoxin country assessments, which will investigate feasible options for aflatoxin mitigation and prevention among private and public sector stakeholders.
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Academic Publishers, the Netherlands, p. 81-88.

Slorachet. al (2010). Options for Enhancing Developing Country Participation in Codex and IPPC activities

IFPRI [accessed April 4, 2012]


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Tanzania Bureau of Standards.Maize Flour – Fortification Specification: The maximum content of
aflatoxins in maize flour when determined in accordance with the method described in TZS 799 (see
clause 2) shall not exceed 5 µg/kg (ppb) for aflatoxin β1 and 10 µg/kg for total aflatoxin (TBS, ii)

TZ Bureau of Standards fats and oils fortification specification: aflatoxin not mentioned

TZ Bureau of Standards wheat flour specification: The maximum content of aflatoxin in wheat flour
when determined in accordance with the method described in TZS 799 (see clause 2), shall note exceed
5 µg/kg (ppb) for aflatoxin β1 and 10 µg/kg for total aflatoxin.


The World Bank, Food and Agriculture Organization, and International Fund for Agricultural Development. 2009. Gender in Agriculture Sourcebook.


World Trade Organization. Understanding the WTO Agreement on Sanitary and Phytosanitary Measures.  

### Annex A: Advantages and Disadvantages of Conventional and Emerging Technologies for Mycotoxin Detection

<table>
<thead>
<tr>
<th>Method</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLC</td>
<td>Simple, inexpensive and rapid</td>
<td>Poor sensitivity (for some mycotoxins)</td>
</tr>
<tr>
<td></td>
<td>Can be used for screening</td>
<td>Poor precision</td>
</tr>
<tr>
<td></td>
<td>Simultaneous analysis of multiple mycotoxins</td>
<td>Adequate separation may require two-dimensional analysis</td>
</tr>
<tr>
<td></td>
<td>Sensitive for aflatoxins &amp; ochratoxin A</td>
<td>Quantitative only when used with a densitometer</td>
</tr>
<tr>
<td>GC</td>
<td>Simultaneous analysis of multiple mycotoxins</td>
<td>Expensive equipment</td>
</tr>
<tr>
<td></td>
<td>Good sensitivity</td>
<td>Specialist expertise required</td>
</tr>
<tr>
<td></td>
<td>May be automated (autosampler)</td>
<td>Derivatization required</td>
</tr>
<tr>
<td></td>
<td>Provides confirmation (MS detector)</td>
<td>Matrix interference problems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-linear calibration curve</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Drifting response</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Carry-over effects from previous sample</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Variation in reproducibility &amp; repeatability</td>
</tr>
<tr>
<td>HPLC</td>
<td>Good sensitivity</td>
<td>Expensive equipment</td>
</tr>
<tr>
<td></td>
<td>Good selectivity</td>
<td>Specialist expertise required</td>
</tr>
<tr>
<td></td>
<td>Good repeatability</td>
<td>May require derivatization</td>
</tr>
<tr>
<td></td>
<td>May be automated (autosampler)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Short analysis times</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Official methods available</td>
<td></td>
</tr>
<tr>
<td>LC/MS</td>
<td>Simultaneous analysis of multiple mycotoxins</td>
<td>Very expensive</td>
</tr>
<tr>
<td></td>
<td>Good sensitivity (LC/MS/MS)</td>
<td>Specialist expertise requested</td>
</tr>
<tr>
<td></td>
<td>Provides confirmation</td>
<td>Sensitivity relies on ionization technique</td>
</tr>
<tr>
<td></td>
<td>No derivatization required</td>
<td>Matrix assisted calibration curve (for quantitative analysis)</td>
</tr>
<tr>
<td>Method</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>-----------------</td>
<td>-----------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>LFD</strong></td>
<td>Rapid, No clean up, No expensive equipment, Easy to use, No specific training required, Quantitative for aflatoxins</td>
<td></td>
</tr>
<tr>
<td><strong>FFIA</strong></td>
<td>Rapid, No clean up required, Validated for DON in wheat</td>
<td></td>
</tr>
<tr>
<td><strong>Infrared spectroscopy (NIR, MIR)</strong></td>
<td>Rapid, Non-destructive measurement, No extraction or clean up, Easy operation</td>
<td></td>
</tr>
<tr>
<td><strong>Capillary Electrophoresis</strong></td>
<td>Rapid, Limited organic solvent use, Good resolution of analyte from interfering substances, Good sensitivity (fluorescence capillary electrophoresis)</td>
<td></td>
</tr>
<tr>
<td><strong>Immunosensors/Biosensors (SPR, FOI, QCM, SPCE)</strong></td>
<td>Rapid, No clean up procedure</td>
<td></td>
</tr>
<tr>
<td><strong>MIP</strong></td>
<td>Low cost, Stable</td>
<td></td>
</tr>
</tbody>
</table>

Appendix C – Interview Guides: Tanzania and Nigeria
Semi-Structured Interview Guide:
Aflatoxin Country Assessment for Tanzania

Introduction (for use at the beginning of each interview)

- [Welcome and thank informant(s), introduce the interviewer and observer (if applicable), and state the objective of the meeting.] Thank you for speaking with us today about the issue of aflatoxins in your district. Our names are ____ and _____, and we are working with a company called Abt Associates to complete an assessment on aflatoxins. Aflatoxins are an important issue that affect agriculture and food security, trade, and human and animal health. We are therefore interested in learning about your opinions, perspectives and experiences, and recommended action steps for controlling and preventing aflatoxins and promoting food safety in your community. We are conducting this assessment on behalf of the Partnership for Aflatoxin Control in Africa (PACA), which is housed in the African Union.

- [Give the justification for the interview.] There are a range of possible ways to prevent or control aflatoxins in food and feed, and we would like your opinion in helping us identify the main challenges and action steps for addressing aflatoxins in your district.

- [Ask permission to use the tape recorder. Use your judgment on whether it is possible to use the recorder; some political officials may not allow it or even want the issue raised.] Your opinion is very important to us. However, it will not be possible to pay attention to what we are discussing and at the same time take detailed notes of what is being said. Therefore, we have brought a tape recorder so that we won’t miss any part of the conversation and so that we can check our notes later on. Is it alright with you if we use the tape recorder? If at any time during the interview you’d like us to stop the tape recorder for a certain portion of the discussion or not transcribe a particular statement, we would be happy to do so.

- [Offer clarification and answer initial questions.] If, at any time, you don’t understand the questions we are asking, please let us know, and we will be happy to try to rephrase the question and clarify our thinking behind it. If there is anything else that you feel is important to tell us that we have not asked, please give us those comments at the end of our discussion. Do you have any questions before we begin?
Questionnaire for Policy Makers

[TBS official interviews]

A. Background on Institutional Mandates

1. Please describe the mandate of your institution.

B. Questions Regarding the Regulatory Environment Pertaining to Aflatoxins

1. Before conducting this assessment, we did some research to find the following standards on aflatoxins for Tanzania. I would like to verify if these standards are current. [Ask for copies of the standards.]

<table>
<thead>
<tr>
<th>Tanzania’s standards for aflatoxins (found in the literature review):</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Cereals and nut maximum limits for aflatoxins: 10 μg/kg for aflatoxin B1, B2, G1, G2 and 5 μg/kg for B1</td>
</tr>
<tr>
<td>• Cashews for consumption: 10 μg/kg (total aflatoxins for cashews)</td>
</tr>
<tr>
<td>• Groundnuts for consumption: 15 μg/kg (total aflatoxins for groundnuts)</td>
</tr>
<tr>
<td>• Maize (to be further sorted) 20 μg/kg</td>
</tr>
<tr>
<td>• B1 is also limited to 5 μg/kg in rice, cashews, barley, sorghum flour, and pearl millet grains</td>
</tr>
<tr>
<td>• Are there standards for aflatoxins in animal feed?</td>
</tr>
</tbody>
</table>

2. Are these standards available on a website? How are they disseminated?

3. Do farmers cooperatives, industry, regional institutional stakeholders, and MOA use and refer to the aflatoxin standards?

4. With the new fortification laws, will aflatoxins in raw product be closely monitored?

C. Questions Regarding Regional Harmonization of Aflatoxin Standards within the East African Community and Tanzania

[Ask only national-level officials from TBS and TFDA.]

1. Does EAC have its own, harmonized standards/recommendations on aflatoxins?

2. Do Tanzania’s standards stray from the EAC or Codex recommendations?

3. Are there any disagreements between Tanzania’s TFDA zonal offices and Dar es Salaam related to aflatoxin standards and mitigation/prevention efforts?
   a) Is Tanzania actively involved in this initiative?
   b) Is the initiative ongoing or complete?
   c) Is this forum a useful forum for informing science-based policy in Africa?
   d) Who participates in this forum from Tanzania?
   e) Lessons learned? Are these disseminated widely?
   f) Did somebody from Tanzania participate in the forum on April 23-25, 2012?

5. Are there other forums beyond the aforementioned regional forum (e.g., CAADP) that Tanzania is/wants to be an active part of to share lessons learned/expertise/technical assistance in developing the regulatory environment addressing aflatoxins?

6. What would be most useful for PACA to do to promote a regional regulatory framework or set of evidence-based guidelines for aflatoxin mitigation?

7. Does TBS engage the media to do outreach about aflatoxins?

8. Would it like to engage the media more? If yes, how can/should this be done?

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?
Questionnaire for Laboratory Officials

[Questions to ask of TFDA and TBS laboratory officials at the national and decentralized levels]

A. Surveillance and Testing and Detection

1. Are TFDA or any other actors currently involved in ongoing surveillance for aflatoxins?
2. What are the procedures for surveillance?
3. What are the current practices for surveillance?
4. What are the gaps between practices and protocols for surveillance?
5. Balancing cost with food safety, what do stakeholders envision as the right methodology for surveillance?
6. What equipment, testing, expertise is needed for surveillance?
7. Does this exist in TFDA? At the national level? Zonal level?

[Skip Sections B-F if not speaking to laboratory technicians within TFDA/TBS.]

B. Testing Methodology

1. What is the methodology for testing products for aflatoxin contamination?
2. Are rapid tests (ELISA) used for surveillance regularly? Are they backed up by the more expensive methods (HPLTC) method? Are other tests used, too?

C. Laboratory Accreditation

1. Is the TFDA mycotoxin laboratory or laboratories accredited internationally?
2. Where is the mycotoxin laboratory? Is there only one? What is the volume of testing capacity? How is it determined what will be tested?

D. Staffing

1. How many staff are in the laboratory? Is that sufficient?
2. Are there gaps in qualified staff? What would be required to shore up national laboratory capacity? What would the shortest route to shoring up that capacity be? Hiring more existing qualified staff? Training more? Offering more scholarships? Doing on-the-job training? Incentivizing existing staff to work in the rural areas?
3. Is there a unit that is trained to maintain the aflatoxin laboratory equipment?
E. Laboratory Equipment and Supplies Procurement
1. How does TFDA procure its equipment, media, reagents, and slides for testing? Are supplies ever out of stock? If yes, why? Is this an issue of financing, awareness, or administrative/political will?

2. How often are there gaps in testing/surveillance due to stock outages of laboratory equipment/supplies? Equipment problems? Staffing shortages? Shortage of resources for conducting tests?

F. Laboratory Data/Surveillance Sharing
1. How are these results shared?


3. Whose responsibility is it to communicate the findings of high/unsafe levels of aflatoxin contamination?

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?
Questionnaire for TFDA Inspection and Enforcement Officials

A. Inspection Capacity
[Ask TFDA Premise/Product Inspectors only.]

1. Please describe your institution’s mandate, size, and scope.

2. Beyond product and premises registration, how often does TFDA inspect products or assess risk for aflatoxins?

3. What percent of processors/manufacturers are inspected annually?

4. During the product registration, are aflatoxin levels always tested? How is the sampling method determined? How often must products be “re-certified”?

5. Does TFDA have sufficient staff, testing equipment, transport, and vehicles to regularly inspect at the zonal/national level?

6. Are some zones more prone to aflatoxins? Should aflatoxin testing/inspection capacity be targeted at those zonal levels?

7. Does TFDA outsource some of its inspection duties to a third-party inspector?

8. If yes, how/where and what is the mechanism for accountability?


10. What percentage of purchased processed cereals may have undergone “TFDA” inspection?

B. Product and Premise Certification

1. What is the methodology for getting products certified as TFDA approved?

2. How often are manufacturers/agro-processors products re-inspected or certified? What are the criteria for manufacturers to get a license for processing/selling food products with maize/groundnut?

3. Are processed products (e.g., cereals/nuts) that display the TFDA/TBS logos always tested for aflatoxins? If not—what percentage of goods are sampled? In other words, does the TFDA logo ensure the food is free of unsafe levels of aflatoxin contamination?

C. Commercial Sector Self-Regulation/Quality Assurance

1. Do some manufacturers have their own aflatoxin control procedures?

2. Which types of firms have these procedures?
3. Do they use their own laboratory services, or do they depend on TFDA’s mycotoxin laboratory?

4. Do some private/commercial sector firms do any testing/sampling of raw cereals for aflatoxins before they purchase the raw commodities?

D. Sampling Approaches

[skip section if you are not speaking with a TFDA inspector.]

1. How does Tanzania prioritize which samples/products/destinations receive sampling? Are there more rigorous product sampling plans for products carrying greater risk to consumers (e.g., baby food?)

2. If yes, which products have these rigorous sampling protocols? Is only TFDA responsible for ensuring that sampling protocols are followed?

3. Do some manufacturers test for aflatoxins on their own and use their own sampling plans? If yes, for what products and where?

4. With what regularity/frequency are aflatoxins being inspected by industry? Is it only when products are licensed for sale for human consumption?

5. Is there a certification process for agro-processors who process the aflatoxin-susceptible maize and groundnuts? How are imports and exports monitored for aflatoxins? Are random tests done? Is there a sampling procedure? What is it?

6. Is there potential for any third party to conduct the testing/sampling on behalf of TFDA? Could that service be contracted out in a way that would save TFDA money, while offering more accurate, efficient testing services?

E. Enforcement Capacity for Aflatoxin Control

[If TBS is not responsible for enforcement, ask this question only of TFDA officials at the national, zonal, and district levels (if applicable).]

1. How does TFDA enforce aflatoxin regulations?

2. Does TFDA do most of its aflatoxin enforcement through the product and premises registration of agro-processors?

3. Where can/should TFDA invest more resources to most immediately strengthen/expand its enforcement capacity?
4. What are the most immediate as well as longer-term gaps? Please rank the materials, equipment, and other inputs needed by TFDA.

5. Does TFDA do other types of inspection for aflatoxins at other points of the value chain (e.g., large markets, among traders, in large warehouses)?

6. Who monitors imports and exports of products for aflatoxins? How often? Are there other public institutions or private actors (third-party inspectors working on a contract basis for TFDA) that help with aflatoxin surveillance and enforcement?

7. Does TFDA follow/enforce Good Manufacturing Protocols (GMP) and Hazard and Critical Control Point (HACCP) recommendations as part of its aflatoxin detection mandate?

8. Does TFDA do aflatoxin testing in the zonal offices? Or do the offices send samples to the national laboratory?

F. Withdrawal of Contaminated Foods

1. Has TFDA had to withdraw aflatoxin-contaminated food or feed from the food/feed supply chains? What were the details (volume, location, quantity)?

2. What are the current procedures for withdrawal? At what points of the value chain have products highly contaminated with aflatoxins been withdrawn?

3. How often has withdrawal been done?

4. What was the method for withdrawal?

5. Is there any compensation to the stakeholders that face the loss of the withdrawn product? Who within TFDA or port/export/import inspection is responsible for withdrawing contaminated foods from the food supply?

6. What was done with the contaminated product? What is the procedure for disposal of withdrawn/contaminated product?

7. Are the procedures/maximum limits set for product withdrawal disseminated to the persons responsible for enforcement?

8. Do the institutions responsible for withdrawal have the equipment and resources to remove/dispose of the product?

9. If not, what resources, equipment, or regulations are needed to ensure that withdrawal is done sufficiently?
G. Media Outreach

1. Does TFDA have a mandate to share inspection/surveillance results with the public or industry? If yes, does it do this?

2. How should/can TFDA communicate with the public to encourage demand for safer, high-quality foods?

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?
Health Questionnaire

[Please record the name, agency, title, email address, and phone number of the respondent to add to the contact list. And ideally collect electronic (hard copy if e-copies not available) data on prevalence of liver cancer/enteric disease and child stunting especially as these are less commonly available online.

Stakeholders with whom this guide can be used (may be best to do this questionnaire in a focus group discussion with the following stakeholders)

- District Health Officers
- Ministry of Health and Social Welfare health officials involved in research and treatment guidelines for:
  - Liver cancer
  - Enteric disease
  - Hepatitis B
- Ocean Road Cancer Institute (ORCI)
- National AIDS Control Programme
- Tuberculosis and Malaria Departments, Directorate of Preventive Services
- Academic researchers (National Institute for Medical Research, MUHAS)

Welcome and Introduction [See above.]

A. Background on Institutional Mandates

1. Please describe the mandate of your institution.

B. Risk and Vulnerability Factors Related to Aflatoxins in Tanzania

[Questions for health officials involved in liver cancer, enteric disease (gut health), and hepatitis B, as well as HIV, TB, and malaria at the national and decentralized levels.]

1. What is the geographic breakdown of HIV/AIDS, hepatitis B (HBV), tuberculosis, liver cancer, enteric disease in Tanzania [or “in your district,” if you are speaking with a District Health Officer]?

2. [Skip to Question #6 if you’re not speaking with a national or regional health officer.]

2. [for national-level health officers] Are any researchers looking at the relationship between nutrition or enteric disease and HIV/AIDS, hepatitis B, TB, or liver cancer?

3. What are the main findings to date?

4. Who are the main funders and institutions involved in this research?

5. Are there any publications available?
6. What is the awareness level of general food safety and nutrition on your topical area of health?

C. Dietary Diversity [District]
1. Our literature review found that subsistence farmer and daily laborers have the least diverse diets in Tanzania. Do you agree? Which other groups of people may be overly reliant on maize or groundnuts (or other commodities prone to aflatoxin contamination)? Why is this?

2. Our literature review also found that regions such as Manya, Dodoma, and Mwatara had less dietary diversity than other regions in Tanzania. Do you agree? Why/why not?

3. What can be done to improve dietary diversity?

D. Stunting and Infant Feeding [District]
1. Though WHO recommends that infants up to 6 months of age be exclusively breastfed, premature introduction to complementary foods is common in Tanzania. This may inadvertently expose infants early in life to aflatoxin exposure, which could lead to child stunting and other problems. What kinds of action steps should be taken to prevent this practice?

2. Besides early introduction to complementary foods, are there other harmful practices that may be increasing exposure to young infants and children (e.g., cooking with water that was used for boiling maize)?

3. Is the practice of eating groundnut cake (kulikuli), which is a residual from the oil-producing process, common in Tanzania?

4. Are many people in your department working on issues of child stunting? Do they discuss food safety as a possible contributing factor affecting stunting? Why/why not?

5. Are there other stakeholders/researchers or practitioners currently investigating the relationship between aflatoxin exposure and HIV/AIDS, HBV, tuberculosis, liver cancer, enteric diseases in within Tanzania/your district?

E. Political Will and Communication [Questions for TFNC and other Nutrition Experts]
1. How much of a priority is the issue of aflatoxins to TFNC in Tanzania [Or “in your district”]?

2. What ongoing initiatives are there to communicate with the public about the problem of aflatoxins in foods?

3. How can TFNC or other institutions work more closely with communities to reduce aflatoxin exposure in foods?
F. Prevalence of Hepatitis B in Tanzania [Questions for Hepatitis Experts]
1. How big is the problem of HBV? What is the number and percentage of people who have HBV infections, and how does it vary by regions, districts, age, sex, and socioeconomic status?

2. What is the coverage of hepatitis B vaccine in Tanzania? How is it delivered, and who gets it? How much does it cost?

3. How big is the problem of hepatitis C (HCV)? What is the number and percentage of people who have HCV infections, and how does it vary by regions, districts, age, sex, and socioeconomic status?

4. What is the number and percentage of people have both HBV and HCV, and how does it vary by regions, districts, age, sex, and socioeconomic status?

G. Liver Cancer Morbidity [Questions for Cancer Experts/Liver Cancer Experts]
1. How big is the problem of liver cancer (HCC)? What is the number and percentage of people who have HCC, and how does it vary by regions, districts, age, sex, and socioeconomic status?

2. Is there any information on the cause of liver cancer and if it is associated with aflatoxins? Is the percentage of aflatoxin-related liver cancer more or less than the overall liver cancer rate?

3. Do the regions with higher HCC incidence overlap with areas that may be more susceptible to aflatoxin contamination?

4. Are there stakeholders/researchers currently investigating this within Tanzania?

H. Cost of Treating Liver Cancer
1. What are the standard medical treatments for HCC?

2. What is the HCC survival rate (by year since the time of diagnosis)? Does it vary by regions, districts, age, sex, and socioeconomic status?

3. If there any medical treatments for HCC, what is their cost?

4. What is an average annual income of a healthy individual?

5. At the current cost for cancer treatment, do people find it worthwhile to get treatment for liver cancer, or do they see it as a luxury they cannot afford? If the cost of treatment goes down, would more people get treatment? By how much would the cost need to go down? What types of people (in terms of socioeconomic status, gender, region) typically get treatment for cancer?
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?
Questionnaire for Ministry of Agriculture Staff

[Stakeholders with whom this guide can be used:
  - Ministry of Agricultural officials at the national and regional/district level
  - MOA production, trade, export experts
  - MOA Good Agricultural Practices experts
  - District livestock and agriculture officers
  - Agricultural extension officers (ward-level)
  - Meat inspectors (ward-level)]

A. Background on Institutional Mandates

1. What is the MOA’s role in preventing/reducing aflatoxins?

2. What is MOA doing specifically to prevent/reduce aflatoxins at the central/zonal or district level?

3. Is there an aflatoxin focal point? Or are there policy champions within MOA or Extension Offices within the National Agricultural Research Organization that see aflatoxin prevention/mitigation and control as part of their mandate?

4. Is it MOA’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 MOA

1. Does MOA (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 MOA 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 (23,443 Tshs) per hectare, would farmers buy it? What if it was $10 (15,700 Tshs) or $8 (7800 Tshs)?

2. How would you recommend that it be marketed or sold?

3. What would need to be done to get farmers to use this?

D. Post-Harvest Handling Questions [District: Ask the post-harvest management staff in the directorate for food security.]

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 are 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 Tanzania/your district? Why/why not?

4. Are these practices feasible at the farm level? Why?

5. How much would this package of materials (jute bags, wooden pallets, and insecticides) cost in your community? Is that affordable?

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 the above?

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 carry 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; for example, cashew in Tanzania.]

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?
Questionnaire for the District Grain Reserve Officer

A. Background on Institutional Mandates

1. Please describe the role of your institution, as well as the number of staff/locations where it has offices.

B. General Awareness of Good Agricultural Practices (GAP)

1. What is the current level of knowledge of GAP among rural farmers?

2. Is there any incentive to encourage farmers’ cooperatives to use GAP? Please explain.

3. Do GAP include all the measures for aflatoxin prevention, control, or mitigation from the farmer’s perspective?

4. Are there any elements of GAP that need to be emphasized to encourage aflatoxin control and prevention among farmers?

C. Pricing Differentials for Contaminated vs. Non-Contaminated Foods

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 carry 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: for example, cashew in Tanzania.]

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?

D. Warehouse Management Practices

1. Do the storage facilities follow good warehousing procedures?

2. Is grain dried to 15% before it is stored? If yes, how?
3. Are there sellers of dryers? Where? How much does it cost? Do communities buy these?

4. Are there any successful methods of community storage (and drying) and warehouse management?

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?
Questionnaire for Livestock Suppliers

A. Background

1. Please explain the mandate/business model of your company.

2. If possible, please provide a snapshot of the livestock market in your region/district. Which is the most important source of livestock for human consumption and income generation?

B. Consumption vs. Animal Feed Consumption

1. Among the grain produced in your district, what percentage of the grain (maize and groundnuts) ends up as livestock feed? What percent is used for human consumption?

2. Does this vary by region? How so?

3. What is the daily intake of crop by livestock?

4. Is silage also given to livestock?

5. Do farmers feed the contaminated crop to livestock (how much)?

C. Knowledge of Aflatoxin Standards

1. Are there standards for aflatoxins in animal feed?

2. If yes, to what extent are they followed, and who enforces them?

3. Do large-scale livestock entrepreneurs know about the risks of aflatoxins in animal feed? Are they doing anything to mitigate them?

4. Do they believe they have suffered economic losses in animal productivity due to aflatoxins?

5. Are they willing to pay for aflatoxin-controlled/regulated animal feed? Why/why not?
6. How much do they say they are willing to pay? Do you know of any marketing firm that has researched how much large firms would pay for aflatoxin-safe feed?

7. Do you use clay binders in your feed to prevent aflatoxin contamination of animals? How much does this cost? What percentage of large-scale livestock companies use this?

D. Economic Impact of Aflatoxin Contamination and Prevention

1. What is the differential price of livestock products that are free of aflatoxins?

2. Do farmers incur any cost for aflatoxin management? If yes, what are these costs?

E. Animal Feed Contamination

1. Do you know of any recent studies/findings on aflatoxin contamination in animal feed? If yes, where?

2. Are any stakeholders doing anything to mitigate aflatoxin contamination in animal feed? If yes, what?

F. Alternative Use

1. Another concern is the increasing practice of using the residue of biofuel for animal feed. As crops raised for biofuel are less likely to have been handled with good agricultural practices, they may be at greater risk for heightened mycotoxin contamination levels. What efforts are currently being made to reduce aflatoxin exposure in animal feed?
Questionnaire for the Ministry of Industry and Trade

A. Background
1. Please describe the mandate of your agency.

B. Withdrawal Questions
1. What percentage of exports is currently rejected (by crop and product) due to aflatoxin (or other) contamination?
2. What happens to the rejected crop and products?

C. Cost of Contaminated Crops on the Export Market
1. What is the export tariff on the crops (maize and groundnut products)?
2. What is the international price of the crop on the world market?

D. Awareness Raising
1. What is the awareness level of the commercial sector (agro-processors) about aflatoxin contamination and methods (through GAP, GMP, and HACCP) to reduce/prevent it?
2. What are current levels of understanding of aflatoxins among traders and industry?
3. Do commercial sector traders grade their commodities? Is there any value for a higher-quality product (that has been tested for aflatoxins)?

E. Raising Consumer Demand for Food Safety
1. Is a consumer awareness campaign for higher food quality needed?
2. Does the public have a sense of food quality? If yes, what does it entail? Does the public care about adoption of the TFDA logo? Does that logo have value?
3. Would a consumer-focused campaign raise demand for foods that have been certified as clean and safe regarding aflatoxins and other contaminants?

F. Potential for Public-Private Partnerships to Improve Food Safety
1. Are there any successful efforts at wide-scale industrial processing efforts in Tanzania? If yes, what are these?
2. What methods do stakeholders see as favorable/promising for processing?
3. Are processors willing to invest in these methods? Are some already investing?
4. Why and how can this investment be promoted and encouraged for scale-up?

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?
Questionnaire for Agricultural Research Experts

A. Background
1. Please describe the mandate of your institution.
2. Is <Name of lead national research organization> involved in any research on bio-controls or aflatoxin controls?

B. Regional Vulnerability
1. Are there areas considered more vulnerable to aflatoxins due to climatic or environmental factors (soil, drought, temperature, humidity, pests)? In these “high-risk” zones or districts, what is the MOA’s resource allocation, including number of staff?
2. Are there other regions of documented high aflatoxin prevalence that need to be prioritized?
3. Are there regions where the population is highly dependent on aflatoxin-susceptible staples?

C. Input Availability
1. How widespread is the availability of insect- or drought-resistant seeds? Fertilizers? Irrigation?
2. What is the availability of soil treatments to prevent aflatoxin growth?
3. What is the awareness of such inputs and their effects on aflatoxin contamination?

D. Willingness to Pay for Preventive Solutions
1. How many farmers are using a soil treatment? How many large-scale, medium-sized, contract, subsistence farmers?
2. Are farmers willing to pay for the aforementioned inputs (insect-resistant seeds, fertilizers, irrigation) if it helps with aflatoxin prevention?
3. Do farmers know/understand the importance of timely harvesting? Do they do this? Why/why not? If they know the risks of aflatoxins, are they more likely to harvest in a timely fashion?

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?
Questionnaire for Food Processors

1. Please describe your company’s business model/product line.

2. Do you know about Tanzania’s aflatoxin standards?

3. Do have your own aflatoxin control procedures? If yes, please describe them.

4. Do you test for aflatoxins among the raw commodities before you buy/sell them?

5. Do you have some in-house aflatoxin testing equipment and procedures?

6. Do you ever send samples for aflatoxin testing by TFDA, the Government Chemist Laboratory Agency, or any other laboratory? Please describe that process.

7. Do you follow Good Manufacturing Protocols (GMP) or a Hazard and Critical Control Point (HACCP) approach for monitoring food quality and aflatoxin contamination?

8. Do you pay for/sell commodities that are known to be without aflatoxin contamination for a higher price? Please describe 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?
Questionnaire for the TFDA Zone Manager and District or Municipal Health Officer

1. Where can/should TFDA or the District Health Department invest more resources to most immediately strengthen/expand its enforcement capacity?

2. Does TFDA or the District Health Department do most of its aflatoxin enforcement through the product and premises registration of agro-processors?

3. Does TFDA or the District Health Department do other types of inspection for aflatoxins at other points of the value chain (e.g., large markets, among traders, in large warehouses)?

4. Does TFDA or the District Health Department follow/enforce GMP and HACCP recommendations as part of its aflatoxin detection mandate?

5. Does TFDA or the District Health Department have sufficient staff and infrastructure to regulate this?

6. Do the TFDA zone office or District Health Department send samples to the national laboratory for aflatoxin testing?

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?
Questionnaire for Farmers’ Cooperatives

A. Background

1. Please describe your cooperative’s mandate.

2. Are there men and women in your cooperative? If yes, please provide the breakdown.

3. Please describe their roles/divisions of labor.

B. Awareness of Aflatoxins

1. What is the awareness level of farmers about aflatoxins? Of subsistence, mid-sized, contract farmers?

2. Do farmers at the community level understand what aflatoxin contamination is and how it is caused?

3. If yes, do farmers’ cooperatives actively engage in aflatoxin mitigation strategies? How?

4. Do men and women get information through different sources?

5. Do extension services reach female farmers?

C. Sorting and Grading

1. Do farmers sort the crops by quality?

2. Would farmers sort if they knew about aflatoxin contamination?

3. Would farmers sell the better quality crop and keep the worse quality crop for consumption?

4. Would farmers discard the contaminated crop (how much)?

5. Would farmers eat the contaminated crop? If yes, would they limit consumption by women and children?

6. Would (or do they) farmers instead direct the contaminated crop to livestock?

7. If farmers sort grains, who is responsible for doing this (men, women, both)?
D. Awareness of Good Agricultural Practices (GAP)

1. Do farmers in your cooperative have a good understanding of GAP (or a similar package of practices)?

2. Is there any incentive to encourage your farmers’ cooperative to use GAP?

E. Behavior Change Opportunities

1. What sources of information do people trust for farming advice?

2. Does this differ for male and female farmers nationally, or in your district (if applicable)?

3. Are farmers aware of the aforementioned recommendations (or similar GAP recommendations) to prevent aflatoxins at the post-harvest stage (e.g., timely harvesting, storing on wooden pallets, using insecticide, sorting grains)? Why/why not?

4. Are farmers willing to adopt some of the basic post-harvest handling practices?

5. If not, how can this awareness and behavior change take place?

6. Do male or female farmers have different willingness to adopt some basic post-harvest practices? If so, why?

F. Input Purchasing among Farmers to Promote Sound Drying and Storage Practices

1. Do farmers actively purchase inputs to promote good drying and storage?

2. How much do they typically pay?

3. Is there access to finance for farmers seeking loans to improve GAP and post-harvest handling options?

4. If they could get a loan, how much would farmers be willing to invest in GAP-related equipment/supplies?

5. Are female farmers able to access loans as easily as men? Do they have different collateral standards for getting a loan?

Thank you for your attention and contribution. Your opinion is very much appreciated. Do you have any other recommendations that you would like to share with us for promoting aflatoxin prevention and control?
Semi-Structured Interview Guide:  
Aflatoxin Country Assessment for Nigeria

Introduction (for use at the beginning of each interview)

- [Welcome and thank informant(s), introduce the interviewer and observer (if applicable), and state the objective of the meeting.] Thank you for speaking with us today about the issue of aflatoxins in your district. Our names are _____ and ______, and we are working with a company called Abt Associates to complete an assessment on aflatoxins. Aflatoxins are an important issue that affect agriculture and food security, trade, and human and animal health. We are therefore interested in learning about your opinions, perspectives and experiences, and recommended action steps for controlling and preventing aflatoxins and promoting food safety in your community. We are conducting this assessment on behalf of the Partnership for Aflatoxin Control in Africa, which is housed in the African Union.

- [Give the justification for the interview.] There are a range of possible ways to prevent or control aflatoxins in food and feed, and we would like your opinion in helping us identify the main challenges and action steps for addressing aflatoxins in your district.

- [Ask permission to use the tape recorder. Use your judgment on whether it is possible to use the recorder; some political officials may not allow it or even want the issue raised.] Your opinion is very important to us. However, it will not be possible to pay attention to what we are discussing and at the same time take detailed notes of what is being said. Therefore, we have brought a tape recorder so that we won’t miss any part of the conversation and so that we can check our notes later on. Is it alright with you if we use the tape recorder? If at any time during the interview you’d like us to stop the tape recorder for a certain portion of the discussion or not transcribe a particular statement, we would be happy to do so.

- [Offer clarification and answer initial questions.] If, at any time, you don’t understand the questions we are asking, please let us know, and we will be happy to try to rephrase the question and clarify our thinking behind it. If there is anything else that you feel is important to tell us that we have not asked, please give us those comments at the end of our discussion. Do you have any questions before we begin?
For each district, please consult with the following groups. Please note: this format requires you to conduct approximately 2 focus group discussions (mothers and farmers) and approximately 28 key informant interviews in 6 days. You may need to split up to accomplish this. You may also find that in some instances (e.g., the input suppliers), two or three key informants may be able to cover all the topics. This can save you time.

State/Local Government/Ward Stakeholders
- State/Local Government Executive Directors (just need to be introduced to the program; no questions)
- State/Local Government Health Officer
- Local/Ward Medical Officer, Nurse, or Nutrition Officer
- State/Local Government Agricultural and Livestock Officers
- State/Local Government Trade Officer
- Agricultural Extension Officers
- State/Local Government or Ward Livestock Experts

Value-Chain Actors
Traders and Marketers:
- 1 Large buyer/seller (if you can find one)
- 1 medium or small buyer/seller of grain or livestock at community markets

Grain Processors:
- Millers (1-2)
- Blenders (if applicable)
- Posho millers (millers who do not sell flour, just milling service) (1)

Warehouses:
- Animal feed suppliers
- Grain Reserve Officer and Warehouse Receipts Officer

Input Suppliers (some providers may sell more than one item; just be sure all items have been asked about):
- Pesticides, insecticides
- Drying equipment
- Storage containers
- Fertilizers
- Seed

Producers:
- Livestock breeders, veterinarians, traders, and feed specialists (poultry, pigs, cattle, and fish)
- Farmers’ cooperatives (1 cooperative; if you cannot find a cooperative, talk with a second farmers’ group)
- Farmers (1–2 focus groups; please talk with women, too, separately is better)

Media:
- Radio station

Consumers:
- Mothers (1 focus group; the health clinic may allow this)
Questionnaire for State/Local Government Health Officers

[Interview 1 per state/local government]

Welcome and Introduction [See above.]

A. Background on Institutional Mandates

1. Please describe the size and scope of your office, the office staff and your mode of operation, and the data and information that you systematically collect and store.

B. Risk and Vulnerability Factors Related to Aflatoxins in Nigeria

[Questions for health officials involved in liver cancer, enteric disease (gut health), and hepatitis B at the national and decentralized levels]

1. What is the (estimated) prevalence of the following diseases in your state/council/ward:
   o HIV/AIDS
   o HBV
   o Liver cancer
   o Enteric disease
   o Child stunting
   o Micronutrient deficiency

2. What percentage of the population is vaccinated against hepatitis B in your jurisdiction?

3. What is the awareness level of general food safety and nutrition in your jurisdiction?

C. Dietary Diversity

4. Are there any populations/groups (e.g., children, women, elderly, rural, poor) that have less access to diverse foods? Which other groups of people may be overly reliant on maize or groundnuts (or other commodities prone to aflatoxin contamination)? Why is this?

5. What can be done to improve dietary diversity among these groups?

D. Stunting and Infant Feeding

1. Though WHO recommends that infants up to 6 months of age be exclusively breastfed, premature introduction to complementary foods is common in Nigeria. This may inadvertently expose infants early in life to aflatoxins, which could lead to child stunting and other problems. What kinds of action steps should be taken to prevent this practice? [Please be as specific as possible. If, for example, “education/awareness raising” is mentioned—please get specific details as to how best to deliver this and with what types of partners, etc.]

   a. Besides early introduction to complementary foods, are there other harmful practices that may be increasing exposure of young infants and children? (e.g., cooking with water that was used for boiling maize)?
b. Is the practice of eating groundnut cake (*kulikuli*), which is a residual from the oil-producing process, common in Nigeria?

c. Is it common to blend maize with groundnut for weaning porridge flour?

d. Do mothers sort grain/groundnuts before making porridge and/or food?

2. How many people in your department are working on issues of child stunting? Do they discuss food safety as a possible contributing factor affecting stunting? Why/why not?

3. In your opinion, how can the district health offices and district agriculture offices work together to promote nutrition, health and food safety? Please be as specific as possible.

4. Are there other stakeholders/researchers or practitioners currently investigating the relationship between aflatoxin exposure and HIV/AIDS, HBV, tuberculosis, liver cancer, and enteric diseases in within Nigeria/your state/your local council?

**E. Political Will and Communication**

1. How much priority do health officers give to issues of aflatoxins in your district?

2. How much of your department’s revenue/income is budgeted for issues of aflatoxins/health and food safety?

3. What ongoing initiatives are there to communicate with the public about the problem of aflatoxins (or food safety and food hygiene)?

4. How can the local health office work more closely with communities to reduce aflatoxin exposure in foods?

5. Can you provide us with any specific recommendations on how to effectively raise awareness/promote consumption of diverse foods and exclusive breastfeeding for children under 6 months? (Both of these are strategies to reduce exposure.)

6. What other stakeholders within your department or community are in a position to help promote behavior change communication or awareness raising about aflatoxins?

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?
Questionnaire for Local/Ward Medical Officers, Nurses, and Nutrition Officers

[Interview 1 per local government area]

A. Risk and Vulnerability Factors Related to Aflatoxins in Nigeria

1. What is the estimated prevalence of the following diseases in your district:
   a. HIV/AIDS
   b. HBV
   c. Liver cancer
   d. Enteric disease
   e. Child stunting
   f. Micronutrient deficiency

2. Are there any groups that are more vulnerable/susceptible to the issues mentioned above in your local government? Why?

3. What percentage of the population in your jurisdiction is vaccinated against hepatitis B?

4. What is the awareness level of general food safety and nutrition on your topical area of health?

5. Which types of organizations (if any) talk about food safety in your jurisdiction?

B. Dietary Diversity

1. Are there any populations in your area that are overly reliant on maize or groundnuts (or other commodities prone to aflatoxin contamination)? Why is this?

2. What can be done to increase dietary diversity among these vulnerable groups?

3. What can be done to improve dietary diversity generally?

4. Typically in households in your area, who decides who eats what? Are the grain, meat, eggs, and milk shared equally by all household members? Do children get what they need first with the rest divided between men and women? Or do men eat first and women eat what is left over? [Try to get an idea of the amount of maize/groundnuts/eggs/milk that the children, men, and women in a household typically eat.]

5. In what types of households do the women and children get less than what they need?

C. Stunting and Infant Feeding

1. Though WHO recommends that infants up to 6 months of age be exclusively breastfed, premature introduction to complementary foods is common in Nigeria. This may inadvertently expose infants early in life to aflatoxins, which could lead to child stunting
and other problems. What kinds of action steps should be taken to prevent this practice? [Please be as specific as possible. If, for example, “education/awareness raising” is mentioned—please get specific details as to how best to deliver this and with what types of partners, etc.]:

a. Besides early introduction to complementary foods, are there other harmful practices that may be increasing exposure of young infants and children? (e.g., cooking with water that was used for boiling maize)?

b. Is the practice of eating groundnut cake (kulikuli), which is a residual from the oil-producing process, common in Nigeria?

c. Is it common to blend maize with groundnut for weaning porridge flour?

d. Do mothers sort grain/groundnuts before making porridge and/or food?

2. Can you provide us with any specific recommendations for how to effectively raise awareness/promote consumption of diverse foods, and exclusive breastfeeding for children under 6 months? (Both of these are strategies to reduce exposure).

3. What other stakeholders within your department or community are in a position to help promote behavior change communication or awareness raising about aflatoxins?

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?
Questionnaire for State/Local Government Agricultural and Livestock Officers

[Interview 1-2 per state/local government]

A. Background on Institutional Mandates

1. Please describe your department mandate and how it fits into the regional/state/local government structure of agriculture, the size and scope of your office, the office staff and your mode of operation, and the data and information that you systematically collect and store.

2. What are the main priorities of the state/local government agriculture/livestock officer?
   a. What is your role in facilitating access to subsidized inputs?
   b. Do you think that all the needy households have access to the subsidized inputs?
   c. In your views, do you think the subsidy system has increased crop production in your area?

3. Is your state/local government prone to droughts, pest stress, or moisture/rainfall during harvest? Is fungus a common problem during harvest?

4. Do you focus on aflatoxin control/prevention in your state/local government?

5. What is the current level of knowledge of Good Agricultural Practices (GAP) among cooperatives? Among rural farmers?

6. How can the state/local government agricultural agency raise awareness and promote GAP among farmers? In other words, what is the best way to raise awareness and encourage purchase and use of effective or improved drying methods, storage methods, and sorting/grading to mitigate aflatoxin contamination?

B. Financing

1. Does the state/local government agricultural office encourage 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? If yes, how?

2. Are there financing services that enable farmers to purchase these inputs? If yes, are these services successful? Are both men and women able to access them? Can they be made more effective at empowering farmers to buy needed inputs (e.g., pesticides, insecticides)?

C. Information Dissemination

1. Are there different ways in which recommended agricultural practices for aflatoxin mitigation should be promoted among female and male farmers?
2. Are there different channels/sources of information or different networks that should be used to engage female farmers?

D. Livestock

1. In your estimation, what proportion of maize and groundnuts are used for animal feed?

2. Which types of livestock (poultry, fisheries, piggeries, cattle) are most important for livelihood in this state/local government?

3. Are aflatoxins a problem for these industries?

4. What is the level of awareness about aflatoxin among livestock farmers? How does that compare with agricultural farmers?

5. Are there many large-scale commercial livestock or commodities farmers in this state/local government? Please describe their volume/size/capacity and knowledge of aflatoxins.

6. What are the commonly used animal feeds in this state/local government? Do any of these types of feeds contain maize bran or groundnut cake?

7. What type of feeding regimes does your office promote by types of livestock?

8. Which type of livestock in your area is more susceptible to aflatoxin contamination?

9. Does your office promote use of binders to prevent aflatoxins from harming the livestock? Please explain why or why not.

10. What do farmers typically feed their livestock, by type of livestock?

E. Economic and Pricing Factors of Aflatoxins in Maize and Groundnut

[For all questions below, ask separately by key commodities of economic/nutrition interest that are also aflatoxin susceptible (maize and groundnuts).]

6. Do farmers sort grain/commodities by quality? [Ask separately for each commodity (e.g., maize, groundnuts).]

7. Is there a difference in the price for grain based on quality in the local market?

8. What about other markets? [Find out the types of markets.]

9. Is there any market where farmers find a higher price for better quality?

10. What types of quality factors carry the most value (e.g., grain with chaff or without chaff, sorted, disease-free, size of grain)?
11. 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).

12. Do markets test for aflatoxins? Do you know anyone in the commodity market who does?

13. Is there a higher price for aflatoxin-free maize and groundnut? What is the price difference?

14. Can you provide us with any specific recommendations for how to effectively raise awareness/promote action steps to prevent aflatoxins from getting into the food supply?

15. What other stakeholders within your department or community are in a position to help promote behavior change communication or awareness raising about aflatoxins?

16. Have you had problems with aflatoxins in your raw material or finished product before? If yes, what steps did you take?

17. Do you have any HACCP program or procedure in place to monitor aflatoxins and take appropriate step if present in commodities?

18. Are the procedures written or verbal? If written, may we please have a copy?

19. Moisture content affects aflatoxin proliferation. Do you monitor moisture content during storage?

20. Insect-damaged products are easily affected by aflatoxins. Do you have any practice of fumigation to prevent damages to grains?

21. Do you accept insect damaged grains for production?

22. Is there any government agency that monitors your raw materials or finished product for aflatoxins?
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?
Questionnaire for the State/Local Government Trade Officer

[Interview 1 per state/local government]

A. Background on Institutional Mandates

1. Please describe your department mandate and how it fits into the regional/state/local government structure of administration, the size and scope of your office, the office staff and your mode of operation, and the data and information that you systematically collect and store.

2. What are the main priorities of the state/local government trade office?

3. What is your role in facilitating access to markets?

4. Do you think that all the producers and traders have access to the international and national markets?

5. Are you aware of any standards for agricultural commodities for domestic consumption?

6. Should there be?

7. How would these be enforced?

8. Is your office working in collaboration with the Standards Organization of Nigeria? How do you support standardization of compliance of products to SON standards?

9. Are sellers aware that their products must conform to standards before exporting them?

10. What is the current level of knowledge of food and feed standards among sellers and buyers of agricultural products or inputs?

11. How can your office raise awareness about food, feed, and input standards? In other words, what is the best way to raise awareness and encourage sale and purchase of products that comply with standards?

12. Do you focus on aflatoxin control/prevention in your efforts to require compliance with standards?
B. Economic and Pricing Factors of Aflatoxins in Maize and Groundnuts

1. Please describe which types of buyers/sellers come to this district (e.g., subsistence, commercial)?

2. Do farmers sort grain/commodities by quality? [Ask separately for each commodity (e.g., maize, groundnuts).]

3. Is there a difference in the price for grain based on quality in the local market?

4. What about other markets? [Find out the types of markets.]

5. Is there any market where farmers find a higher price for better quality?

6. What types of quality factors carry the most value (e.g., grain with chaff or without chaff, sorted, disease-free, size of grain)?

7. 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).

8. Does any buyer that you know of test for aflatoxins? Do you know anyone in the commodity market who does?

9. If yes, what happens if crops are found to be highly contaminated with aflatoxins? Or other contaminants?

10. Is there a higher price for aflatoxin-free maize and groundnut? What is the price difference?

11. Does the market have vendors of pesticides, wooden pallets, field implements, and storage bags to increase quality of commodities sold?

12. What are the prices for these items?

13. Are any traders complaining of failure to access markets due to the poor quality of the products they sell?
15. Can you provide us with any specific recommendations for how to effectively raise awareness/promote consumer value for high-quality (safe) foods?

16. What other stakeholders within your community are in a position to help promote behavior change communication or awareness raising about aflatoxins?

17. What is the cost of grading maize/groundnuts?

C. Access to Markets

1. What types of markets do the farmers sell their grain to?
2. Is there anyone selling to the formal export market?
3. What are the barriers to selling to export markets in your view?
4. Is anyone selling to the informal export market?
5. Is there a price differential in the export markets as compared to domestic markets? If yes, what is it?

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?
Questionnaire for Agricultural Extension Officers

[Interview 1-2 per state/local government. Note, this form is long. Feel free to interview 2 separate officers to complete the form.]

Other stakeholders with whom this guide can be used:
- Good Agricultural Practices experts
- General Agriculture officers
- Agricultural extension officers (ward-level)

A. Background
1. Please describe your role and mandate. Please describe your department mandate and how it fits into the regional/state/local government structure of agriculture. Please describe the number and scope of the extension agents. How do you and the other agents operate? Are there data and information that you systematically collect and store related to food quality, volume, or problems that farmers may have?

2. Does that role include ensuring quality standards both to meet requirements of other markets (national and export) and for food safety? What about aflatoxin control/prevention?

3. What is the current level of knowledge of Good Agricultural Practices (GAP)? Among cooperatives? Among rural farmers? [Ask the question in the context of maize, groundnuts, and/or other crops that might be important (e.g., bush mango seeds, melon).]

4. What is the current level of knowledge of aflatoxins among the farmers that you work with?

5. How can the state/local government-level agricultural agency raise awareness and promote GAP among farmers? In other words, what is the best way to raise awareness and encourage purchase and use of effective or improved drying methods, storage methods, and sorting/grading to mitigate aflatoxin contamination?

6. Does your agency encourage 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? If yes, how?

7. In your state/local government/ward, are there financing services that enable farmers to purchase these inputs? If yes, are these services successful? Are both men and women able to access them? Can they be made more effective at empowering farmers to buy needed inputs (e.g., pesticides, insecticides)?

8. Do you have any recommendations for reaching female farmers with GAP information? Or encouraging them to purchase inputs to improve quality?
B. Pre-Harvest Handling Questions

1. 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 costs about US$15 (2400 Naira) per hectare, would farmers buy it? What if it was $10 (1600 Naira) or $8 (1200 Naira)?

2. How would you recommend that it be marketed or sold?

3. What would need to be done to get farmers to use this pre-harvest treatment?

C. Post-Harvest Handling Questions

[Ask the personnel in the post-harvest management unit of MOA.]

1. What types of storage practices are prevalent? What structures are used more commonly?

2. Why are these storage practices preferred to others?

3. What is the price of these storage structures (by type of structures)? [This question helps us determine what the difference in cost is between storage structures that are recommended for aflatoxins and those that are not.]

4. Do the storage practices vary by region? If yes, can you describe what types of drying and storage practices are used in your region?

5. 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 Nigeria and/or your state/local government? Why/why not?

6. Are these practices feasible at the farm level? Why?

7. How much would this package of materials (jute bags, wooden pallets, and insecticides) cost in your community? Is that affordable?

8. Do male and female farmers have different storage practices?

9. Do they have different abilities to pay for inputs?
D. Availability of Inputs for Storage and Drying in the Rural Area

1. Are there any input suppliers in the rural areas selling the above?

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?)

4. Are there any inputs that are harder to obtain than others?
   a. Do you know of any program in Nigeria that provides subsidized farming inputs to poor or needy households?
   b. In your view, can a subsidy program work to encourage the poor to buy safe drying and storage structures for their harvest to prevent aflatoxin contamination (and other pre-/post-harvest problems)? Why/why not?

E. Information Dissemination

1. Are there different ways in which recommended agricultural practices for aflatoxin mitigation should be promoted among female and male farmers?

2. Are there different channels/sources of information or different networks that should be used to engage female farmers?

3. Can you provide us with any specific recommendations for how to effectively raise awareness about the dangers of aflatoxin contamination?

4. What other stakeholders within your department or community are in a position to help promote behavior change communication or awareness raising about aflatoxins?

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

[For all questions below, ask separately by key commodities of economic/nutrition interest that are also aflatoxin susceptible (e.g., maize, groundnuts, and cashews).]

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?

3. What about other markets? [Find out the types of markets.]
4. Is there any market where farmers find a higher price for better quality?

5. What types of quality factors carry the most value (e.g., grain with chaff or without chaff, sorted, disease-free, size of grain)?

6. 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).

7. Do markets test for aflatoxin contamination? Do you know anyone in the commodity market who does?

8. Is there a higher price for aflatoxin-free maize and groundnut? What is the price difference?

9. Can you provide us with any specific recommendations for how to effectively raise awareness/promote consumer value for high quality (safe) foods?

10. What other stakeholders within your community are in a position to help promote behavior change communication or awareness raising about aflatoxins?

11. What is the cost of sorting maize/groundnuts? [Ask by crop.]

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?
Questionnaire for State/Local Government or Ward and Commercial Sector Livestock Experts

[Interview the following experts: Poultry raising (1), piggery breeding (1), fisheries breeding (1), veterinarian expert (1), meat inspectors (1)]

A. Background

1. Please describe your department mandate and how it fits into the regional/state/local government structure of agriculture, the size and scope of your office, the office staff and your mode of operation, and the data and information that you systematically collect and store.

2. If possible, please provide a snapshot of the livestock market in your regional/state/local government. Which is the most important source of livestock for human consumption and income generation?

B. Consumption vs. Animal Feed Consumption

1. Do farmers use maize (or other crops) for feed? What type of animals (cattle, pigs, poultry, fish) are fed these?

2. What percentage of maize (or other crops) in the country (district, region) is used as livestock feed?

3. What percentage of feed given to livestock is maize? [We need to determine the volume of maize/groundnuts going to this sector.]

4. What is the average daily intake of crop by livestock? Does this vary by region and breed?

5. Is silage also given to livestock?

6. Is it common for farmers to feed the contaminated (or spoiled) crop to livestock (how much)?

7. Is your industry aware of aflatoxin standards?

C. Knowledge of Aflatoxin Standards

1. Are there standards for aflatoxins in animal feed? If yes, to what extent are they followed and who enforces them?
2. Do large-scale livestock entrepreneurs know about the risks of aflatoxins in animal feed? Are they doing anything to mitigate it?

3. Have you, or other livestock growers you know, suffered economic losses in animal productivity? What have been the reasons for these productivity losses, in your view?

4. Are you, or other livestock growers you know, willing to pay for aflatoxin-controlled/regulated animal feed? Why/why not?

5. How much would you be willing to pay for aflatoxin-controlled/regulated animal feed?

6. Do you know of any marketing firm that has researched how much large firms would pay for aflatoxin-safe feed?

7. Do you use clay binders in your feed to prevent aflatoxin contamination of animals? How much does this cost? What percentage of large-scale livestock companies use this?

D. Economic Impact of Aflatoxin Contamination and Prevention

1. What is the differential price of livestock products that are free of aflatoxin?

2. Do you know of any stakeholders that are working toward mitigating aflatoxin contamination in animal feed? If yes, which stakeholders and what are they doing?

E. Alternative Use Questions

1. Is there a market in Nigeria for biofuel made from contaminated grain?

2. One concern among aflatoxin experts is the practice of using the residue of biofuel for animal feed. As crops raised for biofuel are less likely to have been handled with good agricultural practices, they may be at greater risk for heightened mycotoxin contamination levels. What efforts are currently being made to reduce aflatoxin exposure in animal feed?

3. One firm in the United States (Monsanto) has discovered that it can use some aflatoxin-contaminated grains as finishing feed for beef cattle (up to 300 ppb) as an alternative use for contaminated grain.\footnote{http://www.ncga.com/production/35-mycotoxins-acceptable-aflatoxin-amp-fumonisin-levels-for-feed/} Is there a market for this in Nigeria? Are some of the livestock growers using this tactic for lower-priced feed?
4. Can you provide us with any specific recommendations for how to effectively raise awareness/promote use of aflatoxin-safe feeds?

5. What other stakeholders within your department or community are in a position to help promote behavior change communication or awareness raising about aflatoxin?

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?
Questionnaire for Traders and Marketers of Maize and Groundnut

[Interview 1-2 at the ward/rural level]

[For all questions below, ask separately by key commodities of economic/nutrition interest that are also aflatoxin susceptible (e.g., maize, groundnuts, and cashews).]

A. Economic and Pricing Factors of Aflatoxins in Maize and Groundnut

1. Please describe which types of buyers/sellers come to this market (e.g., subsistence, commercial)?

2. Do farmers sort grain/commodities by quality? [Ask separately for each commodity (e.g., maize, groundnuts).]

3. What is the cost of sorting maize/groundnuts? [Ask by crop.]

4. Is there a difference in the price for grain based on quality in the local market?

5. What about other markets? [Find out the types of markets.]

6. Are there any markets where there is higher price for better quality? Which ones?

7. What types of quality factors carry the most value (e.g., grain with chaff or without chaff, sorted, disease-free, size of grain)?

8. 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).

9. Do you wash visibly moldy foods, dry and resell to members of the public, or do you sometimes cut and boil them?

10. Does any buyer that you know of test for aflatoxin contamination? Do you know anyone in the commodity market who does?

11. If yes, what happens if crops are found to be highly contaminated with aflatoxins? Or other contaminants?
12. Is there a higher price for aflatoxin-free maize and groundnut? What is the price difference?

13. Does the market have vendors of pesticides, wooden pallets, field implements, and storage bags to increase quality of commodities sold?

14. What are the prices of these items? Can you provide us with any specific recommendations for how to effectively raise awareness/promote consumer value for high-quality (safe) foods?

15. What other stakeholders within your community are in a position to help promote behavior change communication or awareness raising about aflatoxins?

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?
Questionnaire for Millers and Blenders

[1-2 per state/local government]

[For all questions below, ask separately by key commodities of economic/nutrition interest that are also aflatoxin susceptible (e.g., maize, groundnuts, and cashews).]

A. Economic and Pricing Factors of Aflatoxins in Maize and Groundnut

1. Please describe which types of buyers/sellers come to this market (e.g., subsistence, commercial).

2. Which commodities do you typically mill/blend? [List ingredients for blenders.]

3. Where do you buy your commodities?

4. How much do you pay for the different types of commodities? [List main commodities and price/unit of each.]

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5. Is there a difference in the price for grain based on quality in the local market?

6. Do you sort the grain? What is the cost of sorting? [Ask by crop.]

7. What types of quality factors carry the most value (e.g., grain with chaff or without chaff, sorted, disease-free, size of grain)?

8. 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).

9. Which types of characteristics of quality do you look for when deciding to make a purchase (e.g., price for large grain, price for grain with chaff)?

10. What do you do if you find maize that is moldy among the commodities that you have purchased? Do you wash, cut, or boil it?
11. Is there a higher price for mold-free maize? Uncracked or spoil-free groundnut? What is the price difference?

**Additional Questions for Millers**

1. To whom do you sell your products? *[Ask by products and by type of customers.]*

2. Do you give any recommendations to mothers on how to use the flour?

**Additional Questions for Blenders**

1. How much can you sell your products for?

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2. How do you store the grain/flour that comes in? For how long? *[Please try and see the storage containers and areas if possible and observe the quality of the grain that comes in.]*

3. To whom do you sell the bran (or what do you do with it)? What is the price of the bran?

4. From whom do you buy the grain? *[If the informant says traders and farmers, then ask the following question.]* Is there a difference in quality of the grain that comes from traders?

5. What size packets do you sell the grain in?

6. How do you process it? What sorting and grading do you do in that process?

7. What is the cost of sorting maize/groundnuts? *[Ask by crop.]*

8. What are the ingredients in the blending, and in what proportion?

9. From whom do you buy the ingredients? What quality do you look for?

10. Is there a different price for the ingredients based on the quality?

11. How do you ensure that the raw material is dry enough?

12. What do you do with bran/broken grain?
13. Who buys the blended products from you? [For women customers, ask by economic status.]

14. Do you give any recommendations to mothers on how they should use the blended flour? What are these use recommendations?

15. What is the quantity of sale by month/year?

16. Are you aware of aflatoxins? If yes, through whom? [If they mention training, ask who gave it.]
   How/where did you get this information?

17. What are the sources of information that you trust?

18. Have you gotten approval from SON/NAFDAC to do the milling/blending? If yes, when? If no, why not?

Thank you for your attention and contribution. Your opinion is very much appreciated. Do you have any other recommendations that you would like to share with us for promoting aflatoxin prevention and control?
Questionnaire for Posho Millers (or millers who do not sell flour but just sell milling service)

[1 per local government]

[For all questions below, ask separately by key commodities of economic/nutrition interest that are also aflatoxin susceptible (e.g., maize, groundnuts, and cashews).]

Economic and Pricing Factors of Aflatoxins in Maize and Groundnut

1. Please describe which types of buyers/sellers come to this mill (e.g., subsistence, commercial).

2. Which commodities do you typically mill?

3. What is the price you charge for milling?

4. What quality of maize/grain do you get for milling?

5. Do you recommend any sorting of maize that looks infested?

6. What is the cost of sorting maize/groundnuts? [Ask by crop.]

7. Do you store any grain/flour on the premises? If yes, how long and in what storage?

8. What do you do with the bran?

9. What type of storage do the farmers put maize in?

10. Does anyone ask for milling the whole grain? How many out of 10 customers who may come to you daily would ask for milling the whole grain?

11. How much do you charge for the different types of commodities? [List main commodities and price/unit of each.]

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12. Is there a difference in the price for grain based on quality in the local market?

13. What types of quality factors carry the most value? For example, grain with chaff or without chaff, sorted, disease-free, size of grain.

14. 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).

15. Which types of characteristics of quality do you look for when deciding to make a purchase (e.g., price for large grain, price for grain with chaff)?

16. What do you do if you find maize that is moldy among the commodities that you have purchased?

17. Is there a higher price for mold-free maize? Uncracked or spoil-free groundnut? What is the price difference?

[If respondent is a blender ask: ]

18. How much can you sell your products for?

Thank you for your attention and contribution. Your opinion is very much appreciated. Do you have any other recommendations that you would like to share with us for promoting aflatoxin prevention and control?
Questionnaire for Animal Feed Suppliers

[Interview a supplier of feed for each type of livestock; or 2 suppliers who may cover all types of livestock]

[For all questions below, ask separately by animal feed for each type of livestock: cattle, pigs, poultry, and fish.]

A. Background

1. In your estimation, what proportion of maize and groundnuts are used for animal feed?

2. What is the composition of feed by type of livestock?

3. What are the standards that are applicable to feed?

4. Where do you buy your grain (maize and/or groundnuts)? What quality standards do you apply to it? [Talk in detail about the type of ways in which they distinguish quality (e.g., size of grain, color).]

5. What is the price of the grain that you buy? Does it vary by quality? What is the price by quality?

6. How much do you pay for the different types of commodities? [List main commodities and price/unit of each.]

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7. What is the best-selling type of animal feed by livestock?

B. Knowledge of Aflatoxins

8. Are aflatoxins something that you worry about in your industry?

9. If yes, why? Please explain why you suspect/know that aflatoxins are a problem?

10. What do you do to mitigate the problem among your livestock?

11. Have you suffered economic losses in animal productivity? What in your view has been the reason for these productivity losses?
12. Have you had any training on aflatoxin/quality standards? If yes, when?

13. Are any animal feed suppliers doing anything to mitigate aflatoxin contamination in animal feed? If yes, what?


15. How much would you be willing to pay?

16. Do you use clay binders in your feed to prevent aflatoxin contamination of animals? How much does this cost? What percentage of large-scale livestock companies use this?

17. Have there been any productivity losses that have been linked to animal feed quality?

C. Alternative Use

1. Another concern is the increasing practice of using the residue of biofuel for animal feed. As crops raised for biofuel are less likely to have been handled with good agricultural practices, they may be at greater risk for heightened mycotoxin contamination levels. What efforts are currently being made to reduce aflatoxin exposure in animal feed?

2. One firm in the United States (Monsanto) has discovered that it can use some aflatoxin-contaminated grains as finishing feed for beef cattle (up to 300 ppb) as an alternative use for contaminated grain. Is there a market for this in Nigeria? Are some of the livestock growers using this tactic for lower-priced feed?

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

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2 http://www.ncga.com/production/35-mycotoxins-acceptable-aflatoxin-amp-fumonisin-levels-for-feed/
Questionnaire for the Grain Reserve Officer and Warehouse Receipts Officer

[Interview 1]

[Ask separately for maize, groundnuts, and any other important commodity; for example, cashew in Nigeria.]

A. Background of the Warehouse/Grain Reserve

1. Please describe the role of the grain reserve/warehouse receipts system.

2. Where do you source your commodities from?

3. What volume do you store?

4. How long do you typically store it?

5. For whom do you store the crops?

6. Do you have a procedure that you use to manage the warehouse? May we see it?

7. Does anybody come out here to inspect your warehouse/grain reserve?

B. Pricing Differentials for Contaminated vs. Non-Contaminated Foods

1. Do farmers sort grain/commodities by quality? [Ask separately for each commodity (e.g., maize, groundnuts).]

2. What is the cost of sorting maize/groundnuts? [Ask by crop.]

3. Is there a difference in the price for grain based on quality in the local market?

4. What about the general market?

5. Is there any market where farmers find a higher price for better quality?

6. What types of quality factors carry the most value? For example, grain with chaff or without chaff, sorted, disease-free, size of grain.

7. 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).
8. Do markets test for aflatoxins? Do you know anyone in the commodity market who does?

9. Is there a higher price for aflatoxin-free maize and groundnut? What is the price difference?

[Skip next set of questions if respondent is not a warehouse manager.]

C. Warehouse Management Practices

5. Do you test for moisture before taking in grain?

6. What do you do if you find wet grain (above 15% moisture)?

7. What moisture levels of grain are you willing to accept?

8. Do you inspect grain for mold or other contaminants before you accept it?

9. Are there sellers of dryers? Where? How much do they cost? Do communities buy these?

10. Are there any successful methods of community storage (and drying) and warehouse management?

D. General Awareness of GAP

5. What is the current level of knowledge of Good Agricultural Practices (GAP) among people working at the grain reserve?

6. Is there any incentive to encourage farmers’ cooperatives to use GAP? Please explain.

7. Do GAP include all the measures for aflatoxin prevention, control, or mitigation from the farmer’s perspective?

8. Are there any elements of the GAP that need to be emphasized to encourage aflatoxin control and prevention among farmers?

Thank you for your attention and contribution. Your opinion is very much appreciated. Do you have any other recommendations that you would like to share with us for promoting aflatoxin prevention and control?
Questionnaire for Input Suppliers

[Interview 3-4 suppliers or until you have covered each of the inputs below]

[Use this form to talk with at least 1-2 commercial vendors of:

- Insecticides
- Pesticides
- Drying equipment
- Storage containers
- Fertilizers
- Seed]

A. Background

1. Please describe your company’s business products. What do you sell?

2. What is your average sales volume by product for each type of crop?

3. What is your typical selling price? [Ask by product.]

4. Please describe your customer base. What percentage of your customers do you think are small, mid-sized, and larger farmers?

B. Awareness of GAP

1. Do you think your customers have a good understanding of good agricultural practices (or a similar type package of practices?)

2. Is there any incentive to encourage farmers’ cooperatives to use GAP?

3. Are customers aware of quality standards? How do they know about this?

C. Behavior Change Opportunities

1. What sources of information do people trust for farming advice for inputs/supplies?

2. Does this differ for male and female farmers?

3. What is the best way to promote purchase/appropriate use of your product in order to promote crop/commodity quality?

4. What tactics can be used to motivate farmers to be informed and adopt GAP if using products like yours?
D. Input Purchasing among Farmers to Promote Sound Drying and Storage Practices

1. Is there access to financing for farmers seeking to buy your products so they can improve GAP and post-harvest handling options?

2. If they could get a loan, how much would farmers be willing to invest in GAP-related equipment/supplies?

3. Are female farmers able to access loans as easily as men? Do they have different collateral standards for getting a loan?

4. Do farmers invest loan amounts in farming or other ventures?

5. Do farmers pay back loans after harvesting to ensure continued access to loan facilities?

6. Do farmers think it will be profitable if they invest the loan amounts in GAP?

7. How can farmers be encouraged to invest in GAP?

8. Do male and female farmers have different willingness to purchase your product?

E. Awareness Level of Quality Standards and Aflatoxin Standards

1. Are you aware of quality standards in feed? What are the standards that you adhere to?

2. What is the awareness of quality standards among your customers?

3. Do you know about the aflatoxin standards in animal feed products?

4. What is the awareness level of aflatoxins among the customers you identified above?

5. Do you think your customers know that your products can be helpful in preventing/mitigating aflatoxins?
6. How do your customers know about your products?

7. Do men and women get information through different sources?

Thank you for your attention and contribution. Your opinion is very much appreciated. Do you have any other recommendations that you would like to share with us for promoting aflatoxin prevention and control?
Questionnaire for Livestock Suppliers

[Interview 1 supplier from each industry (poultry/pig/cattle/fish) per state/local government]

[For use with breeders, veterinarians, traders, feed specialists working in the following small, medium, and large commercial sector operations:

- Poultry farms
- Piggeries
- Cattle farms
- Fisheries]

A. Background

1. Please explain your company’s business model.

2. What volume of livestock do you buy/sell per year?

3. What volume of grain goes to feed?

B. Animal Feed Contamination

1. How much do you typically pay for feed per metric tonne (or other unit)?

2. Please describe the feed composition by type of livestock, and the average price for each.

C. Knowledge of Aflatoxins

1. Are aflatoxins something that you worry about in your industry?

2. If yes, why? Please explain why you suspect/know that aflatoxins are a problem?

3. What do you do to mitigate the problem among your livestock?

4. Have you suffered economic losses in animal productivity due to aflatoxins?

5. Have you had any training on aflatoxin QUALITY standards? If yes, when?

6. Are any animal feed suppliers doing anything to mitigate aflatoxin contamination in animal feed? If yes, what?
7. Are you willing to pay for aflatoxin-controlled/regulated animal feed? Why/why not?

8. How much would you be willing to pay?

9. Do you use clay binders in your feed to prevent aflatoxin contamination of animals? How much does this cost? What percentage of large-scale livestock companies use this?

10. Have there been any productivity losses that have been linked to animal feed quality?

D. Alternative Use

1. Another concern is the increasing practice of using the residue of biofuel for animal feed. As crops raised for biofuel are less likely to have been handled with good agricultural practices, they may be at greater risk for heightened mycotoxin contamination levels. What efforts are currently being made to reduce aflatoxin exposure in animal feed?

2. One firm in the United States (Monsanto) has discovered that it can use some aflatoxin-contaminated grains as finishing feed for beef cattle (up to 300 ppb) as an alternative use for contaminated grain. Is there a market for this in Nigeria? Are some of the livestock growers using this tactic for lower-priced feed?

Thank you for your attention and contribution. Your opinion is very much appreciated.

Do you have any other recommendations that you would like to share with us for promoting aflatoxin prevention and control?

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Questionnaire for Farmers’ Cooperatives

[1 per state/local government]

A. Background
1. Please describe your cooperative’s mandate.
2. Are there men and women in your cooperative? If yes, please provide the breakdown.
3. Please describe their roles/divisions of labor.

B. Sorting and Grading
1. Do farmers sort the crops by quality?
2. What is the cost of sorting maize/groundnuts? [Ask by crop.]
3. Would farmers sort if they knew about aflatoxin contamination?
4. Would farmers sell the better quality crop and keep the worse quality crop for consumption?
5. Would farmers discard the contaminated crop (how much)?
6. Would farmers eat the contaminated crop? If yes, would they limit consumption to women and children?
7. Would (or do they) farmers instead direct the contaminated crop to livestock?
8. If farmers sort grains, who is responsible for the sorting (men, women, children, all)?

C. Awareness of GAP
1. Do farmers in your cooperative have a good understanding of good agricultural practices (or a similar type package of practices?)
2. Is there any incentive to encourage farmers' cooperatives to use GAP?
D. Behavior Change Opportunities

1. What sources of information do people trust for farming advice?

2. Does this differ for male and female farmers nationally, or in your state/local government (if applicable)?

3. Are farmers aware of the aforementioned recommendations (or similar GAP recommendations) to prevent aflatoxins at the post-harvest stage (e.g., timely harvesting, storing on wooden pallets, using insecticide, sorting grains)? Why/why not?

4. Where did they learn this?

5. Are farmers willing to adopt some of the basic post-harvest handling practices?

6. If not, how can this awareness and behavior change take place?

7. Do male or female farmers have different willingness to adopt some basic post-harvest practices? If so, why?

E. Input Purchasing among Farmers to Promote Sound Drying and Storage Practices

1. Do farmers actively purchase inputs to promote good drying and storage?

2. How much do they typically pay?

3. Is there access to finance for farmers seeking loans to improve GAP and post-harvest handling options?

4. If they could get a loan, how much would farmers be willing to invest in GAP related equipment/supplies?

5. Are female farmers able to access loans as easily as men? Do they have different collateral standards for getting a loan?

F. Awareness of Aflatoxins

1. What is the awareness level of farmers about aflatoxins?

2. Do farmers at the community level understand what aflatoxins are and how they are caused?
3. If yes, do farmers’ cooperatives actively engage in aflatoxin mitigation strategies? How?

4. Do men and women get information through different sources?

5. Do extension services reach female farmers?

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

[Conduct 1-2 focus groups with farmers per state/local government]

[Please note gender of respondent; always get female perspectives either in the group or separately.]

A. Sorting and Grading

1. Do you typically sort crops by quality?
   a. What factors do you use to sort crops?
   b. Do you get a better price for higher quality crops? Please describe for maize and groundnuts

2. Do farmers in your community typically sell the better quality crop and keep the worse quality crop for consumption?

3. Do farmers discard the contaminated crop (how much of it)?

4. Do farmers eat the contaminated crop? If yes, who in the family would eat the contaminated crop? Will it be equally distributed? Eaten more by women, men or children?

5. Would (or do they) farmers instead direct the contaminated crop to livestock?

6. If farmers sort grains, who is responsible for doing this? (men, women, children (all)?)

7. In your household, who decides who eats what?

8. Are the grain, meat, eggs, and milk shared equally by all household members? Do children get what they need first with the rest divided between men and women? Or do men eat first and women eat what is left over?

9. In times of food shortage, how is the limited food supply shared?

10. [Try to get an idea of the amount of maize, groundnuts, egg, and milk that the children, men, and women in a household typically eat.] In the last 24 hours, how much maize, groundnut, milk, and egg has each of the household family members eaten?
    a. Children under 5?
    b. Children under 2?
c. Children five and over?

   d. Adults (men and women)?

11. In times of food shortage, how is the limited food supply shared?

12. Would you eat food that has fungus? After cleaning it, boiling it, cutting it? Are there only certain times when you do this? When?

B. Awareness of GAP

1. Do farmers in your cooperative have a good understanding of Good Agricultural Practice (or a similar type package of practices?)

2. Is there any incentive to encourage farmers’ cooperative to use GAP?

C. Behavior change opportunities

1. What sources of information do people trust for farming advice?

2. Does this differ for male and female farmers nationally, or in your district (if applicable)?

3. Are farmers aware of the aforementioned recommendations (or similar GAP recommendations) to prevent aflatoxin at the post-harvest stage? (Timely harvest, storing on wooden pallets, using insecticide, sorting grains etc.)? Why/why not?

4. Are farmers willing to adopt some of the basic post-harvest handling practices?

5. If not, how can this awareness and behavior change take place?

6. Do male or female farmers have different willingness to adopt some basic post-harvest practices? If so, why?

D. Input Purchasing among Farmers to Promote Sound Drying and Storage Practices

1. What kind of inputs do you typically purchase to promote good drying and storage?

2. How much do these inputs normally cost?
3. Do you have access to financing/loans to improve GAP and post-harvest handling options?

4. Have you received a loan in the past to invest in GAP-related equipment/supplies? How large a loan are you and people in your community willing to take out to promote better drying/storage? Please explain.

5. Are female farmers able to access loans as easily as men? Do they have different collateral standards for getting a loan?

E. Awareness of Aflatoxins

1. In your community, what is farmers’ general awareness level about aflatoxins?

2. Where do farmers get this information?

3. Do farmers at the community level understand what aflatoxins are and how they are caused?

4. If yes, do farmers’ in your community engage in aflatoxin mitigation strategies? How?

5. Do men and women get information through different sources?

6. Do extension services reach female farmers?

Thank you for your attention and contribution. Your opinion is very much appreciated. Do you have any other recommendations that you would like to share with us for promoting aflatoxin prevention and control?
Questionnaire for the Radio Station

[1 per district]

1. List the name/call number of the station and contact information.

2. Please describe the coverage of your radio station? How many people listen to it? What are the peak hours? What languages do you report in?

3. Do you broadcast stories about health and nutrition?

4. Do you broadcast stories/learning programs about agriculture?

5. Have you ever aired programs on aflatoxins?

6. Has advertising on aflatoxins ever been placed in your radio station?

7. What types of educational programs are the most popular? Why? What makes them successful?

8. Do you have radio-call in programs where people can ask an expert about health, nutrition, or agricultural topics?

9. How much would it cost for an organization to air a 15-minute program on an educational topic during peak hours? Once per month? One per week?

10. Would collaboration with the government allow for the programs to be aired free of charge?

Thank you for your attention and contribution. Your opinion is very much appreciated. Do you have any other recommendations that you would like to share with us for promoting aflatoxin prevention and control?
Questionnaire for Mothers of Children under 5

[1 focus group per state/local government]

A. Consumption Patterns among Children

1. Describe foods eaten by each household member in the last 24 hours and the frequency with which they are eaten. Please describe what the following household members ate:
   a. Children under 5?
   b. Children under 2?
   c. Children 5 and over?
   d. Adults (men and women)?

2. Are the grain, meat, eggs, and milk shared equally by all household members? Do children get what they need first with the rest divided between men and women? Or do men eat first and women eat what is left over?

3. In times of food shortage, how is the limited food supply shared?

4. Would you eat food that has fungus? After cleaning it, boiling it, cutting it? Are there only certain times when you do this? When?

B. Perception of Food Safety

1. What type of foods would you consider to be “good for your child”?

2. Do you ever worry about the food that your child is eating? Why/why not?

3. What do you think about when you think of “good health” for your child?

4. Do you typically buy your own food or eat what you raise at home?

5. If you purchase food, what kinds of foods do you buy? Which foods are considered “good for your child”?

6. Which sources of information do you listen to in order to learn about which foods are “good for your child”?

[If woman is not a farmer—thank respondent and end the interview. For mothers who are farmers, continue.]
C. Perceptions about GAP and Its Effects on Food Safety

1. Have you heard of Good Agricultural Practices? Or in other words, recommendations for preventing bugs in, weeding, drying, storing, and sorting crops?

2. Whose responsibility is it to do the tasks above?

3. Are these considered important tasks? Why/why not?

D. Sorting and Grading

1. Do you typically sort crops by quality?
   a. What factors do you use to sort crops?
   b. Do you get a better price for higher quality crops? Please describe for maize and groundnuts.

2. If farmers sort grains, who is responsible for doing this (men, women, children, all)?

3. What is done with the grain that is considered of poor/lower quality?

E. Behavior Change Opportunities

1. What sources of information do people trust for farming advice?

2. Does this differ for male and female farmers nationally, or in your district (if applicable)?

3. Are you a member of any savings group through the community development office? How often do you meet there? [The purpose of the question is to determine whether there is an opportunity to use those meetings for behavior change messages.]

Thank you for your attention and contribution. Your opinion is very much appreciated. Do you have any other recommendations that you would like to share with us for promoting aflatoxin prevention and control?
Appendix D – Welfare Impact of Aflatoxin Contamination in the Domestic Market
Appendix D – Welfare Impact of Aflatoxin Contamination in the Domestic Market

This appendix presents a proof that the domestic market impact of aflatoxin contamination is positive. We assume a closed economy where the entire produce is consumed in the domestic market. For simplicity we assume linear demand and supply curves, but the proof is generally applicable for non-linear demand and supply curves.

\[ P(q) \] – denotes the demand for aflatoxin-free (good) maize, which is the same before the product is differentiated because the consumers assume that the available maize is safe for consumption.

\[ S(q) \] – denotes the supply of corn

\[ C(q) = \int_{0}^{q} S(x)dx \], is the cost of producing \( q \) amount of maize

Producer Surplus, with no contamination = \( P(q^0)q^0 - C(q^0) \)

Consumer Surplus, with no contamination = \( \int_{0}^{q^0} P(x)dx - P(q^0)q^0 \)

Total Welfare, with no contamination, \( W^0 = \int_{0}^{q^0} P(x)dx - C(q^0) \) also given by the shaded triangle in below.

Figure D-1 Welfare Impacts with no Aflatoxin Contamination
Case 1: Aflatoxin Contamination with No Market for Bad Maize

We assume that contamination is exogenously determined by environmental conditions. Out of the total production of $q^0$, only $q^G$ is good maize. The remaining bad maize, $q^0 - q^G$, is discarded because of zero demand for bad maize.

Producer Surplus $= P(q^G)q^G - C(q^0)$; the cost of production is the same because the producers planned to produce $q^0$ but part of the produce was bad.

Consumer Surplus $= \int_0^{q^G} P(x)dx - P(q^G)q^G$

Total welfare under case 1, $W^1 = \int_0^{q^G} P(x)dx - C(q^0)$

Loss in welfare from aflatoxin contamination $= W^0 - W^1 = \int_0^{q^0} P(x)dx - \int_0^{q^G} P(x)dx$, which is greater than zero because $q^0 > q^G$ and $P(x)$ is decreasing in $x$.

This loss in welfare is denoted by the green shaded area in Figure B-1.

Case 2: Aflatoxin Contamination with Market for Bad Maize

$P^B(q)$ – denotes the demand for bad maize.

We assume that the demand for bad maize at zero price will be lower than the demand for good maize at zero price, that is:

$$ P^B(0) < P(q^0) $$

Furthermore,

In the good maize market:

Producer Surplus $= P(q^G)q^G - C(q^0)$; the cost of production is the same because the producers planned to produce $q^0$ but part of the produce was bad.

Consumer Surplus $= \int_0^{q^G} P(x)dx - P(q^G)q^G$

In the bad maize market:

Producer Surplus $= P(q^B)q^B$; the cost of production is the same because the producers planned to produce $q^0$ but part of the produce was bad.

Consumer Surplus $= \int_0^{q^B} P^B(x)dx - P^B(q^B)q^B$

This loss in welfare is denoted by the green shaded area in Figure B-2.

Total producer surplus from good and bad maize market:

$$ P(q^G)q^G + P^B(q^B)q^B - C(q^0) $$
Total consumer surplus from good and bad maize market:

\[
\int_0^{q^G} P(x)dx - P(q^G)q^G + \int_0^{q^B} P^B(x)dx - P^B(q^B)q^B
\]

Total welfare, equal to the light brown shaded area:

\[
W_2 = \int_0^{q^G} P(x)dx + \int_0^{q^B} P^B(x)dx - C(q^0)
\]

Loss in welfare under Case 2:

\[
W_0 - W_2 = (q^0 - q^G)[(P(q^0) - P^B(0)) - (P(q^G) - P^B(q^B))]
\]

**Figure D-2 Welfare Impacts with Aflatoxin Contamination**
Appendix E – Aflatoxin Hazard Identification
Appendix E – Aflatoxin Hazard Identification

The purpose of this appendix is to review the evidence of health effects associated with aflatoxin exposure. This is a critical step to determine the economic impact that may result due to consumption of aflatoxins by humans.

When humans ingest aflatoxins, there is evidence that it is rapidly absorbed by the gastrointestinal (GI) tract and that the circulatory system transports aflatoxins to the liver (Azziz-Baumgartner et al., 2005). It is estimated that 1–3 percent of the ingested aflatoxins bind irreversibly to proteins and DNA bases, which can cause toxicity in the liver (Azziz-Baumgartner et al., 2005). High levels of exposure (i.e., acute exposure) may result in acute aflatoxicosis, which can lead to jaundice, edema, GI hemorrhage, and eventually death. Acute exposure outcomes are discussed in Section E.1.

Additionally, studies have shown that chronic exposure to aflatoxins is a cause of hepatocellular carcinoma (IARC, 2002), and there is strong evidence of an association between aflatoxin exposure and cirrhosis of the liver (Kuniholm et al., 2008). Further, there is evidence that chronic exposure may be associated with immunologic suppression (Williams et al., 2004) and growth impairment (Khlangwiset et al., 2011).

The evidence for the aflatoxin-endpoint association, along with a discussion on the feasibility of understanding the economic impacts associated with developing these endpoints, is presented in Section E.2 for hepatocellular carcinoma, Section E.3 for immunologic suppression, Section E.4 for growth impairment (stunting), and Section E.5 for liver cirrhosis.

E.1 Acute Aflatoxicosis

Aflatoxins have been definitively associated with acute aflatoxicosis (Azziz-Baumgartner et al., 2005; Lewis et al., 2005). Early symptoms of liver toxicity due to aflatoxin exposure may include anorexia, malaise, and low-grade fever. However, as aflatoxicosis progresses, it can lead to lethal acute hepatitis, which is preceded by jaundice, edema, GI hemorrhage, vomiting, and abdominal pain. In 2004 reports came from Kenya indicating the largest outbreak of aflatoxin poisoning in history. During the outbreak 317 cases of hepatic failure were reported in eastern Kenya, and 125 cases occurred in people who subsequently died. After the outbreak, the maize supplies of 65 markets and more than 240 vendors were analyzed, and it was found that 55 percent of the maize products had aflatoxin levels greater than the 20 ppb safe level recommended by the Kenyan government (Lewis et al., 2005). Concentrations of aflatoxins were as high as 4,400 ppb (Azziz-Baumgartner et al., 2005).

It is known that high levels of aflatoxins can cause aflatoxicosis, but the data pertaining to the dose necessary for aflatoxicosis to occur remain sparse. Kensler et al. (2011) report that ingestion of 2–6 mg/kg-day of aflatoxin consumption over a month produced hepatitis in India. However, there is also evidence that a pure aflatoxin dose as high as 1.5 mg/kg resulted in minor health effects.

Although it may be possible to calculate the dose necessary to result in acute aflatoxicosis, this dose-response curve has not yet been developed (Wu et al., 2011). Data exist showing that wet maize and maize stored inside the home are more likely to result in high aflatoxin concentrations (Azziz-Baumgartner et al., 2005), but it is “virtually impossible to know how often humans around the world are exposed to that dose from sporadic high occurrences in food” (Wu et al., 2011). Thus, in this
modeling framework, we do not quantify acute aflatoxicosis in the economic health impact assessment of aflatoxin exposure.

### E.2 Hepatocellular Carcinoma

In 1992 an IARC working group reviewed the literature examining the association between aflatoxins and hepatocellular carcinoma (HCC) and concluded there was “sufficient evidence in humans for carcinogenicity” (IARC, 2002). In 2002, new evidence relating aflatoxins to hepatocellular carcinoma was reviewed by IARC, and the working group confirmed that aflatoxins are carcinogenic in humans (Group 1) (IARC, 2002). For an overview of the studies that have examined the association between aflatoxins and cancer up to 2002, see Tables 10 through 12 of the IARC monograph (IARC, 2002). The IARC review summarizes both the human health and animal studies that support the causal link between aflatoxin exposure and liver cancer, and they will not be summarized again here.

**Comorbidity with HBV.** As evidenced by the plethora of studies presented in IARC, HCC as a result of aflatoxin exposure has been well documented. In addition, the evidence suggests that chronic hepatitis B virus (HBV) infection strongly modifies the effect of aflatoxin exposure on the occurrence of liver cancer, such that the presence of both aflatoxin exposure and HBV increases the risk of liver cancer more than either exposure alone. It is found that carcinogenicity is most common in individuals with chronic HBV infections (Groopman et al., 2008; Qian et al., 1994). Compared to individuals without HBV infection or detectable aflatoxin biomarkers, the relative risk estimates for HCC occurrence from aflatoxins alone, HBV alone, and both risk factors together were 4, 7, and 60, respectively (McGlynn, 2011; Qian et al., 1994). *Thus, it has been concluded that individuals with exposure to HBV are a sensitive subpopulation when it comes to aflatoxin exposure.* Moreover, HBV infection is heterogeneously distributed globally, and areas of high endemicity occur in Asia and most of Africa, where the route of transmission is primarily mother-to-child and child-to-child among household contacts, such that 70 percent of infections occur among children at a young age (Lavanchy, 2005; McGlynn, 2011). HBV prevalence in these areas is estimated to be over 50 percent (Lee, 1997). These areas are coincident with areas of high aflatoxin exposure.

**Comorbidity with HCV.** Evidence has also begun to suggest that the same relationship may be true for individuals with exposure to the hepatitis C virus (HCV), as a double mutation associated with HBV infection was also found among HCC cases with HCV infection in Thailand (Kuang et al., 2005). A community-based epidemiologic study in Taiwan found aflatoxin exposure to be associated with progression to HCC and advanced liver disease among those infected with HCV (Chen et al., 2007). However, this relationship is not as well characterized as that for hepatitis B (Kirk et al., 2006; Wild and Montesano, 2009). Estimates of the prevalence of HCV infection in sub-Saharan Africa range from less than 3 percent to as high as 13.8 percent in Cameroon, below the prevalence of HBV infection (McGlynn, 2011). However, seroprevalence rates for HCV in sub-Saharan Africa rise with age, unlike for HBV, and the primary route of transmission is thought to be via contaminated injections, particularly transfusions among sickle-cell patients (Te, 2010). We are not aware of any protective humoral immunity with respect to one hepatitis virus from infection with the other, so the share of HCV+ population alone may be even smaller. *Therefore, we are not modeling variability with respect to HCV prevalence in our health effects framework.*

The synergistic relationship among aflatoxin exposure, HBV, and hepatocellular cancer was demonstrated by Yeh et al. (1989). In this study Yeh et al. (1989) examined the correlations of HBV
and aflatoxin B1 (AFB1) on hepatocellular carcinoma\(^1\) with a cohort of more than 7,917 men aged 25 to 64 years old in southern Guangxi, China, where the incidence of HCC at the time of the study was among the highest in the world. At the end of the study, 30,188 person-years of observation had occurred, and 149 deaths were observed, 76 of which (51 percent) were due to HCC. Sixty-nine of the 76 who died due to HCC (91 percent) were HBsAg+ (positive for HBV) when they enrolled in the study.

To determine AFB1 exposure estimates, Yeh et al. (1989) regularly collected and sampled staple food consumed in southern Guangxi between 1978 and 1984. The AFB1 exposure levels for each commune were then calculated by multiplying the yearly amount of a consumed raw food by the average AFB1 content as determined from the tested samples of raw foodstuffs. This product was then summed over all staple foods, and the total figure was divided by the total population to obtain and estimate intake per person per year. This is summarized in the equation below:

\[
E_i = \frac{\sum c P_c F_n [AFB1]}{P_c}
\]  

\[\text{[E-1]}\]

Where

\(E_i\) = an individual’s exposure;
\(\sum c F_n [AFB1] = \) the total sum of the products of the amount of food consumed (F) and the AFB1 concentration [AFB1] in the foodstuffs for all locations \(c\) to \(x\);
\(P_c\) = the population for location \(c\).

When the mean estimated AFB1 exposure levels in each subpopulation were plotted against mortality rates, Yeh et al. (1989) found an almost perfectly linear relationship (see Figure E-1). However, it is important to note that presence of HBV was very high and homogenous across the study areas, and, therefore, no significant association was observed between study area HBV prevalence and HCC mortality. The authors concluded that despite the “crudeness” of their exposure estimates, it was reasonable to conclude that AFB1 plays a role in the unusually high rates of HCC in southern Guangxi.

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\(^1\) Yeh et al. (1989) specifically examined the association between aflatoxin exposure and primary hepatocellular carcinoma. However, the unit risk estimates they developed have been used for general HCC, and thus throughout this section we refer to HCC in general terms, not primary HCC.
Economic Impact of Aflatoxin Contamination

Source: Figure 2, Yeh et al. (1989).

**Figure E-1: Relationship between the Mortality Rate for Primary Hepatocellular Cancer and Dietary Aflatoxin B1 in Four Communes in Southern Guangxi, China**

Potential shortcomings of this study to note, given its importance in understanding the cancer potency of aflatoxins, are that the exposure estimates for AFB1 are based on raw foodstuffs available to the population but attributed to individuals. In addition, the correlation between hepatocellular carcinoma and AFB1 exposure was not adjusted for any confounders, such as HCV, alcohol, tobacco, or nutritional status. Additionally, HBV exposure may be underestimated in the study due to the lack of PCR methodology. Further, HBV prevalence was measured only in a 25 percent random sample of the cohort and attributed to the region. Despite these shortcomings, this was an important study showing that in a region where HBV is highly prevalent and HCC is common, those chronically infected with HBV (often called carriers) are at a very high risk of cancer. It also showed that in areas with high AFB1 exposure, the HCC mortality rates are higher than in areas with lower AFB1 exposure. The results of this study are the basis for the cancer risk estimates recommended by WHO (World Health Organization, 1998) and are used in many recent risk assessments (Shephard, 2008; Wu et al., 2011) estimating the health impacts from aflatoxin exposure.

**Mode of Action.** In addition to the epidemiological studies that support the association between hepatocellular carcinoma and aflatoxins, there are mode-of-action studies that explain how aflatoxins cause cancer in humans. Ingested aflatoxins are metabolized into an epoxide, aflatoxin B1 8,9-exo-

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2 PCR (polymerase chain reaction) methodology is a scientific technique that amplifies a single or a few copies of a piece of DNA across several orders of magnitude, generating thousands to millions of copies of a particular DNA sequence.
epoxide, which results in DNA adduct formation via multiple cytochrome P450 enzyme pathways and a glutathione S-transferase enzyme pathway (Khlangwiset et al., 2011). This epoxide can either bind to liver proteins, potentially resulting in acute aflatoxicosis, or it may bind to DNA as a precursor step to causing cancer (Khlangwiset et al., 2011; Wu et al., 2011). Additionally, there is evidence that aflatoxins may cause mutations at the p53 gene, the tumor suppressor gene, that lead to uncontrolled cell division and proliferation, which can result in tumor formation as well (Wu et al., 2011). The biology of the synergistic effect of aflatoxin exposure with hepatitis exposure remains under investigation. However, some hypotheses are: mutations from AFB1 can more easily occur in the presence of liver regeneration due to the hepatitis virus; hepatitis-infected liver cells are predisposed to aflatoxin-induced DNA damage; aflatoxin-exposed individuals may be more susceptible to HBV infection; or there is additional oxidative stress due to the co-exposures of aflatoxins and chronic hepatitis infection (Wild and Montesano, 2009).

Given the extensive support for the relationship between aflatoxin exposure in addition to an understanding of the mode of action, we concur with the IARC conclusion that aflatoxins are a carcinogen. Thus, the economic impact of hepatocellular carcinoma as a result of aflatoxin exposure can be estimated.

### E.3 Immunologic Suppression

Williams et al. (2004) conducted a review of the literature on the health effects associated with aflatoxin exposure, concentrating on the potential for immunologic suppression. They found that although human studies are limited for this endpoint, many animal studies support the association between aflatoxin exposure and immunologic suppression. For example, aflatoxins have been shown to reduce T-lymphocyte function and number and to suppress phagocytic activity (Williams et al., 2004). Further, studies conducted in a variety of animals including poultry, pigs, and rats have shown that exposure to aflatoxins results in suppression of a cell-mediated immune response. Other studies have also shown that aflatoxins may impair the function of macrophages, a major player in a host’s defenses against infection (Williams et al., 2004).

As for human studies, Turner et al. (2002) examined aflatoxin-albumin adduct concentrations and changes in immunity in a Gambian population. In their study immunoglobulin A was lower in children with detectable aflatoxin-albumin concentrations compared to those with non-detectable concentrations (Turner et al., 2002). They also observed a weak antibody response to pneumococcal challenge. However, the study subjects’ response to the rabies vaccine and cell-mediated immune responses to test antigens were not related to their adduct status (Turner et al., 2002). A different study, looking at a population in Ghana, also showed impairments in cellular immunity, including decreases in activated T cells and B cells and significantly lower levels of perforin- and granzyme A-expressing CD8+ cytotoxic T cells in response to aflatoxin exposure (Jiang et al., 2005).

Shephard (2008) attempted to conduct a risk assessment based on immunologic suppression due to aflatoxin exposure. In 2007 the European Commission’s Scientific Panel on Contaminants in the Food Chain (2007 as cited by Shephard, 2008) recommended a no observed adverse effects level (NOAEL) for immunologic effect in rodents of 30 µg/AFB1/kg/bw/day. Shephard (2008) then divided this NOAEL by 100, which is the uncertainty factor used in other mycotoxin risk assessments, resulting in a tolerable daily intake of 300 ng/kg/bw/day. Based on his analysis Shephard (2008) concluded that “although immune suppression may occur in humans, it may occur at
a higher exposure level than that at which stunting and malnutrition is evident in children and that these effects themselves could influence immune responses and consequently disease burden.” Further, he stated that “at certain chronic exposures, no immunological toxicity will be found in rats but significant tumor rates will be observed. The extent to which this is reflected in human populations remains a topic for future epidemiology.” These statements demonstrate that although immunologic suppression may be associated with aflatoxin exposure, the levels of exposures at which these impacts may occur are higher than those for other impacts that are already being considered in the economic analysis. In addition, there is no meaningful health endpoint currently associated with immunosuppression.

**Links to Human Immunodeficiency Virus (HIV) and Tuberculosis (TB).** Given aflatoxins’ impact on immunologic suppression, it is reasonable to examine the correlation between aflatoxins and HIV. According to Jiang et al. (2008), CD4 proteins, the proteins that interact with the cells that are the gateway for HIV infection, are weakened by aflatoxin exposure and may correlate positively with HIV. Further, Williams et al. (2004) hypothesized that HIV infection is likely to increase aflatoxin exposure by two routes: (1) HIV infection decreases the levels of antioxidant nutrients that promote the detoxification of aflatoxins, or (2) the high degree of co-infection of HIV-infected people with HBV also increases the biological exposure to aflatoxins. Further, Keenan et al. (2011) associated aflatoxin levels with an increased risk of developing TB in HIV-positive individuals. This raises more concerns about HIV-positive individuals, who are already susceptible to liver disease.

*Given that the currently available data associating aflatoxin exposure with an immune response are mostly on animals and that the endpoints measured for immunologic suppression are not ones that can be quantified in terms of economic impacts, we do not plan to quantify this impact. However, when considering the overall qualitative impact of aflatoxins it is important to consider immunologic suppression, along with the potentially sensitive subpopulations of HIV-positive or TB-positive individuals.*

**E.4 Growth Impairment**

Typically, growth impairment is indicated if an individual is two standard errors or more below the WHO growth standards (i.e., $Z \leq -2$). If this is the case, the individual will be classified as having one of three diseases: stunting (height for age), underweight (weight for age), or wasting (weight for height) (Khlangwiset et al., 2011). Given that children can be exposed to aflatoxins in utero, through breast milk, or in their weaning foods, the impact of aflatoxin exposure is of particular interest due to the large potential public health implications (Khlangwiset et al., 2011). Over the past few decades the evidence pertaining to the connection between aflatoxin exposure and growth impairment in children has been increasing. Khlangwiset et al. (2011) reviewed both the animal and human literature from the past 50 years on the association between aflatoxin exposure and growth impairment. Their results are summarized below.

**Animal Studies.** Thirty studies examining the impact of aflatoxins on growth in animals were located, of which 29 indicated that, when treated with aflatoxins, animals experienced a reduction in

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weight gain or other signs of growth impairment, such as reduced feed intake or increased feed conversion ratio. The one study that did not support the association was conducted in pigs that were recently weaned (n=110) by Keyl and Booth (1971 as cited by Khlangwiset et al., 2011). However, the other 29 studies that did find an association were conducted on a wide variety of animals: mule ducklings, mice, Japanese quail, Cherry Valley commercial ducks, chickens, turkeys, pigs, Nile tilapia, and channel catfish. A summary of these studies can be found in Khlangwiset et al. (2011).

Additionally, there were five animal studies, conducted on rats, hamsters, sows and their piglets, and Japanese quails, which examined the association between in utero aflatoxin exposure and growth parameters in baby animals. All five studies reported either reduced fetal or egg weights or fetal lengths in the offspring animal (Khlangwiset et al., 2011). This comprehensive review of the past 50 years of toxicological studies examining the association between AFB1 exposure and growth impairment supports the association between aflatoxin exposure and growth impairments. These studies provide strong evidence that aflatoxin exposure is associated with growth impairment.

However, a dose-response function for human health endpoints should ideally be derived from a clinical trial or epidemiological study. Thus, the human studies examining this association are summarized below.

**Human Studies.** Nine studies were located that found a positive association between various indicators of growth impairment and aflatoxin exposure. These studies were conducted in Benin, Togo, The Gambia, Ghana, Iran, Kenya, and the United Arab Emirates:

- Gong et al. (2002) studied a cohort of 480 children (aged between 9 months and 5 years) from 16 villages in Benin and Togo. In this cohort, the stunting prevalence was 33 percent; the biomarker for aflatoxin exposure (AF-alb adduct) was found in 99 percent of the samples; and the geometric mean level of AF-alb adduct was 32.8 pg/mg (95 percent CI: 25.3-42.5) (Gong et al., 2002). After accounting for the socioeconomic status, weaning status, and agroeconomic zone, Gong et al. (2002) found a statistically significant negative effect of height-for-age Z-scores (HAZ; as represented by four categories: HAZ>0, -2<HAZ<=0, -3<HAZ<=-2, and HAZ<=-3) on the AF-alb adduct level.

- In contrast, a 2003 study of a cohort of 472 children (aged 6 to 9 years old) in The Gambia did not find the same association between AF-alb levels and HAZ or weight-for-age Z-scores (WAZ) (Turner et al. 2003 as cited by Khlangwiset et al., 2011). However, the children in this study cohort benefitted from a 5-year maternal supplementation program (Turner et al., 2003, as cited in Khlangwiset et al., 2011). On the other hand, in a follow-up study of 138 Gambian neonates who were followed for one year, a significant association between aflatoxin exposure in mothers during pregnancy and height and weight gain of their infants in the first year of life was found (Turner et al., 2007, cited by Khlangwiset et al., 2011).

**Mode of Action.** The mode of action for which growth impairment occurs due to aflatoxin exposure is still in question. Several mechanisms have been proposed. One is that the suppression of the immune system, which can occur with aflatoxin exposure, can result in a higher rate of recurrent infections in children, which in turn can lead to growth impairment (Khlangwiset et al., 2011). Another hypothesis is that the aflatoxins change the integrity of the intestines, which could make the children more vulnerable to infection as well. It is also possible that aflatoxins may cause a down-
regulation of genes that are associated with metabolism and growth, and thus growth impairment occurs (Khlangwiset et al., 2011).

Even though there is evidence to support the association between aflatoxin exposure and growth impairment in animals and humans (Khlangwiset et al., 2011), growth impairment also highly correlates with poor nutrition and poor gastrointestinal function (including increased GI infections). Because the latter problems are common in sub-Saharan Africa, it has not yet been possible to definitively ascertain whether aflatoxin exposure by itself causes growth impairment in the absence of malnutrition and/or poor GI function, nor to definitively answer whether there is a synergistic effect where aflatoxin exposure amplifies the effects of malnutrition and poor GI function on growth impairment. There is only one study by Gong et al. (2002) that demonstrates a statistically significant negative effect of HAZ on the AF-alb level (while controlling for various factors that can also impact AF-alb levels) for children aged 9 months to five years. However, the current literature on stunting and aflatoxin exposure among children does not contain an estimate of the dose-response relationship (i.e., a relationship that describes the change in HAZ caused by differing levels of exposure to aflatoxins after a certain exposure time). For these reasons, we do not characterize the stunting endpoint in this framework.

### E.5 Liver Cirrhosis

Recent evidence has found that there may also be a link between aflatoxin exposure and liver cirrhosis; however, this link is not the same as that found for hepatocellular carcinoma. In one study, Kuniholm et al. (2008) examined 97 individuals with cirrhosis and compared them to 397 controls. The participants in the study were surveyed on demographics and food frequency. Additionally, blood samples were tested for the hepatitis B and hepatitis B e antigens (HBsAG and HBeAg, respectively) along with hepatitis C virus, HCV RNA, and the aflatoxin-associated mutation. They found that exposure to aflatoxins, as measured by high lifetime groundnut intake and by presence of the gene mutation, increased the risk of cirrhosis 2.8 fold and 3.8 fold, respectively (OR = 2.8, 95 percent CI: 1.1-7.7, and OR = 3.8, 95 percent CI: 1.5-9.6). Additionally, Kuniholm et al. (2008) found that aflatoxin exposure and hepatitis B virus exposure appeared to interact synergistically to increase the risk of cirrhosis; however, this was not statistically significant.

Given that the evidence supporting the association between aflatoxins and liver cirrhosis is still developing, we do not quantify this endpoint when examining the potential economic impacts due to aflatoxin exposure. However, liver cirrhosis is an endpoint to consider when examining the qualitative impacts of exposure to aflatoxins.
References


etiology of liver cirrhosis in the Gambia, West Africa. Environ Health Perspect, 116(11), 1553-1557.


Appendix F – Agendas from the Tanzania and Nigeria Workshops
Nigeria Aflatoxin Workshop Objectives and Agenda
November 5\textsuperscript{th} 8:00-am to 5:00 pm
November 6\textsuperscript{th} 8:00 am to 5:00 pm

The Conference Hall of the Agricultural Research Council of Nigeria (ARCN)
Agriculture Research House
Plot 223D Cadastral Zone B6
Mabushi District, Wuse

Objectives

• Convene key actors in the campaign against aflatoxins in Nigeria

• Review the key findings from the country assessment and impact assessment with emphasis on:
  
  o Using economic data to identify and measure losses in trade, human health and food security and nutrition;

  o Identification and panel discussions on some of the most promising solutions and remedies (technological, pre-harvest, post-harvest, market-based, behavioral change etc);

  o Participants prioritize key interventions for aflatoxin prevention/containment and mitigation in the areas of trade, human health, food security and nutrition, described as the (“three pillars”)

• Identify the most promising points and types of intervention for each of the three PACA pillars (agriculture & food security, trade and human health) as well as crosscutting themes such as gender mainstreaming

• Lay the groundwork for a national mycotoxin (especially aflatoxin) policy and strategy, with key institutions and champions identified and committed
<table>
<thead>
<tr>
<th>Time/</th>
<th>Session</th>
<th>Introduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderator</td>
<td><strong>Session</strong></td>
<td><strong>Introduction</strong></td>
</tr>
<tr>
<td><strong>Introduction and Protocol</strong></td>
<td>8:00-8:15 Registration and breakfast</td>
<td>Foluke Areola and the MoA.</td>
</tr>
<tr>
<td><strong>Objectives:</strong></td>
<td>8:15-8:45 The Honorable Minister of Agriculture, Dr. A. A. Adesina will declare the opening of the workshop and its objectives.</td>
<td>Foluke Areola (MoA)</td>
</tr>
<tr>
<td><strong>Session 1</strong></td>
<td><strong>Defining and Measuring the Problem: Country Assessment and Economic Impact Assessment: Discussion of Main Findings</strong></td>
<td>8:45-10:00 Session Objectives: Introduction and country assessment findings</td>
</tr>
<tr>
<td>Moderator: John Lamb</td>
<td></td>
<td>o Orient the participants to the goal of the assessment, and provide an overview of aflatoxins, mycotoxins with some solutions including alternative use. (John Lamb, Project Director, Abt Associates)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o Discuss methodology, main findings and offer an in-depth discussion of the economic impact of aflatoxin in Nigeria. (Angela Stene, Abt Associates and John Lamb)</td>
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<td></td>
<td></td>
<td>o Health impacts of aflatoxin exposure in humans (Patience Osinubi and Prof. Fatima Abdulkareem)</td>
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<td>o Describe the role of the Partnership for Aflatoxin Control in Africa. (Ernest Aubee, (PACA steering committee member)</td>
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<td></td>
<td></td>
<td>o Question, Answers, and Discussion</td>
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<tr>
<td><strong>Overview of solutions</strong></td>
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<tr>
<td><strong>Session 2A</strong></td>
<td><strong>Overview of the legal and regulatory environment pertaining to aflatoxin</strong></td>
<td>10:00 to 10:45 am Session Objectives: Assessing the legal and regulatory environment around aflatoxin mitigation.</td>
</tr>
<tr>
<td>Moderator: Professor. Fapohunda</td>
<td></td>
<td>o NAFDAC’s detection role, challenges, capacities and a review of the EU trade alerts for Nigeria (Denloye Stella NAFDAC, Folasade Oluwabamiwo)</td>
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<td></td>
<td>o Review of food safety, nutrition, key commodities (Dr Nwaneri, Nigeria Agricultural Quarantine Services)</td>
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<td>o Codes of practice and commodities standards (Mrs. Eshiet, SON)</td>
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<td></td>
<td>o Revision of Food Safety Policy Regulation (Dr. Onyeagocha, Food Safety Programme, Department of Food and Drug Services)</td>
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<td>o Q&amp;A as time allows</td>
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<tr>
<td>10:45-11:15</td>
<td><strong>Coffee</strong></td>
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<tr>
<td><strong>Session 2B</strong></td>
<td><strong>Session Objectives: Overview of the CODEX regulations in Nigeria</strong></td>
<td>11:15-12:00</td>
</tr>
<tr>
<td>Moderator: Professor Fapohunda</td>
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<td>o Codex regulations. (Dr. Oyedeji, Ministry of Agriculture)</td>
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<td>o Codex rules as they apply to animal feed. (Dr Joseph Nyanger, Federal Department of Livestock and Veterinary Service)</td>
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<td>o Remaining time: Q&amp;A in Plenary</td>
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<tr>
<td>12-1:00 pm</td>
<td><strong>Lunch</strong></td>
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</table>
### Session 3

**Overview of how aflatoxin affects livestock, problems, challenges and recommendations from the commercial sector**

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
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<tbody>
<tr>
<td>1:00-1:30</td>
<td><strong>Presentation and Q&amp;A:</strong></td>
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<td></td>
<td>o Dr. Dotun Oladele, Principal Manager (Tech. Lab Services), Animal Care, Ltd</td>
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</table>

#### Angela Stene

### Session 4

**Panel discussions on ongoing remedies found in the CA: pre-harvest, post-harvest and public health solutions**

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
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<tbody>
<tr>
<td>1:30 -3:00</td>
<td><strong>Panel discussion on promising pre-harvest solutions</strong></td>
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<td></td>
<td>o Status with the commercialization of Aflasafe (Tola Sunmonu, Doreo Partners)</td>
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<td>o Resistant plant breeding (TBD, Invited Speaker, ACRN)</td>
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<td>o Botanical fungicides (Dr. Anjorin, University of Abuja)</td>
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<td></td>
<td>o Improved Storage (Dr. Femi Oyebamiji, NISPRI)</td>
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<td>o Irradiation (Mr. Akueche)</td>
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<td>o 30 minute Q&amp;A: questions on the presentations</td>
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#### Moderator:

Dr. Atanda, President, Mycotoxicology Society of Nigeria

### Session 5

**Synthesis of the Discussion and Addressing Key Questions:**

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<tr>
<th>Time</th>
<th>Event</th>
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<tbody>
<tr>
<td>3:30-5:00</td>
<td><strong>Plenary Discussion:</strong></td>
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<tr>
<td></td>
<td>o What is the proper balance between prevention, regulatory control, and mitigation?</td>
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<td>o Should Nigeria take a supply chain approach, if yes at which level?</td>
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<td>o Who are the main actors that need to be involved?</td>
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<td>o Does Nigeria have mechanisms to coordinate these roles?</td>
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<td></td>
<td><strong>Wrap Up</strong></td>
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<td></td>
<td>o Costs of interventions</td>
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<td>o Overview for tomorrow</td>
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</tbody>
</table>

#### Moderator:

John Lamb

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**The organizers invite you to join us for a dinner buffet at the 3J’s hotel**

**Immediately following the conference**

**3J’s hotel near NHIS behind RCCG Master’s place 31 P.O.W Mafemi Crescent, Utako, Abuja**

0807-331-6621

081-355-82217

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*In preparation for Day 2 of the workshop, please review the technical brief, Country Assessment Summary and the Felicia Wu paper on Costing (especially Table 2) to be handed out during day 1.*
<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Speaker</th>
<th>Details</th>
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<tbody>
<tr>
<td>8:00-8:30</td>
<td>Registration and breakfast</td>
<td>Foluke Areola</td>
<td></td>
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</tbody>
</table>
| 8:30-9:00  | **Intro**                                                                | Rex Raimond              | **Content**  
• Review key findings from Day 1  
• Overview of the day’s agenda, objectives, timeframe and expected outcomes |
| 9:00-10:30 | **Session 6**                                                            | Dr. Makun                | **Integrated considerations for promoting behavioral change for aflatoxin mitigation**  
• Panel discussion on: MOA ICT4Development Initiative using input vouchers distributed via text to farmers. (Mr. Osho, MoA)  
• Producer access to credit, Central Bank of Nigeria (Jude Uzonwanne, CBN)  
• Commodities exchange board (Khadijat Abdulazid, Nigeria Commodities Exchange)  
• Q&A                                                                                   |
| 10:30-11:00| **Coffee Break**                                                         |                          |                                                                                                                                        |
| 11:00-12:00| **Session 7**                                                            | John Lamb                | **Action Planning for a system wide response to aflatoxin control and mitigation in public health, trade, food security and nutrition**  
• Collaboration across MOH and MOA to enhance dietary diversity and food safety awareness especially related to liver cancer impacts. (Patience Osinubi, MOH)  
• Gender considerations for mitigation strategies (Mrs Liz Igbine, Foluke Areola and and Patience Osinubi)  
• Q&A                                                                                   |
| 12:00-1:00 pm | **LUNCH**                                                     |                          |                                                                                                                                        |
| 1:00-2:00  | **Session 8**                                                            | Angela Stene             | **Strategic Objectives:** *Identify and prioritize action steps*  
### Introduction: Action Planning.  
Groups will be asked to identify those interventions which achieve greatest impact on their pillar. They should chose interventions that are feasible given the estimated costs, Nigeria’s current technologies, human resources and public/private investments in agriculture, trade and health.  
### Small group prioritizing of interventions:  
Participants will break into three small groups (one group to analyze each of the three pillars). Groups will receive a template with a sample top three action steps. Groups will decide the top three types of strategies most effective for their topical area a) use previous knowledge, experience and discussions select top interventions they wish the country to prioritize the top 3 interventions for their area.
<table>
<thead>
<tr>
<th>Session 8</th>
<th>Group Presentations on the Priority Action Plans</th>
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<tbody>
<tr>
<td>2:00-2:50 pm</td>
<td>Plenary</td>
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</table>
| Ernest Aubee | o Groups receive and share feedback, ideas and new information.  
| | o As needed, each group may choose to revise their interventions.  
| | o Discussion, debate and review the small group #1 priorities. Consensus building on the top priorities.  |
| 2:50-3:10 | Coffee |
| Session 9 | Action planning: identifying action steps: 6 month, 1 year and 3 year goals for the top intervention of each pillar. |
| 3:10-3:50 | In plenary, a sample (model) of a 3-year action step will be presented (each listing action steps that can be reached in 6 months, 1 year and 3 years for each top intervention per pillar). This sample action plan will get participants thinking about concrete steps that need to be taken for interventions to be developed.  
| Angela Stene or John Lamb | Small group facilitators  
| | Small Groups: Each group will take one of the top 3 interventions per group and design a small, skeletal action plan for that one intervention. Action steps will consist of: a) labeling the intervention; b) identifying the 6 month benchmark, a 1 year and 3 year benchmark; and c) a home institution or initiative (possibly public private) that may lead the initiative. |
| 3:50-4:45 | In Plenary groups present their skeletal plan, and get feedback. Plans are revised and recorded by a rapporteur. |
| Rex Raimond |  |
| **Close** | Content  |
| 3:50 - 4:50 | Discussion of next steps.  
| John Lamb | Review achievements of two days  
| | Secure commitment to follow-up and complete actions outlined in Plan  
| | Closing remarks from hosting institution  |
| **Evaluation** | Fill out evaluation forms |
| 4:50-5:00 |  |
|  | Honorable Minister of Agriculture, Dr. A. A. Adesina  
|  | Dr. Atanda  |
Tanzania Aflatoxin Workshop Objectives and Agenda
December 3 and 4, 2012

Objectives
- Review the key findings from the country assessment and impact assessment with emphasis on:
  - Measuring losses in trade, human health and food security and nutrition using economic data and results of the aflatoxin prevalence tests completed through PACA.
  - Identifying aflatoxin contamination risk along the value chain of aflatoxin-susceptible crops.
  - Panel discussions on some of the most promising solutions and remedies to address these risks (technological, pre-harvest, post-harvest, market-based, behavioral change etc).
  - Facilitating discussion among participants to prioritize key actions for aflatoxin prevention/containment and mitigation in the areas of trade, human health, food security and nutrition, described as the “three pillars”.
- Identify some short-term gains that can help promote aflatoxin mitigation along each of the three pillars.
- Identify some long-term steps and policy champions that can follow up with certain key interventions identified by the group as being a priority for longer term action planning.
- Agree on an aflatoxin coordinating body which will provide future guidance on aflatoxin action steps for the country.

Methodology
The workshop is designed to be participatory, allowing for small and plenary group discussion, dialogue and prioritization of key interventions, using a systems wide approach that addresses pre-harvest, post-harvest, market, behavioral change, and policy and legal/regulatory reform for aflatoxin mitigation.

Read Ahead Materials that will be provided to participants prior to the workshop
- Summary report of the country and economic assessment that summarizes findings in each of the three study areas, and includes a menu of promising interventions/solutions that were identified during the country and economic impact assessment.
- Itinerary and schedule of the 2-day event.
<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Facilitator</th>
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<tbody>
<tr>
<td>8:00-8:20</td>
<td>Registration of participants and Coffee</td>
<td>Secretariat</td>
</tr>
<tr>
<td>8:20-8:40</td>
<td>Introduction of Participants</td>
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</tr>
<tr>
<td>8:40-8:50</td>
<td>Introduction to the Objectives of the Workshop</td>
<td>John Lamb, Abt Associates Inc.</td>
</tr>
<tr>
<td>8:50-9:00</td>
<td>Welcome Remarks</td>
<td>Hiiti B. Sillo</td>
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<td>Director General, Tanzania Food and Drugs Authority</td>
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<tr>
<td>9:00-9:20</td>
<td>Opening Speech</td>
<td>Regina Kikuli</td>
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<td>Ag Permanent Secretary, MoHSW</td>
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</table>

**Session 1**

**Defining and Measuring the Problem: Country Assessment and Economic Impact**

**Session Objectives:** Orient the participants to the goal of the assessment, and the role of PACA, share results of the country and economic assessment.

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Facilitator</th>
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<tbody>
<tr>
<td>9:30-10:15</td>
<td>Discuss methodology, main findings and offer an in-depth discussion of the country assessment and economic impact of aflatoxin in Tanzania. Discuss the findings of the maize sampling tests that were done in 2012, 30 minutes</td>
<td>Tulika Narayan, Abt Associates Inc.</td>
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<tr>
<td>10:15-10:40</td>
<td>Coffee</td>
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**Session 2**

**Overview of Policy, Institutional and Regulatory Framework**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Facilitator</th>
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</thead>
<tbody>
<tr>
<td>10:40 to 12:00</td>
<td>Panel I. Overview of the standards and regulatory environment pertaining to aflatoxin</td>
<td>Moderator: Prof. Bendantunguka Tiisekwa, Sokoine University of Agriculture (will confirm about coming)</td>
</tr>
<tr>
<td>Time</td>
<td>Activity</td>
<td>Presenter/Institution</td>
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<tr>
<td>12:00-12:10</td>
<td><strong>Introduction to objectives of Session 3 and 4, 10 minutes</strong></td>
<td>John Lamb, Abt Associates Inc.</td>
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<tr>
<td>12:00-12:10</td>
<td><strong>Overview of Session 3</strong></td>
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<tr>
<td></td>
<td><strong>Session 3: Overview of Solutions</strong></td>
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</tr>
<tr>
<td>1:10 to 2:10</td>
<td><strong>Panel II. Discussion on promising pre-harvest and related Behavior Change Communications</strong></td>
<td>Moderator: Katemani Mdily, Plant Health Service, Ministry of Agriculture, Food Security and Cooperatives</td>
</tr>
<tr>
<td></td>
<td>o Key pre-harvest strategies for aflatoxin control, <em>Dr. Omary Mponda, Naliendele Agricultural Research Institute, 10 minutes</em>;</td>
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<td></td>
<td>o Aflasafe and the status of commercialization, <em>Dr. Fen Beed, IITA, 10 minutes</em>;</td>
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<td>o Update on the BecA-ILRI Hub and the Capacity and Action for Aflatoxin Reduction in Eastern Africa (CAAREA) project, <em>Dr. Jagger Harvey, 10 minutes</em>;</td>
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<td></td>
<td>o Resistant varieties and role of plant health in aflatoxin control, <em>Dr. Anold Mushongi, Uyole Agricultural Research Institute, 10 minutes</em>;</td>
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<td></td>
<td>o Questions and answers -20 minutes )</td>
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<tr>
<td>2:10- to 3:00</td>
<td><strong>Panel III. Discussion on promising post-harvest solution</strong></td>
<td>Moderator: Prof. Bendantunguka Tiisekwa, Sokoine University of Agriculture</td>
</tr>
<tr>
<td></td>
<td>o Key post-harvest solutions for aflatoxin control, <em>Dr. Said Massomo, Open University of Tanzania 10 minutes</em>.</td>
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<td></td>
<td>o Codes of practices and guidelines for post-harvest management in cereals and groundnuts, <em>Margareth Natai, Ministry of Agriculture, Food Security and Cooperatives, 10 minutes</em>;</td>
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<td></td>
<td>o Constraints for farmers practicing Good Agricultural Practices that can directly/indirectly affect aflatoxin levels, incentives and awareness of aflatoxin among farmers---and whether there are incentives for higher quality commodities, <em>Josephat Kionaumela, KIFFISACCOS and AMCOS in Kongwa, 10 minutes</em>;</td>
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<tr>
<td></td>
<td>o Questions and answers, 20 minutes (2/3 questions)</td>
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<tr>
<td>3:00-3:40</td>
<td><strong>Panel IV. Public Health</strong></td>
<td>Moderator: Dr. Joyceline Kaganda,</td>
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<tr>
<td></td>
<td>o Investigation, surveillance and reporting of aflatoxin exposure and related health effects. <em>Dr. Frank Madinda, ALMC hospital in Arusha, 10 minutes</em>.</td>
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<td>o Health impacts, aflatoxin exposure database and risk assessment. <em>Candida Philip, Nutritionist, TFDA, 10 minutes</em></td>
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<tr>
<td>Time</td>
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<td>Topic</td>
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<tr>
<td>3:40-3:55</td>
<td>Coffee Break</td>
<td>Coffee Break</td>
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<tr>
<td>3:55-4:25</td>
<td>Trade</td>
<td>Update on EAC wide efforts to mitigate aflatoxins in trade,</td>
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<td>Role of SME in processing and storage and in supplying</td>
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<td>aflatoxin-free commodities in the domestic market,</td>
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<td>Questions and answers, 10 minutes (1/2 questions)</td>
</tr>
<tr>
<td>4:25-5:25 pm</td>
<td>Session 4</td>
<td>Cross –Cutting Interventions: Gender, Commercialization and Behavior Change Communications</td>
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<tr>
<td>4:25-5:25 pm</td>
<td></td>
<td>Discussion on collaboration with Agro-dealers / commercial sector to promote use of pre-harvest and post-harvest solutions known to reduce aflatoxin, Katemani Mdily, MoAFSC, 10 minutes</td>
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<tr>
<td>4:25-5:25 pm</td>
<td></td>
<td>Discussion on collaboration across Ministries of Health, Agriculture and Livestock to enhance dietary diversity and food safety awareness, Dr. Claude J S Mosha Chief SPS (Food Feed Safety &amp; Quality) Consultant Nderyingo Food Feed Consulting International, 10 minutes</td>
</tr>
<tr>
<td>4:25-5:25 pm</td>
<td></td>
<td>Role of dietary diversity and behavior change communications in aflatoxin control, Dr. Joyceline Kaganda, Tanzania Food and Nutrition Centre, 10 minutes.</td>
</tr>
<tr>
<td>4:25-5:25 pm</td>
<td></td>
<td>Questions and answers, 20 minutes</td>
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<tr>
<td>5:25-6:00</td>
<td>Wrap up Day 1</td>
<td>Wrap up Potential Questions (as they emerge from discussions above, but may include):</td>
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<tr>
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<td>Should prevention (pre-harvest) vs. mitigation (post-harvest) be prioritized?</td>
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<td>At what level should this problem be addressed? Aflatoxin/mycotoxin? Food safety? SPS?</td>
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<td></td>
<td>Which institution(s) should take ‘ownership’ of an aflatoxin mitigation strategy?</td>
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<tr>
<td>6:30</td>
<td>Drinks and Bites followed by Dinner</td>
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<td>DAY TWO MORNING</td>
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<tr>
<td><strong>7:30-8:00</strong></td>
<td><strong>Convening and Coffee</strong></td>
<td>Secretariat</td>
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<tr>
<td><strong>Introduction</strong></td>
<td><strong>Review and Overview of Day 2</strong></td>
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<tr>
<td><strong>8:00-8:30</strong></td>
<td><strong>Content</strong></td>
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<tr>
<td><strong>• Review key findings from Day 1</strong></td>
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<tr>
<td><strong>• Overview of the day’s agenda, objectives, timeframe and expected outcomes</strong></td>
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<td><strong>Jennifer Pratt Miles, Meridian Institute</strong></td>
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<tr>
<td><strong>Session 5</strong></td>
<td><strong>Mycotoxin Coordinating Body and Focal Point</strong></td>
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<td><strong>8:30-9:30</strong></td>
<td><strong>In this session a 20 minute presentation on establishment and roles of the Tanzania Mycotoxin steering committee will be made. Participants will be asked to consider the Nigeria approach in formulating a committee like this for Tanzania. With moderation participants will determine the following:</strong></td>
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<td><strong>• What main activities will the committee accomplish</strong></td>
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<td><strong>• What will be the structure or form of the committee</strong></td>
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<td><strong>• Who will the steering committee be accountable to</strong></td>
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<td><strong>• Who should be on the committee to ensure representation by key areas of expertise and interest (including ensuring consideration for women’s participation, access, and time constraints)</strong></td>
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<td><strong>• Where will it be housed</strong></td>
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<td><strong>• Who will be the secretariat</strong></td>
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<td><strong>• How often will the committee meet</strong></td>
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<td><strong>• What will be the relationship between the committee and the national Codex or SPS committees</strong></td>
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<td><strong>• Who will fund the activities of the committee</strong></td>
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<td><strong>• Participants identify possible members to the committee and nominate a possible host institution to serve as the secretariat. Discuss potential for a p a rotational secretariat.</strong></td>
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<td><strong>Presenters will be nominated within the conference on day 1.</strong></td>
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<td>Session 6</td>
<td>Ranking priorities for a system wide response to aflatoxin control and mitigation in public health, trade, food security and nutrition</td>
<td>Facilitated by Conference Organizers</td>
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<td>9:30-10:30</td>
<td><strong>Learning Objectives:</strong> In groups based on areas of expertise: public health, trade, and food security (pre-harvest and post-harvest).</td>
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<td><strong>Small group prioritizing of interventions:</strong> Participants will break into small groups to prioritize interventions in the following areas: agriculture, trade, public health, policy reforms and gender. All groups will be prompted to consider behavioral change. Each group will be asked to use previous knowledge, experience and discussions to suggest and rank the top 3 types of interventions they would like to see implemented for their pillar.</td>
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<td>Groups will be asked to identify three interventions which achieve greatest impact on their pillar, for the least cost. They should chose interventions that are feasible and realistic given Tanzania’s current technologies, human resources and public/private investments in agriculture, trade and health. Also groups may identify one “reach” area where further research could lead to a viable remedy.</td>
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<td><strong>Product:</strong> Groups will write on a flip chart, the pillar they are addressing, the value chain nodes, and the interventions they prioritized.</td>
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<td>10:30-11:00</td>
<td><strong>Coffee break</strong></td>
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<td>Session 5, part 2</td>
<td><strong>In Plenary:</strong> Groups present their priority actions for pillars and receive and share feedback, ideas and new information.</td>
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<td>11:00-12:30</td>
<td>11:00-11:50 Group presentations (10 minutes each for the five groups). We will use a flip chart for this activity. All 5 presentations will be posted to the front of the room. 11:50-12:30 Q&amp;A and possible revisions discussed.</td>
<td>Facilitated by Conference Organizers; Presenters will be nominated from small groups.</td>
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<td>Outcome of this session: Each of the five groups will have identified 3 priority aflatoxin control, mitigation or action items. If groups are unable to come to consensus on which 15 action items, are worthy of investment, conduct a ‘vote’. Each participant will be given 3 sticky tabs or “votes.” Based on the entire action plan presented, participants will be allowed 10 minutes to post their sticky notes according to those interventions they see most worthy of investment. Participants will review the resulting priorities and contemplate on their own and in lunch discussions whether the priorities seem appropriate for Tanzania.</td>
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<tr>
<td>12:30-1:30</td>
<td><strong>Lunch</strong></td>
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### DAY TWO AFTERNOON

<table>
<thead>
<tr>
<th>Session 6</th>
<th>Feedback based on lunch discussions</th>
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<tr>
<td>1:00 – 1:30</td>
<td>Review the map of ranked interventions. Offer one last opportunity for feedback and revision.</td>
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<td><strong>Session 7</strong></td>
<td>Action planning: identifying SMART 6 month, 1 year and 3 year goals for the top intervention of each pillar.</td>
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<td>1:30 to 2:30</td>
<td>In plenary, a sample (model) of a 3-year action step will be presented (each listing objectives and action steps that can be reached in 6 months, 1 year and 3 years for each top intervention per pillar). This sample action plan will get participants thinking about concrete steps that need to be taken for interventions to be developed. Next, participants will break into their small groups again. Each group will take one of the top 3 interventions per ‘pillar’ and design a small, skeletal action plan for that one intervention. Action steps will consist of: a) labeling the intervention; b) identifying the 6 month benchmark, a 1 year and 3 year benchmark; and c) a home institution or initiative (possibly public private) that may likely absorb the intervention.</td>
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<td>2:30 – 3:00</td>
<td><strong>Coffee break</strong> During the coffee break, all ‘plans’ are consolidated and posted to the wall for presentation during plenary</td>
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<td>3:00-4:30</td>
<td>In Plenary groups present their skeletal plan, and get feedback. Plans are revised and recorded by a rapporteur. Next steps will be reviewed.</td>
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<td><strong>4:30-4:35</strong></td>
<td>Thanks to Participants and Contributors</td>
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<td>Wrap up</td>
<td>Closure and Evaluation</td>
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<td>4:35-5:00</td>
<td>Closing Speech</td>
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Facilitated by Conference Organizers.