Country and Economic Assessment for Aflatoxin Contamination and Control in Tanzania

Preliminary Findings

Contract #9678.2

January 8, 2013

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

Preface

This country assessment was commissioned by the 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 Department for International Development of the United Kingdom of Great Britain and Northern Ireland (DFID). Prevention and control of aflatoxin requires a comprehensive, systematic approach, involving a broad range of stakeholders in Africa and globally. PACA aims to provide consistent coordination and coherent leadership to the continental efforts on aflatoxin control. In support of continent-wide efforts, the following report provides an overview of the current status of aflatoxin contamination and potential solutions for Africa. More information is available at http://www.aflatoxinpartnership.org.

Abt Associates Project Director Mr. John Lamb and Principal Investigators Dr. Tulika Narayan and Ms. Angela Stene wish to acknowledge and thank all of the individuals and institutions who contributed their valuable data; insights; and above all, professional and personal time in support of this activity. In particular, they would like to acknowledge Dr. Martin Kimanya from Nelson Mandela African Institute of Science and Technology, who provided key consultant support; from Abt Associates, Dr. Anna Belova, Ms. Lauren Brown and Ms. Jacqueline Haskell, who were a part of the economic analysis team; and Ms. Carleen Ghio, who developed the maps.

We express our sincerest gratitude to Honorable Dr. Hussein A. Mwinyi, Minister for Health and Social Welfare, for recognizing the importance of controlling aflatoxins in Tanzania for public health promotion. We thank him for co-organizing the workshop through the Tanzania Food and Drug Authority (TFDA), and we thank Dr. Donan Mmbando, Acting Chief Medical Officer, Ministry of Health and Social Welfare, for formally launching the aflatoxin stakeholders meeting in Dar es Salaam, December 3 and 4, 2012. We also express our gratitude to Honorable Eng. Christopher Chiza, Minister for Agriculture, Food Security and Cooperatives, for recognizing that good agricultural practices should be the cornerstone of aflatoxin control and mitigation, and to Ms. Sophia E. Kaduma, Deputy Permanent Secretary, Ministry of Agriculture, Food Security and Cooperatives, for officiating the closing ceremony of the workshop.

We are very grateful to Mr. Hiit Sillo, the Director General of TFDA, who through Mr. Raymond Wigenge, the Director of Food Safety, accepted our request to co-fund and organize this workshop. We also thank the Director General of TFDA, who through the Directorate of Laboratory Services analyzed aflatoxins in samples of maize and groundnuts to generate the data that we needed for mapping of aflatoxin prevalence in Tanzania. We also thank the Ministry of Agriculture and International Institute of Tropical Agriculture (IITA) in Dar es Salaam for making maize and groundnut samples from many parts of Tanzania available to us and TFDA for analysis.

We acknowledge the generosity and expertise that countless policy and institutional leaders of agriculture, trade, and nutrition; agricultural practitioners; policymakers; and researchers have shared with us. In particular we thank Dr. W. C. H. Mleche and Mrs. A. P. Njombe and their team (Ministry of Livestock Development and Fisheries); Mr. Elias Chinamo (Ministry of Health and Social Welfare); Dr. Joseline Kaganda and her team (Tanzania Food and Nutrition Centre); Dr. Julius Mwaiselage (Ocean Road Cancer Institute); Mr. Odilo Majengo and colleagues (Ministry of Industry and Trade); Dr. Fidelis A. Mnyaka, Mr. Mpondo Fabian, and Ms. Josephine Omolo and their colleagues (Ministry of Agriculture, Food Security and Cooperatives (MoAFC)); Mr. Leondri Kinabo and his colleagues (Tanzania Bureau of Standards); Mr. Fidelis Mugenyi (Tanzania Trade Development Authority); and Mr. Edward R. Mtango (National Food Reserve Agency).

Our sincere gratitude also goes to all leaders at local government authorities of Njombe, Kongwa, and Bukombe who provided valuable information from their districts for this assessment. Their help in identification of the potential farmers, animal keepers, nurses, trade leaders, health and medical officers, agricultural officers, nutritionists, animal feed dealers, agricultural input suppliers and other business entities we interviewed is highly appreciated. Information we obtained from all the government officers, individuals, and companies we interviewed in those three districts and in Dar es Salaam was also very useful.

We also wish to thank several individuals who facilitated the stakeholders workshop for their contribution and very interactive discussions that led to achievement of the workshop's objective. These include Mr. Ridhiwan Rapmadhani, Mr. Raymond Wigenge, Mr. Linus Gedi, Dr. Fen Beed, Prof. Bendantunguka Tiisekwa, Dr. Said Massomo, Dr. Arnold Mushongi, Dr. Joseline Kaganda, Dr. Neema Rusibamayila , Dr. Frank Madinda, Dr. Omari Mponda, Mrs. A. P. Njombe, Dr. Sero Luwongo, Mr. Mkondo Fabian, Ms. Margareth Natai, and Mr. Josephat Kionaumela.

We thank Ms. Candida Philip and colleagues at the TFDA Department of Risk Analysis for their help in facilitating preparation of the workshop.

The authors have done their best to convey information, ideas, and findings as clearly and accurately as possible. Responsibility for any errors of commission, omission, or interpretation rests solely with the authors and Abt Associates Inc. None of this report should be construed as representing the views of the Meridian Institute as principal grantee, nor of the funding sources cited above.

Table of Contents

List of Exhibits

List of Acronyms

BMI	Body mass index
BMR	Basal metabolic rate
DALY	Disability Adjusted Life Year
DFID	Department for International Development of the United Kingdom of Great Britain and Northern Ireland
EID	Establishment Inspectorate Division
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FAS	Foreign Agricultural Service
FDA	U.S. Food and Drug Administration
GAIN	Global Agriculture Information Network
GAP	Good agricultural practices
GI	Gastrointestinal
GMP	Good manufacturing practices
HACCP	Hazard Analysis and Critical Control Points
HBV	Hepatitis B virus
HCC	Hepatocellular carcinoma
HIV	Human immunodeficiency virus
IARC	International Agency for Research on Cancer
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IITA	International Institute of Tropical Agriculture
ISA	Integrated Surveys on Agriculture
IYCN	Infant and Young Child Nutrition
LOD	Level of detection
LSMS	Living Standards Measurement Study
MoAFC	Ministry of Agriculture, Food Security, and Cooperatives
MoHSW	Ministry of Health and Social Welfare
MoIT	Ministry of Industry and Trade
MT	Metric Ton
PACA	Partnership for Aflatoxin Control in Africa
PAL	Physical activity level
SIDO	Small Industries Development Organization
SUN	Scaling up Nutrition
TBS	Tanzania Bureau of Standards
TEE	Total daily energy requirement
TFDA	Tanzania Food and Drugs Authority
TFNC	Tanzania Food and Nutrition Centre
USDA	United States Department of Agriculture
VLIR-UOS	Vlaamse Interuniversitaire Raad University Development Cooperation
WHO	World Health Organization

1 Introduction

Aflatoxins are naturally occurring toxins produced by certain fungi: especially *Aspergillus flavus and Aspergillus parasiticus.* There are several types of aflatoxins (B1, B2, G1, and G2) produced by these fungi, of which aflatoxin B1 is the most toxic. These aflatoxin-producing fungi are widely found in soil and contaminate a variety of food commodities that are important to Tanzania, such as maize, oilseeds, spices, groundnuts, tree nuts, and dried fruit (Strosnider et al., 2006).

Aflatoxin contamination during crop development and maturity depends on environmental conditions that are optimal for the growth of fungi. During crop development, damage by pests (birds, mammals, and insects) or the stress of hot, dry conditions can result in significant infections. Drought stress (elevated temperature and low relative humidity) increases the number of *Aspergillus* spores in the air, increasing the chance of contamination. In addition, other stresses (e.g., nitrogen stress) that affect plant growth during pollination can increase the level of aflatoxin produced by the *Aspergillus* fungi. The impact of drought on aflatoxin contamination is further exacerbated by the fact that drought stress can reduce the ability of crops to resist the growth of aflatoxin-causing fungus. At the time of harvest, high moisture and warm temperatures can increase the risk of aflatoxin contamination. Inadequate drying and improper storage also increases the risk of aflatoxin contamination. Countries such as Tanzania that are located between 40ºN and 40ºS latitude offer suitable growing conditions for the fungi, subjecting their populations to risk of exposure.

Aflatoxins cause serious health effects in humans, leading to significant adverse impacts in the form of disease burden and consequent impacts on a country's agriculture, food security, and trade.

Aflatoxin contamination can reduce the volume and value of agricultural sector output, generally, and impact each of the four pillars of food security - availability of food, access to food, utilization of food and stability in each of these three elements. Contamination in staple crops can directly reduce the local *availability* of safe and nutritious food. Producers not able to comply with more stringent regulations may earn less, which reduces farm households' capacity to *access* purchased food. Greater food insecurity can result from poor *utilization* if the food consumed is not nutritionally adequate or if it has deteriorated due to mold. The dependence of aflatoxin prevalence on climatic conditions places the *stability* of food security at risk as well.

Aflatoxins can impact domestic and international trade of affected commodities. Many countries have established regulations to limit human and animal exposure to aflatoxins, typically expressed in parts per billion (ppb). Some have different limits depending on the intended use: the tightest applying to human consumption and exports, lower levels to animal and fish feed, and the lowest to industrial products derived from commodities such as maize and cottonseed. Consequently, aflatoxin contamination and the safety regulations to prevent exposure to it, can result in foregone revenues and profit from domestic commerce and international trade. Producers, traders, and processors incur operating costs as they strive to meet the standards. If they fail to comply, additional costs arise from rejection of shipments; increased rates of sampling at borders; and in the worst case, loss of admissibility into foreign markets. While the regulatory control regime with respect to aflatoxins varies across most African countries, any or all such costs may occur if regulations are tightened or more strictly enforced. Similarly, actual costs of contamination will rise to the extent that consumers become more aware and demanding, that retailers apply higher private standards, or that processors begin to test susceptible raw materials.

Aflatoxins are a global public health threat. They are known to cause liver disease and liver cancer. Aflatoxins are linked to suppression of the immune system, which lowers the body's defenses against human immunodeficiency virus (HIV), malaria, and possibly other communicable diseases such as tuberculosis. They interact in an adverse way (i.e., exhibit "co-morbidity") with hepatitis B virus (HBV). Chronic exposure to even low doses of aflatoxin can lead to adverse health effects. Acute exposure can lead to aflatoxin poisoning, which can be fatal. Hundreds of deaths attributed to aflatoxicosis have occurred in Africa, and many more mortalities may have occurred for this reason, but without proven attribution. Some experts suspect an association between chronic aflatoxin exposure and child stunting, apparently linked to gut health and the child's capacity to utilize available nutrient intake. Stunting is widely recognized as a major human and development problem throughout Africa, because it lowers lifetime productivity and national output.

This country assessment is organized around the three pillars of the Partnership for Aflatoxin Control in Africa—agriculture and food security, trade, and health—that are adversely affected by aflatoxins Since the institutions, policy, and regulatory frameworks in countries are also organized along these three pillars, this is a useful way to identify opportunities for aflatoxin control.

The remainder of this report is organized as follows. Chapter 2 briefly presents a conceptual framework for conducting country assessments, while the subsequent chapters present the results of this particular assessment. Chapter 3 identifies the key crops of concern in Tanzania. Chapter 4 examines the prevalence of aflatoxin—both the distribution and degree of contamination—in these crops. Chapter 5 presents the current risks of aflatoxin contamination and exposure that exist in Tanzania. Chapter 6 analyzes the economic impact of such contamination in Tanzania. Chapter 7 examines the opportunities for aflatoxin control, and Chapter 8 summarizes the avenues for further action in Tanzania.

2 Overview of the Conceptual Framework

The core steps in conducting a country assessment include:

Step 1: Identify Key Crops of Concern. It is desirable to focus the assessments on crops that are known to have high aflatoxin contamination in the target country, and are either produced or consumed in large quantities and/or contribute significantly to gross national product. If information on aflatoxin contamination is not available, then the focus can be on the crops that are known for their susceptibility to high aflatoxin contamination globally and are produced and consumed in large quantities in the country of interest.

Step 2: Determine the Prevalence of Aflatoxin. Once the crop mix is identified, the next step is to assess the data on the distribution and degree of aflatoxin contamination in those crops. Here, we review both available secondary data and published studies for evidence. If resources permit and data are lacking, actual testing for aflatoxin levels can be conducted in areas that are primary producers of the crop of interest.

Step 3: Characterize Risks of Aflatoxin Contamination and Exposure. In this step, the core risk of aflatoxin contamination is established (i.e., whether the biggest impact is expected to be on the country's agriculture and food security, trade, or health). Final uses of aflatoxin-susceptible crops determine how the economic impacts are distributed, which can be helpful in narrowing down the focus of the analysis to the most significant areas of concern. Therefore, in this step we assess the main uses of the commodity in the country—whether for consumption, sale, or trade.

In addition, the core aflatoxin risks are examined all along selected value chains, beginning with pre-harvest and post-harvest contamination risks that directly impact agriculture, then considering risks of contamination and exposure in domestic commerce and international trade, and finally considering factors that directly affect human health.

Step 4: Estimate Economic Impact from Aflatoxin Contamination. In this step we estimate the economic impacts on agriculture and food security, economic impacts resulting from market losses in both domestic and international markets, and economic impact resulting from the consumption of aflatoxin-contaminated food by humans are estimated. Depending on the finding from step 3, the analysis can focus on the most significant impacts.

Step 5: Identify Opportunities for Aflatoxin Control. In the fifth step, we describe the institutional, legal, and regulatory framework that can support aflatoxin control in a country, and summarize the results of the stakeholder workshop that helped identify opportunities for mitigation.

Step 6: Conduct Stakeholder Workshop to Validate findings and Identify Priority Action Steps. In this final step, a multi-sectoral workshop is conducted with key stakeholders representing agriculture, trade, and health from the public and private sectors to discuss the draft assessment. Key stakeholders (which include solutions providers, researchers and legal and regulatory experts) make presentations that augment the discussion to identify current prevention, control and mitigation opportunities and gaps. Breakout sessions with small groups work to identify and sketch out priority action steps.

Data availability and quality greatly influence the accuracy and usefulness of a country assessment. In Tanzania, the data came both from secondary sources and via a primary data collection effort of limited scope. Secondary data sources included FAOSTAT and CountrySTAT on production and export volumes of the commodity; the Living Standard Measurement Survey – Integrated Surveys on Agriculture (LSMS-ISA), 2008-2009; and a literature review of articles on aflatoxin prevalence and on control strategies, policies, standards, and regulations affecting aflatoxin detection and control.[1]

These secondary data were supplemented by aflatoxin prevalence testing data that involved collection of maize samples for one district, and aflatoxin testing of samples already collected by another research effort by IITA. More details on the prevalence data and the results are provided in Chapter 4.

Other primary data came from in-depth qualitative data gathering from field sites in Tanzania in three districts. We used semi-structured questionnaires to conduct interviews with key informants in the three districts with agriculture, health, and trade representatives as well as mothers, farmers, and commercial sector solution providers. Districts were selected from three important maize growing areas within Tanzania, which also have measurable groundnut production: Irenga (District Djombe), Dodoma (District Kongwa), and Shinyanga (District Bukombe). See Exhibit 2-1.

Exhibit 2-1: Field Research Snapshot

Region (District)	Key Characteristics	Regional Maize Production (Percentage of Total)	Groundnut Production (Percentage of Total)
Irenga (Djombe)	One of the two main maize growing areas. Higher altitude and humid climate.	421 MT (10.4%)	11 MT (2.5%)
Dodoma (Kongwa)	Dry climate prone to droughts. One of the two key groundnut growing areas.	158 MT (3.9%)	78 MT (16.8%)
Shinyanga (Bukombe)	One of the two main maize and groundnut growing areas.	375 MT (9.3%)	86 MT(18%)
Data Source: Statistics Unit, MoAFC 1. 2009/2010 production data, percentage estimate using average production in five years (2005/6-2009/2010)			

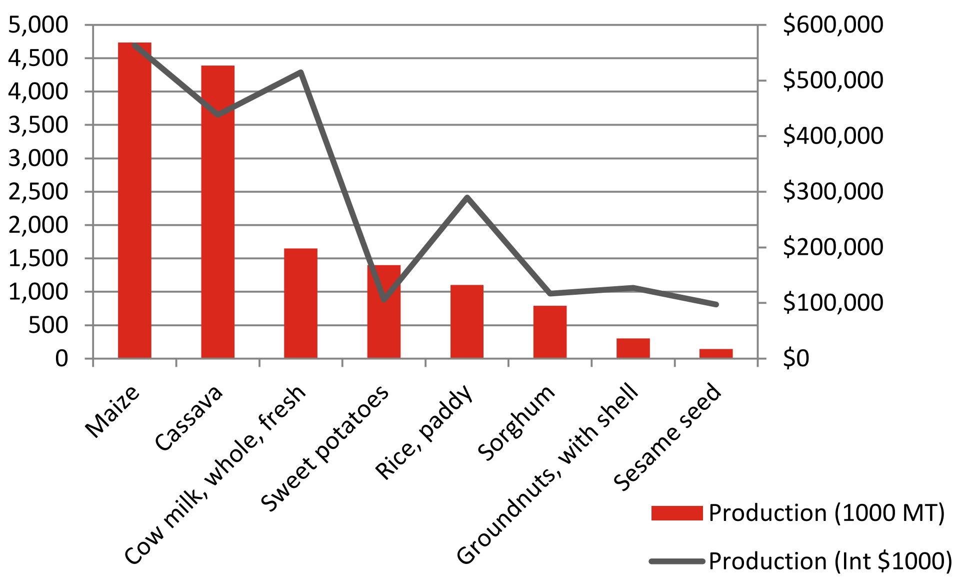
[1] The most recent LSMS-ISA data are now available, but they were not available in time to incorporate into this report.

3 Identification of the Key Crops of Concern

Crops commonly affected by aflatoxin include maize, groundnuts, cottonseed, sorghum, millet, rice, Brazil nuts, pecans, walnuts, pistachio nuts, sesame and spices (particularly chilies). Food and feed products made from these crops are also at risk.

For Tanzania, agricultural data suggest that of these crops, maize is the most important agricultural crop, followed by cassava (see Exhibit 3-1). IITA is focusing its efforts on aflatoxin contamination in cassava, and its work on determining aflatoxin prevalence in cassava is ongoing. Even though groundnut is not as important a crop in Tanzanian production or diets, groundnuts generally have a higher level of aflatoxin contamination and in Tanzania can be an important crop for weaning foods for children. In fact, the Small Industries Development Organization (SIDO) has been promoting the use of blended flours that mix groundnut with maize.[2] Ideally the country assessment would cover these three crops but resource constraints meant that we could focus only on two. Consequently, this country assessment focused on maize and groundnuts.

Exhibit 3-1: Tanzania's Key Agricultural Crops (2010)



Data Source: FAOSTAT, Accessed 2012

2 Conversation with village-level weaning foods blender –Mariet Natural Foods in Djombe district.

4 Prevalence of Aflatoxins

Currently, several efforts are ongoing to establish prevalence of aflatoxins in maize, groundnuts and cassava in Tanzania (see Exhibit 4-1). These efforts overall have the potential to provide a fuller picture of the prevalence of aflatoxins in maize and groundnuts across the country.

The country assessment took into account these ongoing efforts and worked with TFDA to conduct additional tests that would help provide a complete picture of aflatoxin prevalence in maize and groundnuts for Tanzania. In particular, TFDA conducted aflatoxin testing for 254 maize samples and 100 groundnut samples that had been collected by IITA between May and July 2012 for identifying fungus culture under another PACA project. The High Performance Liquid Chromatography (HPLC) method was used to estimate aflatoxin prevalence. This test had a minimum level of detection (LOD) of 0.6 ppb.

The results indicate that there is significant variability in the prevalence across the regions and overall prevalence was low (see Exhibit 4-2). Overall, only 14 percent of the 274 maize samples (includes 254 PACA samples and 20 samples in Tukuyu district in Mbeya from VLIR-UOS) had aflatoxin B1 levels above the regulated levels (5 ppb) in Tanzania. In the Eastern zone (Morogoro), 43 percent of the maize samples were above 5 ppb; and in the Western zone (Shinyanga), 40 percent of the samples were above 5 ppb, with average contamination of 50 ppb and 28 ppb, respectively. The contamination was much lower in other zones. In the Northern zone (Manyara), 9 percent of the samples were above 5 ppb; in the Southern Highlands (Iringa, Mbeya, and Rukwa), only 4 percent were above 5 ppb; and in the Southern zone (Ruvuma), none of the samples were above 5 ppb.

The groundnut samples had more limited geographical coverage. As noted above, however, there should be more information available on groundnut contamination in Tanzania once other ongoing prevalence testing is complete. Furthermore, Ministry of Agriculture also has some ongoing sampling for which we did not have data. Samples from the Northern, Southern (Mtwara), and Western zones indicate that 20 percent, 20 percent and 8 percent of the samples, respectively, had aflatoxin B1 above 5 ppb with mean contamination at 20 ppb, 18 ppb and 20 ppb.

In summary, prevalence data from 2012 suggest that there are aflatoxins in Tanzanian maize and groundnuts. However, the prevalence varies significantly in maize, with certain regions having very little contamination (Southern zone and Southern Highlands), and others having more prevalence (Western and Eastern zones).

Exhibit 4-1: Ongoing Efforts for Aflatoxin Prevalence Testing in Tanzania

Region	District	Project Supporting Aflatoxin Prevalence Testing					
		PACA (2012), Aflatoxin Testing by TFDA[1]		Africa Rising (2012)[2]		VLIR-UOS (2011)[3]	Univ. of Leeds (2010)
		Maize field	Ground-nut field	Maize field	Stored maize	Stored maize	Maize flour
		Number of Samples					
Manyara	Babati, Kiteto, Hanang	64	20	150	135	>100	-
Dodoma	Bahi, Chamwino, Dodoma, Kondoa, Kongwa, Mpwapwa		90*	100	115	-	-
Tanga	Pangani, Handeni	-	-	-	-	-	-
Tabora	Urambo, Nzega, Uyui	-	40*	-	-	-	37
Rukwa	Nkasi, Sumbawanga	40	-	-	-	-	-
Shinyanga	Kahama, Bukombe	30	40	-	-	-	-
Mwanza	Ukerewe, Misungwi	-	-	-	-	-	-
Morogoro	Kilosa, Ifakara	40	-	-	-	>100	-
Iringa	Iringa Rural, Makambako	40	20*	-	-	-	56
Mbeya	Mbeya, Tukuyu	-	-	-	-	>100	-
Ruvuma	Songea, Mbinga	40	-	-	-	-	-
Kilimanjaro	Rombo	-	-	-	-	-	55
Mtwara	Nanyumbu, Masasi, Tandahimba	-	40	-	-	-	-
National	**All**	**254**	**250**	**250**	**250**	**>300**	**148**

1. Aflatoxin prevalence testing was completed by TFDA for these maize and groundnuts samples, except 20 samples of groundnut each in Urambo, Nzega, Iringa rural, and Chamwino (marked with *) that are being analyzed currently.

2. Funded by the U.S. Agency for International Development; has prevalence testing.

3. Vlaamse Interuniversitaire Raad University Development Cooperation (VLIR-UOS), Belgium funded; has prevalence testing.

Exhibit 4-2: Aflatoxin Prevalence Summary for Tanzania

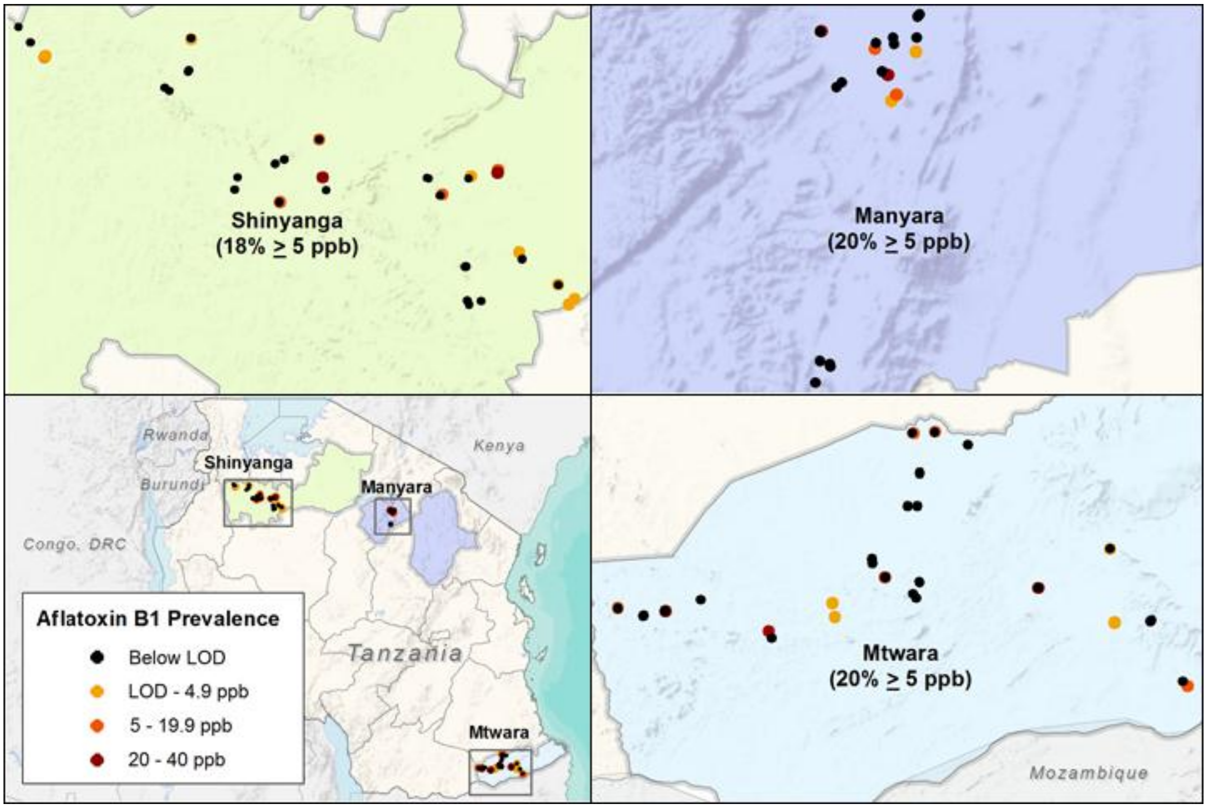
Zone	N	Aflatoxin B1 Share >5 ppb	Aflatoxin B1 Mean of Detects >5 ppb	Aflatoxin B1 Range (ppb)	Aflatoxin Total Share >10 ppb	Aflatoxin Total Mean of Detects >10 ppb	Aflatoxin Total Range (ppb)
Maize							
East	40	43%	49.92	5.30-159.5	43%	61.69	12.5-162.4
North	65	9%	17.79	12.1-23.5	9%	21.30	16.4-27.6
South	40	0%	--	--	0%	--	--
Southern Highlands	99[1]	4%	11.85	5.7-19.2	2%	17.53	15.3-19.7
West	30	40%	27.72	6.3-58.4	40%	52.27	11.8-99.5
National	**274**	**14%**	34.24	5.3-159.5	**14%**	49.70	11.8-162.4
Groundnuts							
North	20	20%	20.31	5.2-38.3	20%	28.67	17.8-40.3
South	40	20%	18.26	5.5-31	20%	23.60	10.3-37.5
West	40	18%	19.51	11.6-30.7	18%	25.54	13.7-33.6
National	**100**	**19%**	19.15	5.2-38.3	**19%**	25.1	10.3-40.3

Data Source: Aflatoxin testing by TFDA, 2012.

1. Includes 20 samples from Tukuyu district, Mbeya from VLIR-UOS effort.

Exhibit 4-3 presents the prevalence data for aflatoxin B1 and total for 100 groundnut samples. Exhibit 4-4 and Exhibit 4-5 present the prevalence data for aflatoxin B1 and total aflatoxin, respectively, in 274 maize samples.

Exhibit 4-3: Prevalence of Aflatoxin B1 and Total Aflatoxin in Groundnuts in Tanzania



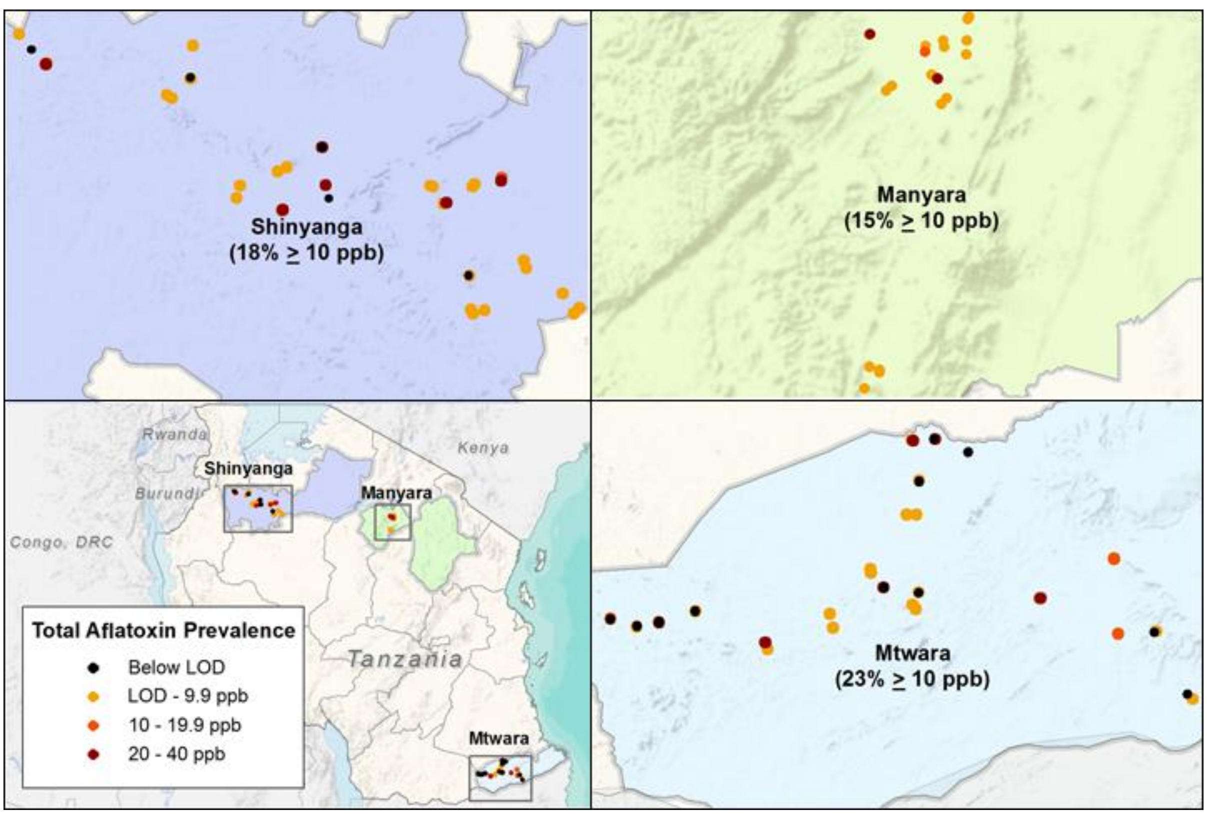


Exhibit 4-4: Prevalence of Aflatoxin B1 in Maize in Tanzania

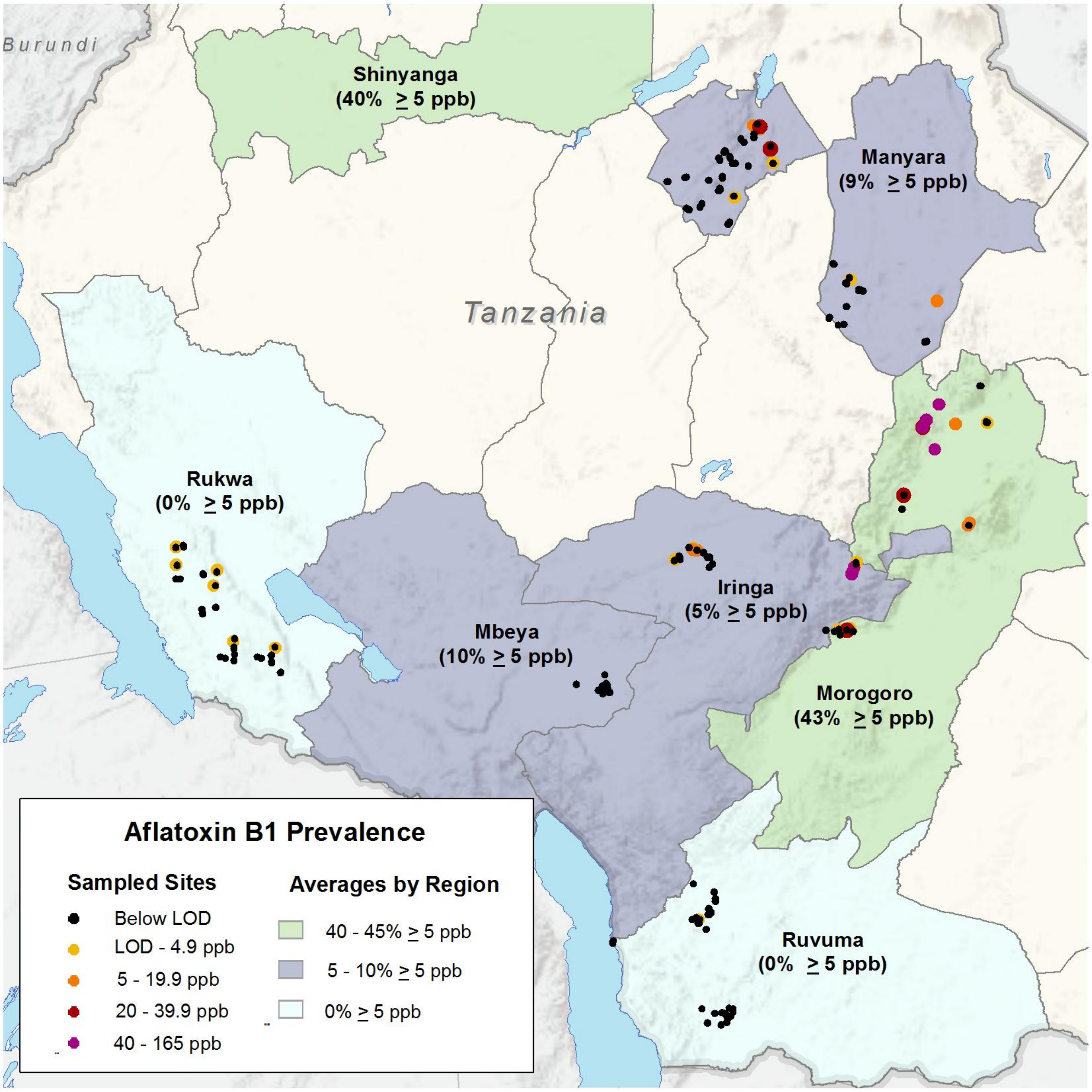
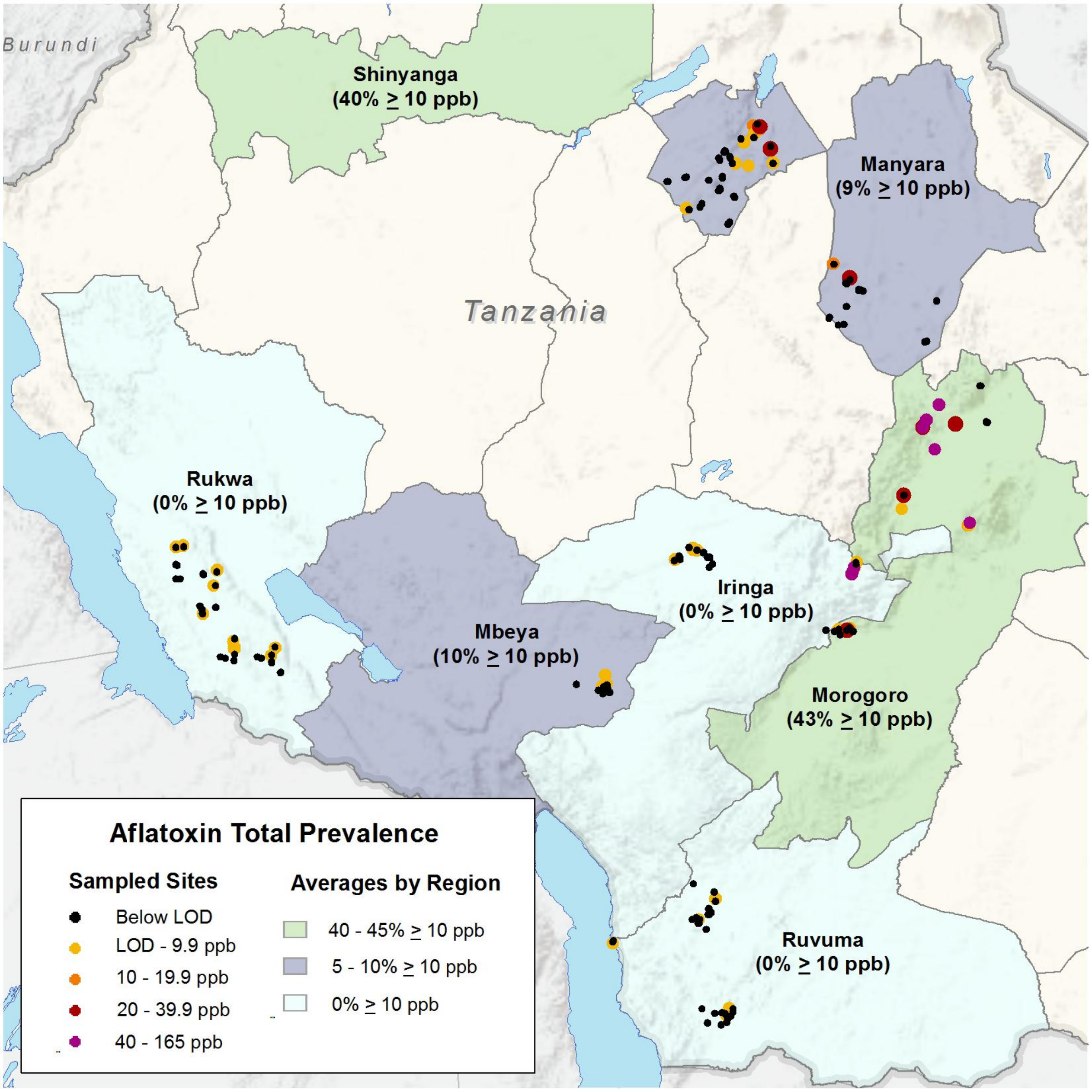


Exhibit 4-5: Prevalence of Total Aflatoxin Levels in Maize in Tanzania



5 Characterization of Risks of Aflatoxin Contamination and Exposure in Tanzania

Whether the risks of aflatoxin contamination are greater for a country's agriculture and food security, trade, or health is determined by: (1) the final market and uses of the aflatoxin-contaminated crop (whether it is used primarily for domestic human consumption or animal feed, or international trade); (2) levels of awareness about aflatoxins among farmers and consumers; and (3) the application of tolerances within the food marketing system and types of actions taken by regulators and buyers to mitigate the risk. If there is general awareness and use of aflatoxin controls in a country, and there are supporting regulations and institutions, then the human health impact of aflatoxin contamination will be low, while the impact on agriculture, food security and trade will be high. On the other hand, if awareness is low—both among farmers and consumers—and there are inadequate regulations to control it, aflatoxin-contaminated grain will be traded freely, then the health impacts will be high.

Most of Tanzania's maize crop is used for direct human consumption. According to the 2009 Food Balance Sheet, for example, of the 3,324 MT of maize produced with additional 416 MT from stocks and net imports, 68 percent was used for human consumption, 19 percent used for feed, 12 percent was used for other residual uses, and a small percentage (2 percent) was set aside for re-planting (FAOSTAT, 2012). Groundnuts are also primarily destined for human consumption either as groundnuts or as groundnut oil. Of the 270 MT of groundnut production, 51 percent was used directly as food, and 38 percent was used for other purposes.

Average agricultural households report selling 17 percent of their maize produce, retaining 2 percent for feed, using 1 percent for seed, and using the residual 77 for own consumption or storage (based on analysis of 2008/2009 LSMS-ISA data). Our field research indicated that the majority of the maize sold in the market is for human consumption, while the maize bran is processed for the feed sector, or used at the household level for livestock. Given that maize exports were banned, this implies that as much as 94 percent of maize produced by agricultural households is bound for human consumption, and 77 percent of that is through own consumption.

The hazard of aflatoxin contamination in maize and groundnuts originates in farmer fields, but can then be controlled or exacerbated at the post-harvest and storage stages. As the grain enters the domestic and international markets, the existence, content, and enforcement of regulations then affect the extent to which aflatoxin-contaminated products are traded in the market. Finally, consumer perceptions and the market's response to those perceptions affect the risk that aflatoxin-contaminated food is consumed, resulting in adverse health impacts.

5.1 Agriculture and Food Security – Risks of Contamination on Farmer Fields

Use of good agricultural practices (GAP) that promote plant health, reduce moisture content, and reduce susceptibility to aflatoxin-causing fungus can mitigate or minimize the risk of aflatoxin contamination. Targeted aflatoxin control measures such as biological controls (Aflasafe™), precision drying of grains and nuts, and hermetic storage can significantly reduce the risk of aflatoxin exposure. Currently, a national agriculture policy is being drafted to revise the 1987 policy, which includes GAP. Our interview with officials in the ministry of agriculture indicated that there is no manual or strategy for GAP and consequently the use of GAP is low in the field.[3] Most importantly, GAP is not understood to have a role to play in food safety. However, with the release of new agriculture policy there will be an opportunity to include aflatoxins and mycotoxin control in the context of implementing GAP. Not surprisingly, our field research suggests that the use of GAP is indeed low in Tanzania. Drying of maize, groundnuts and other crops is typically done on the ground, although there is some evidence of use of brick and mud structures that are above the ground. Storage units are often self-made, and commodities are stored without means of monitoring the temperature and humidity of such local storage units. There is little or no use of hermetic storage in the country.

Analysis of nationally representative data also confirms our qualitative findings from field research (see Exhibit 5-1 and Exhibit 5-2). Analysis of nationally representative LSMS data suggests that nationally 64 percent of the household report storing maize in sacks or open drums, and the remaining 19 percent store it in traditional structures that are typically not well-protected from humidity or pests. Post-harvest storage for groundnuts is also poor, with 78 percent of households reporting using open drums or sacks for storage.[4]

Exhibit 5-1: Distribution of Households by Type of Post-Harvest Storage of Maize (Percentage of Households Using Each Method)

Zone and Income Group	Improved			Unprotected				
	Improved Structure	Modern Store	Airtight Drum	Traditional Structure	Sacks/ Open Drum	Pile	Ceiling	Other
By Zone								
Central	0%	0%	0%	13%	72%	0%	0%	15%
East	0%	6%	0%	0%	80%	0%	8%	7%
Lake	2%	0%	0%	25%	68%	2%	2%	2%
North	1%	4%	18%	17%	43%	1%	16%	0%
South	2%	0%	1%	25%	34%	3%	15%	20%
Southern Highlands	0%	0%	1%	14%	80%	1%	2%	3%
West	1%	1%	0%	29%	65%	0%	3%	0%
Zanzibar	0%	0%	0%	68%	0%	0%	32%	0%
National	**1%**	**1%**	**4%**	**19%**	**64%**	**1%**	**6%**	**4%**

Data Source: LSMS-ISA Tanzania, 2008-2009

3 Conversation with Mr. M. Fabian, Acting Director, Crop Development, Ministry of Agriculture, Food Security and Cooperatives, July 2012.

4 The level of detail in the data was not sufficient to determine if the sacks referred to are jute sacks that have sufficient aeration for aflatoxin control.

Exhibit 5-2: Distribution of Households by Type of Post-Harvest Storage of Groundnuts (Percentage of Households Using Each Method)

Zone and Income Group	Improved			Unprotected				
	Improved Structure	Modern Store	Airtight Drum	Traditional Structure	Sacks/ Open Drum	Pile	Ceiling	Other
By Zone								
Central	0%	0%	0%	13%	76%	0%	0%	11%
East	0%	0%	0%	0%	100%	0%	0%	0%
Lake	7%	0%	0%	17%	76%	0%	0%	0%
North	0%	0%	0%	0%	100%	0%	0%	0%
South	0%	0%	8%	23%	29%	0%	6%	34%
Southern Highlands	0%	0%	0%	12%	72%	9%	0%	7%
West	2%	0%	0%	9%	86%	0%	3%	0%
Zanzibar	0%	0%	0%	0%	100%	0%	0%	0%
National	**2%**	**0%**	**0%**	**12%**	**78%**	**1%**	**1%**	**6%**

Data Source: LSMS-ISA Tanzania, 2008-2009

Nationally, only 18 percent of agricultural households use improved seeds (which are linked with good plant health) for maize, and 3 percent use improved seeds for groundnuts. Use of pesticides is at 11 percent for maize and 3 percent for groundnuts. Use of fertilizer is at 17 percent for maize and 1 percent for groundnuts. Only 2 percent of the area cultivated under maize is irrigated, and negligible area is irrigated for groundnuts. This is similar to government of Tanzania estimates that only 2 percent of cultivated area in Tanzania is irrigated (MoAFC, 2009). See Exhibit 5-3.

Exhibit 5-3: Pre-Harvest Risk Factors for Aflatoxin Contamination in Tanzania

Zone	Use of Improved Seeds (Percentage of Communities)	Use of Improved Seeds		Use of Pesticides		Use of Fertilizer		Use of Irrigation	
		(Percentage of Households)						(Percentage of Cultivated Area per Household)	
By Zone	**Maize**	**G'nut**	**Maize**	**G'nut**	**Maize**	**G'nut**	**Maize**	**G'nut**	**Maize**
Central	18%	1%	11%	0%	3%	0%	21%	0%	0%
East	24%	0%	18%	0%	0%	0%	3%	0%	0%
Lake	63%	0%	16%	0%	2%	0%	4%	0%	0%
North	26%	26%	35%	0%	16%	0%	23%	0%	9%
South	25%	8%	6%	0%	9%	0%	14%	0%	0%
Southern Highlands	37%	2%	16%	15%	18%	3%	40%	1%	1%
West	64%	2%	15%	0%	5%	0%	10%	0%	0%
Zanzibar	21%	15%	15%	0%	0%	0%	0%	0%	0%
National	**35%**	**3%**	**18%**	**3%**	**11%**	**1%**	**17%**	**0%**	**2%**

Data Source: LSMS-ISA Tanzania, 2008-2009

To improve the adoption of GAP, the Post-Harvest Management Service (in the MoAFC Directorate of Food Security) provides education and guidelines to agricultural extension officers who work with farmers on a day-to-day basis. The directorate has developed guideline documents on good crop management practices for crop categories to guide the farmers and extension officers in the districts. Currently, there is a document on guidelines for harvesting, processing, and storage of cereals (including maize) and another for preparation, processing, and storage of oil seed crops, including groundnuts.[5] However, aflatoxin and mycotoxin control is not currently included in these guidelines. Furthermore, these guidelines were disseminated to a limited number of extension officers due to financial constraints.

Awareness among farmers about the causes and consequences of aflatoxin contamination was lacking in the three districts where the field research was conducted. There is no set "agenda" for extension messaging on aflatoxins (or mycotoxins), or even more broadly on food safety or good agricultural practices. Some of the inspectors deployed by Plant Health Services may have knowledge about fungal infections, but they lack training and manuals for more systematic coverage of the topic. Agriculture extension officers are not trained in mycotoxin and aflatoxin control. Extension messaging responds to problems raised by urgent issues such as insecticide damage. That said, insofar as extension services get out the message about general GAP, extension messaging can have a positive impact on aflatoxin control. However, our quantitative analysis suggests that even the use of agricultural extension services is very low among agricultural households: nationally, only 19 percent of households report using government extension services (see Exhibit 5-4). Therefore, there may be

5 Available at www.kilimo.go.tz (in Kiswahili).

significant challenges in relying solely on government infrastructure to increase adoption of GAP. On the other hand, there is some potential for policy on integrating aflatoxin and food safety in GAP, and of improving extension delivery, given the planned increase of extension workers by 11,000. This might address the current gap in demand and supply of extension services.

Exhibit 5-4: Distribution of Households by Use of Extension Services for Agriculture or Livestock Activities (Percentage of Households Using Each Type of Extension Service)

Zone	Government	NGO	Cooperative/ Farmer's Association	Large Scale Farmer	Other
Central	33%	4%	4%	1%	0%
East	18%	1%	0%	1%	3%
Lake	17%	1%	3%	2%	0%
North	22%	2%	3%	1%	3%
South	15%	0%	2%	0%	0%
Southern Highlands	20%	2%	5%	1%	1%
West	13%	1%	2%	3%	3%
Zanzibar	20%	1%	1%	2%	0%
National	**19%**	**2%**	**3%**	**1%**	**1%**

Data Source: LSMS-ISA Tanzania, 2008-2009

Our in-depth field interviews suggest that farmers, on their own, do basic sorting (easier in the case of groundnuts) to realize the price premium associated with cleaner and unspoiled maize and groundnuts. The prices are also higher for dryness for both products. These incentives work in favor of reducing the probability of aflatoxin contamination, but they neither guarantee it nor imply that farmers and traders incur losses for carrying aflatoxin-contaminated grain (or realize premiums for aflatoxin-free grain). Consequently, there is significant risk that aflatoxin-contaminated grain can leave farmers' fields. This suggests that there are real opportunities for aflatoxin control in the agriculture sector. These are discussed in detail in Section 7.1.

5.2 Trade – Risk for Contamination in Markets

The Tanzania Bureau of Standards (TBS), which is under the Ministry of Trade and Industry (MoIT), has set standards for maximum aflatoxin concentrations for several aflatoxin-susceptible products: maize, groundnuts, sorghum, millet, groundnut, and maize products. The Tanzania Food and Drugs Authority (TFDA) enforces these standards and has laboratory capacity to conduct aflatoxin testing. However, it does so mostly for packaged foods and foods bound for the formal export market. Insofar as a large majority of these aflatoxin-susceptible foods are consumed in unpackaged form, the national food safety system does not address a large share of food consumed by its citizens.

Our field research in Kongwa, Njombe, and Bukombe found no evidence of testing for aflatoxins in the domestic maize and groundnut markets in Tanzania. Consequently, aflatoxin-contaminated grain can enter the domestic markets and the informal international markets (e.g., Kenya and Zambia for maize). Interviews with maize sellers at Bukombe and Kongwa indicated that visibly moldy maize and groundnuts are usually rejected, but even the rejects may be sold by suppliers to others at a lower cost. The major challenge with most of the sellers and farmers is that of low awareness about aflatoxins and its health impact. In Tanzania, the most important quality factor that buyers are looking for is the presence of chaff. Farmers may face additional sorting costs if their grain is not chaff-free. Other factors such as color and size of grain are secondary considerations.

On the other hand, in the animal feed sector, there is aflatoxin control. Even though there are no regulations on aflatoxin in this sector, the commercial feed formulators are vigilant about feed quality. Unfortunately, since there is no mandate for withdrawal and destruction of contaminated commodities, grain deliveries rejected by large commercial operations will likely be sold by a trader to smaller feed manufacturers that do not test for aflatoxins.

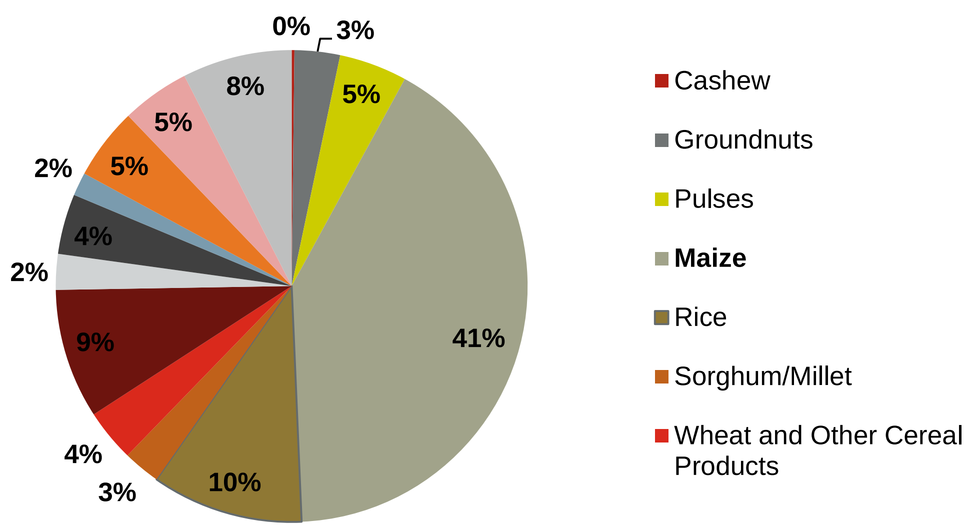
5.3 Health – Risk of Aflatoxin Contamination in Consumption

The last point of aflatoxin contamination and control occurs at the point of consumption. If consumers are aware of aflatoxin risks, they can control exposure by demanding aflatoxin-free supply of the affected crop or by shifting consumption to crops that are less susceptible to aflatoxins. Greater awareness amongst farmers would also imply reduced aflatoxin exposure insofar as their own consumption comprises a large fraction of the consumption. Yet field research suggests that consumers' level of aflatoxin knowledge is still very low in Tanzania.

The Tanzania Food and Nutrition Centre (TFNC) has the mandate to work on reducing exposure to aflatoxins as part of their functions to work on food safety, utilization of products and nutrition education and training. However, their current work has not focused on generating awareness about aflatoxins and has been limited to conducting test of aflatoxins (e.g., a 2004 study in which they studied aflatoxin prevalence in milk from Dar es Salaam area).

The biggest risk factor in Tanzania is the heavy reliance on maize for households' daily calorie needs. Nationally, maize contributes as much as 41 percent of the calorie intake of Tanzanian diets, while groundnuts comprise 3 percent of the calorie intake (see Exhibit 5-5). Together, they account for 44 percent of the calorie intake.

Exhibit 5-5: Share of Maize and Groundnuts in Calorie Intake of Tanzanian Households



Data Source: LSMS-ISA, 2008/2009.

Other factors that can lead to increased exposure include heavy reliance on maize-based porridges during a child's weaning stage. Infants are also fed cereal-based infant food mixed with other products such as soybean, which is also prone to aflatoxin contamination. Several household meal preparation processes (hulling, sorting, threshing, and culling) can be promoted to reduce the contamination levels of maize, groundnut, and other susceptible crops.

In summary, in Tanzania the lack of aflatoxin control in production agriculture and the lack of enforcement of aflatoxin standards in the domestic marketplace mean that aflatoxin-contaminated maize and groundnuts (and other products) can easily enter the consumption stream, leading to the risk of adverse health impacts. The fact that a majority of the maize and groundnuts produced are consumed domestically further enhances the risk, particularly because consumers are not aware of the problem. There may be some reduction in this risk because of the sorting and processing that the products undergo before consumption. Nevertheless, the impact of aflatoxin contamination in Tanzania is expected to be the greatest on human health, and secondarily on animal health, while the impact on agriculture and trade is probably minimal.

The next section presents the economic impacts of aflatoxin contamination on Tanzania's agriculture and food security, trade, and health.

6 Economic Impact from Aflatoxin Contamination

6.1 Agriculture and Food Security

The biochemical risk of aflatoxin contamination begins with planting, and can be mitigated or worsened later through suboptimal harvesting, handing, storage, processing, and transport practices. Control measures (or their absence) taken along the supply chain can directly affect the availability of aflatoxin-free crop to households for both own consumption and sale that contributes to farm household income. The sum total of action and inaction can impact all four elements of food security: availability of food, access to food (by affecting incomes), utilization of food (by affecting what households consume), and stability (in terms of continuity of safe food supply as well as associated price determination).

In Tanzania the *perceived* impact of aflatoxin contamination on agriculture and food security has so far been negligible because aflatoxin contamination often does not cause visible damage to the crop. In the current market environment, Tanzanian farmers do not have to discard harvest because of aflatoxin contamination, nor do they face lower prices for aflatoxin-contaminated food. Because the market does not differentiate between aflatoxin-free and aflatoxin-contaminated food, farmers also do not incur any costs for mitigating aflatoxin. In fact, as discussed in detail in Section 5.1 above, the use of GAP is low. This increases the risk of aflatoxin contamination in grains so that the majority, if not all, of the impact of aflatoxin contamination is on the third element of food security – utilization of food. As mentioned above, maize and groundnuts together account for 44 percent of the calorie intake (see Exhibit 6-1). There is some regional variation in diets. In the Eastern zone, maize constitutes 31 percent of the calorie contribution, while in the Southern Highlands the contribution of maize is as high as 55 percent. In other zones the calorie contribution of maize is within this range with the exception of Zanzibar, which is an outlier: maize constitutes only 8 percent of the calorie contribution in the island. Across the board, groundnuts account for a small percentage of calorie intake ranging from 1 percent in the Zanzibar, Northern, and Eastern zones to 8 percent in the Central zone (which not surprisingly also contributes a larger share of production of groundnuts). Overall, the aggregate contribution of maize and groundnuts to calorie intake is very high. This implies that even small levels of aflatoxin contamination could present a high risk of aflatoxin exposure, particularly in mainland Tanzania. The consumption patterns in different regions also offer opportunities for diet diversification. In the Eastern zone, rice is the second most important staple, which has a reduced degree of aflatoxin contamination. In the Lake region, cassava accounts for 14 percent and bananas account for 12 percent of the calorie intake, and in the South cassava accounts for 26 percent of the calorie intake.

Exhibit 6-1: Share of Foods in Households' Calorie Intake by Key Zones in Tanzania

Zone	Cashew	Cassava	Groundnut	Maize	Milk and milk products	Rice	All Other Crops
Central	0%	1%	8%	43%	1%	5%	41%
East	0%	6%	1%	31%	1%	20%	41%
Lake	0%	14%	3%	32%	2%	7%	43%
North	0%	4%	1%	46%	4%	8%	37%
South	1%	26%	3%	35%	0%	9%	27%
Southern Highlands	0%	6%	3%	55%	1%	6%	28%
West	0%	9%	5%	51%	1%	11%	23%
Zanzibar	0%	9%	1%	8%	1%	37%	45%
National	**0%**	**9%**	**3%**	**41%**	**2%**	**10%**	**34%**

Although currently there is no *perceived* impact of aflatoxin contamination on household food availability and food access, it is useful to consider the roles that maize and groundnuts play in households' agricultural income and the extent to which own and purchased groundnuts contribute to their availability. We consider the extent to which households rely on own and purchased maize for their consumption needs (see Exhibit 6-2). Overall, for agricultural households a large share of maize consumption comes from own production. In the South as much as 82 percent of maize consumption (which accounts for 35 percent of households' calorie intake – see Exhibit 6-1) comes from own production. This percentage is lowest for the North region within mainland Tanzania but still substantial at 42 percent. On an average for the nation, as much as 63 percent of maize consumption by agricultural households comes from own production. Correspondingly, the contribution of maize sales to households' agricultural income is lower (9 percent for the nation). This implies that aflatoxin contamination would have a direct impact on the availability of food for agricultural households. Insofar as maize is consumed widely by Tanzanians, it will also have an impact on utilization of food.

Groundnuts have a smaller contribution in the calorie intake of Tanzanian households. This is also not an important crop for food security. Nevertheless, for agricultural households, a large majority of their consumption is supplied by own production (72 percent). Insofar as groundnuts are used as weaning foods, there can be a direct impact on the availability of aflatoxin-free groundnuts.

Exhibit 6-2: Percentage Contribution of Groundnut and Maize on Food Availability and Access for Agricultural Households

	Food Availability (Percentage from Own Production)		Food Access (Percentage Contribution to Agricultural Income)	
Zone	Maize	Groundnuts	Maize	Groundnuts
Central	73%	77%	9%	10%
East	44%	30%	2%	14%
Lake	61%	79%	2%	6%
North	42%	18%	0%	17%
South	82%	80%	7%	13%
Southern Highlands	71%	67%	3%	19%
West	61%	75%	5%	6%
Zanzibar	1%	12%	12%	8%

Exhibit 6-2: Percentage Contribution of Groundnut and Maize on Food Availability and Access for Agricultural Households

Zone	Food Availability (Percentage from Own Production)		Food Access (Percentage Contribution to Agricultural Income)	
	Maize	Groundnuts	Maize	Groundnuts
National	63%	72%	9%	10%

Source: Estimated from LSMS (2008) data

6.2 Trade

6.2.1 Domestic

In Tanzania the regulatory standard for aflatoxin in maize and groundnuts for human consumption is set at 10 ppb, and for aflatoxin B1 at 5 ppb. TFDA has the mandate to enforce these standards, but actual enforcement is limited to packaged foods in the domestic market, which constitute a negligible fraction of maize and groundnut production in Tanzania.

Aside from regulatory action, another situation in which producers may incur losses from aflatoxin contamination is if consumers become aware of the adverse impacts of aflatoxins and refuse to buy or are only willing to pay less for aflatoxin-contaminated grain. Yet so far, awareness about aflatoxins (and other mycotoxins) is very low or nonexistent among Tanzanian consumers. Our interviews with traders and farmers in of Djombe, Kongwa, and Bukombe confirmed that farmers do not receive a higher price for aflatoxin-free commodities, nor do traders seek aflatoxin-free maize and groundnuts. On the other hand, well-dried grain without chaff does attract higher prices. Essentially, the difference in price comes from the additional cost that the buyer charges for additional sorting. Groundnut price differentials are largely based on the size of the grain, low moisture, and percentage of unspoiled nuts. Although better dried and insect-free maize and nuts are associated with lower aflatoxin presence, the current price differentials are not a result of aflatoxin contamination and cannot be attributed as a cost resulting from it. Consequently, we conclude that for Tanzania the domestic market impact of aflatoxin contamination in maize and groundnuts is negligible because there is no enforcement of existing regulations on aflatoxins on the majority of groundnuts and maize that are traded unpackaged, and there is lack of awareness about the adverse health impacts of aflatoxin.

6.2.2 International Trade Impacts

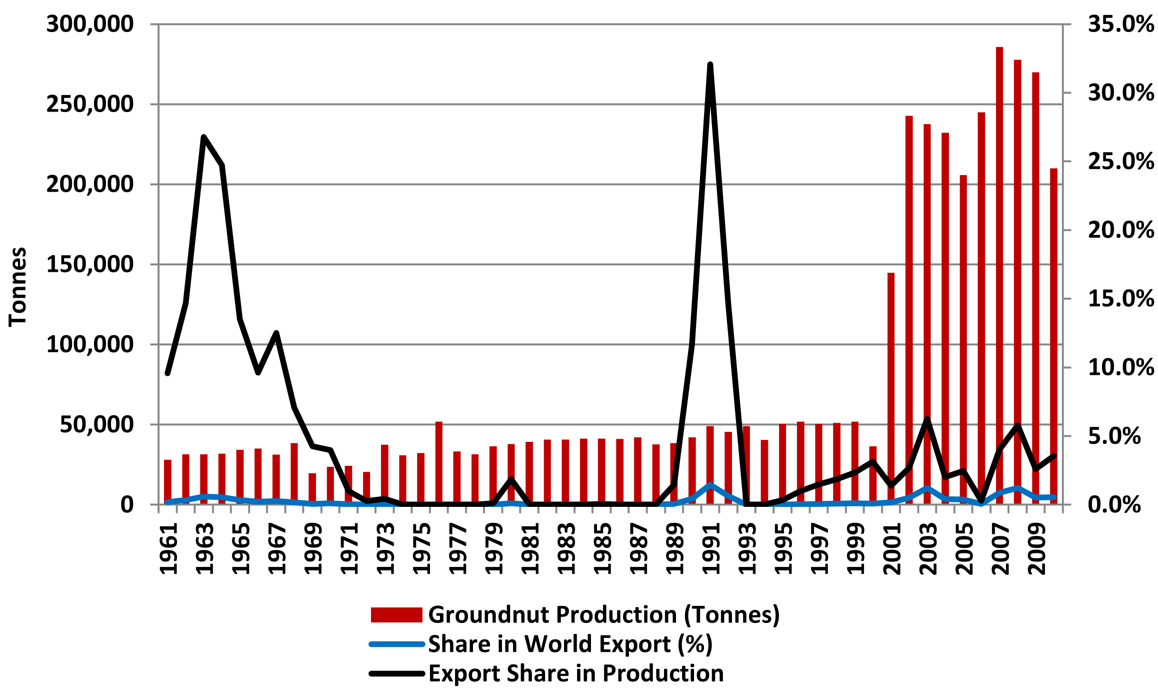
As early classical theorists Ricardo and Heckscher point out, gains from trade stem from specialization in production according to a country’s comparative advantage. This improves allocation efficiency because resources can be shifted to the production of the good(s) a country produces best, resulting in improved welfare in the country and all trading nations. It follows that if aflatoxin contamination in a country means that the country no longer has a comparative advantage in producing the commodity—either because control strategies are not available, or because the management costs related to the controlling the problem are high—trading in that commodity may not be welfare enhancing; the commodity may instead be traded domestically.[6] Thus, in the long run,

[6] Developed countries have domestic regulation along with access to control strategies and are not excluded from international trade. Instead, developed countries face economic costs of managing aflatoxin by establishing and enforcing regulations, testing for aflatoxin, and controlling for it. Robens and Cardwell

as the market adjusts to new knowledge about aflatoxin, the welfare losses may not be significant, and may only be incurred in the short run.

In Tanzania, groundnut trade has historically never been a large share of the world export market (see Exhibit 6-3). Overall, Tanzania's groundnut exports have been less than 1.5 percent of the world export market. As a share of total production, historically between 1962 and 1963 the share of exports ranged from as much as 25 percent to 27 percent. In 1991, the export of groundnuts in domestic production spiked to 32 percent but since has settled to between 2 to 6 percent of domestic production. Undoubtedly there are gains to be had by entering the international market for groundnuts. Some of these gains cannot be accessed because of aflatoxin contamination, particularly because of the increased production of groundnuts since 2001, when the total domestic production has been greater than 200,000 MT.

Exhibit 6-3: Historical Tanzanian Groundnut Production and Export Share



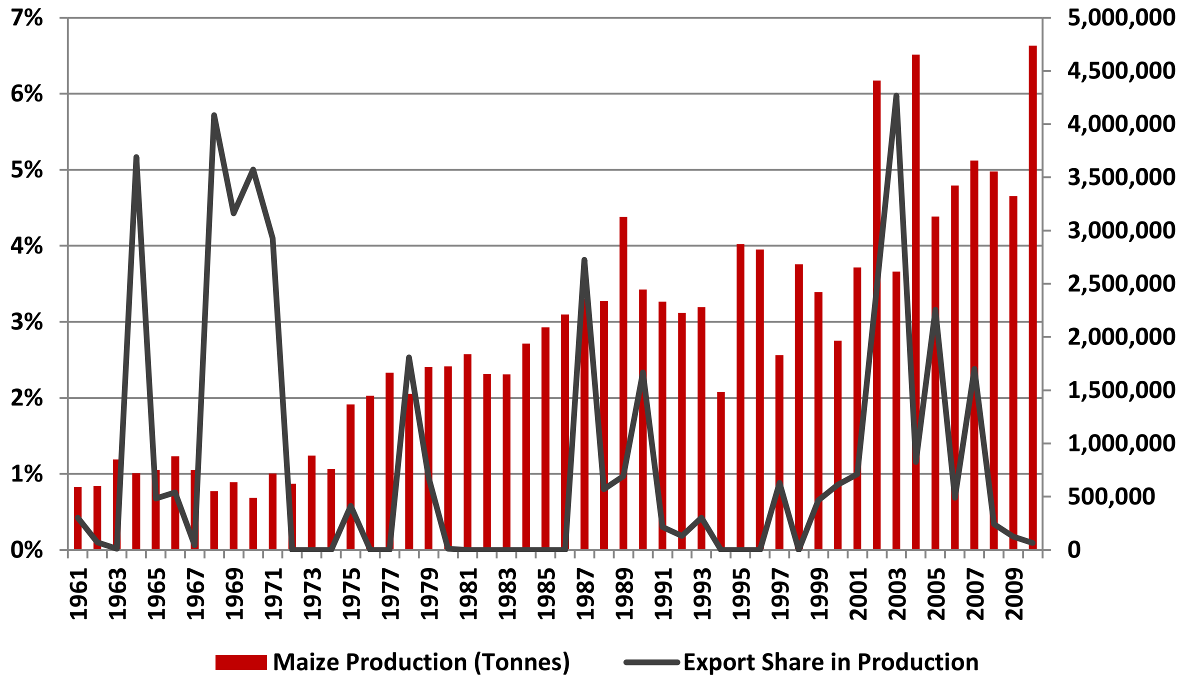
Data Source: FAOSTAT (2012).

In the short run, Tanzania may incur some costs because of rejection of groundnut and maize consignments, however small they may be. *A review of the European Union (EU) alerts and border rejections suggests that between 2007 and 2012, there were no notifications related to aflatoxins for Tanzania*.

(2003) assess the impact of managing mycotoxin and the cost of testing in the United States. Since this framework is written in the context of developing countries, it will not go into further detail in estimating these costs.

Maize is an important staple crop for Tanzania and grown largely for own consumption; therefore, in the long run this crop will continued to be produced even if there are no international markets that it can reasonably access. There will be realized losses if any excess production cannot be sold in the international market. However, because maize is an important crop for food security, its export is often prohibited. Historical data for maize production and exports indicate that exports are a small share of total maize production in Tanzania. The share increased to 6 percent in 2003, but from 2008 to 2010 export share was less than 0.35 percent (see Exhibit 6-4). Given these export bans and generally low volume of exports, aflatoxin contamination is not resulting in significant international trade loss.

Exhibit 6-4: Maize Exports as Share of Total Domestic Production in Tanzania

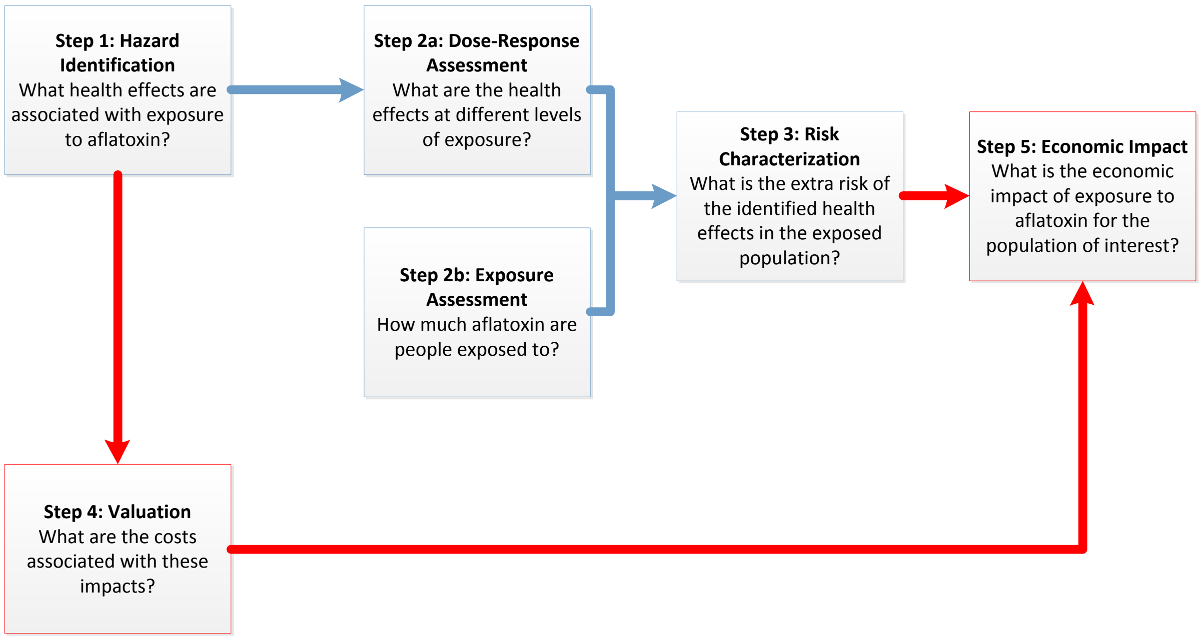


Data Source: FAOSTAT (2012)

6.3 Health

For reasons explained earlier, the largest impact of aflatoxin contamination in Tanzania is expected to be on human health. Economic impacts/damages due to consumption of aflatoxin-contaminated food by humans come from health impacts of aflatoxin toxicity. To determine these impacts, it is necessary to conduct a quantitative risk assessment for aflatoxin and then value the estimated damages to human health. A risk assessment is a four-step process consisting of (1) determination of the health effects associated with exposure to aflatoxin (hazard identification, step 1 in Exhibit 6-5); (2) determination of the health effects at different levels of exposure (dose-response analysis, step 2a in Exhibit 6-5); (3) determination of the levels of aflatoxin that people are exposed to (exposure assessment, step 2b in Exhibit 6-5); and (4) determination of the extra risk for the identified health effects to occur in the exposed population (risk characterization, step 3 in Exhibit 6-5). The risk assessment steps in Exhibit 6-5 are shown in blue. Steps 2a and 2b are concurrent. Once the risk characterization is complete, it is possible to estimate the economic impacts from aflatoxin exposure. Step 1 of risk assessment (i.e., hazard identification) and Step 3 (risk characterization) contribute directly to economic impact estimation. The steps for economic impact estimation (steps 4 and 5 in Exhibit 6-5) are shown by the red arrows and boxes in Exhibit 6-5.

Exhibit 6-5: Approach to Estimating the Economic Impact of Aflatoxin Contamination



Hazard identification is based on several studies that have found evidence that *chronic exposure* to aflatoxin is associated with several human health effects, including liver cancer (IARC, 2002), liver cirrhosis (Kuniholm et al., 2008), immunologic suppression (Williams et al., 2004), and growth impairment (Khlangwiset et al., 2011). High levels of exposure (i.e., *acute exposure*) may result in acute aflatoxicosis. We do not include this endpoint in our assessment because the dose-response relationship has not yet been developed and the frequency of such high exposures is unknown (Wu et al., 2011). We develop numerical estimates of health impacts due to aflatoxin exposure only for liver cancer (hepatocellular carcinoma, HCC), because this is the only endpoint for which a dose-response relationship was established and accepted by the Joint FAO/WHO Expert Committee on Food Additives (WHO, 1998). There is evidence that supports the association between aflatoxin exposure and stunting in animals and humans (Khlangwiset et al., 2011; Gong et al. 2002). However, stunting is also correlated with poor nutrition and poor gastrointestinal function, and the interactions between contributing factors are not well understood. Because the latter problems are common in sub-Saharan Africa, it is difficult to ascertain whether aflatoxin exposure by itself causes stunting in the absence of malnutrition and/or poor GI function, or if there is a synergistic effect where aflatoxin exposure amplifies the effects of malnutrition and poor GI function on growth impairment. Nevertheless, because the evidence for the association is strong, preliminary estimates of the economic impact are estimated using Gong et al. (2002).

The **dose-response** relationship between aflatoxin exposure, measured in nanograms (ng) of aflatoxin per kilogram (kg) of body weight (bw) per day, and HCC incidence per 100,000 population is linear. Further, consistent with other carcinogens, *it is assumed that the dose-response relationship does not have a threshold, meaning that any aflatoxin exposure level can cause a risk.* Cancer potency (i.e., an increase in annual HCC incidence rate per unit change in aflatoxin exposure) varies across populations by HBV status: There is a 30-fold higher liver cancer risk for HBV-positive individuals. Specifically, in HBV-positive populations, aflatoxin HCC potency is 0.3 cancers/year per 100,000 population per one ng/kg-bw/day, while in HBV-negative populations, aflatoxin HCC potency is 0.01 cancers/year per 100,000 population per one ng/kg-bw/day (WHO, 1998).

Exposure assessment, or determining the exposure of Tanzanians to aflatoxins, requires information on the amount of aflatoxin-contaminated food consumed by individuals, the concentration of aflatoxin in the food, and the body weight of the individual. It is important to note that in the case of HCC, the dose response is defined for aflatoxin B1. Hence, we consider the prevalence only of aflatoxin B1 in our analysis. Body weight is important because the same amount of consumption can have different health impacts for people with different weights.

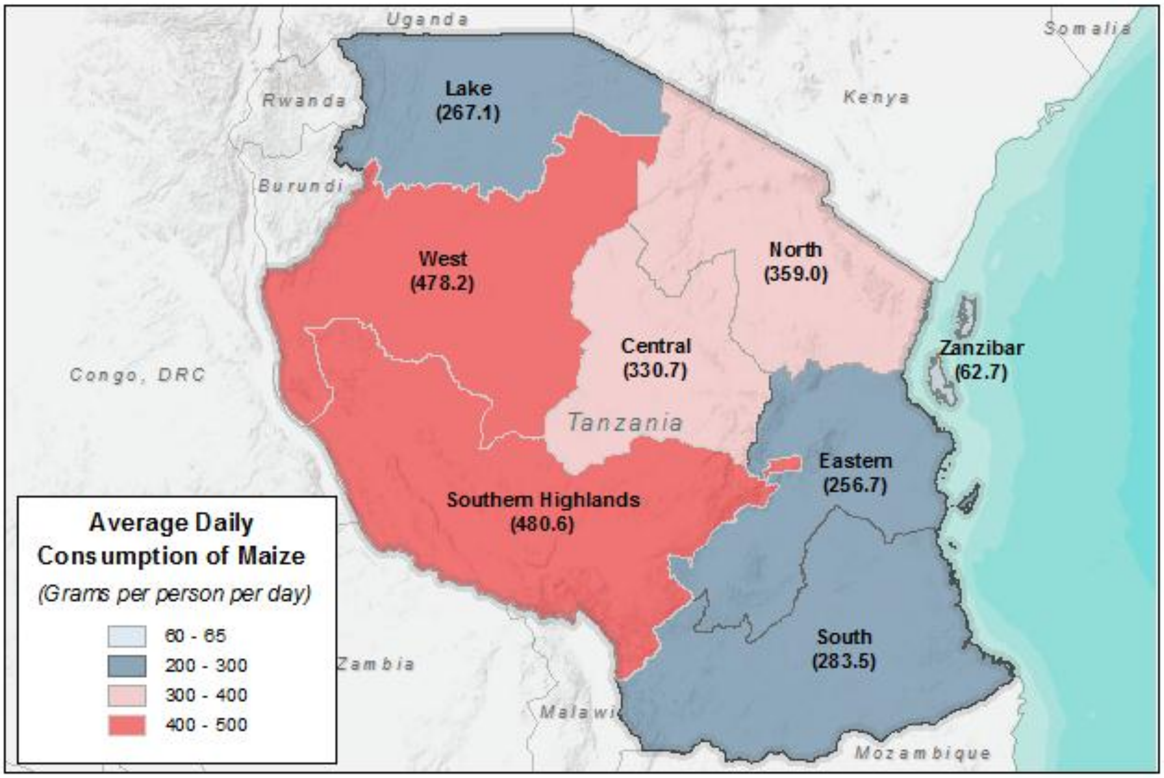
$$\text{Exposure (ng/kg-bw/day)} = \frac{\text{Amount Consumed } \left(\frac{\text{g}}{\text{day}}\right) \times \text{Aflatoxin Concentration } \left(\frac{\text{ng}}{\text{g}}\right)}{\text{Body Weight (kg)}}$$

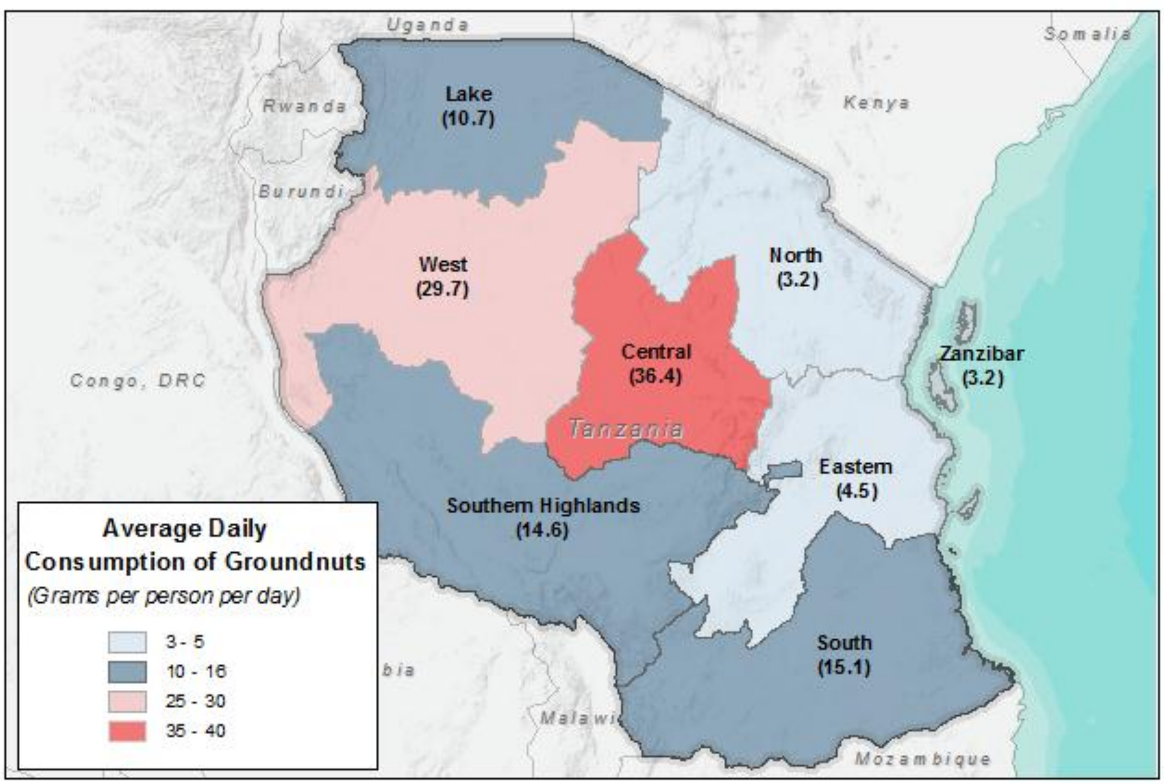
Information on consumption was derived from the LSMS surveys for Tanzania that provide household-level weekly consumption of various food items and several individual characteristics (e.g., age, sex, height, and/or weight). To allocate household consumption to individuals and obtain estimates of individuals' daily intake of maize and groundnuts, we used the Adult Male Equivalent approach that has been applied to develop inputs for food fortification and other nutrition program evaluations (Neufeld et al., 2012). This approach uses individuals' age and sex, reference body weights from the World Health Organization (WHO), basal metabolic rate (BMR) based on body weight, and physical activity levels (PAL) to calculate total daily energy requirements (TEE).[7]

Exhibit 6-6 presents the estimated average consumption of maize and groundnuts in grams per person. For our health estimates we estimated the average consumption per person per kilogram of body weight using LSMS-ISA (2009). In general, maize consumption is very high in the West and Southern Highlands, ranging from 400-500 grams per person per day. Overall in mainland Tanzania, maize consumption is quite high and above 200 grams per person per day. As discussed more in detail below, this implies that the risk of aflatoxin exposure at a given prevalence level is likely to be the highest in this region. In fact, as is argued later, even at low levels of prevalence such high levels of consumption can imply a measurable health impact.

7 **WHO reference weights:** We use the weights provided by Weisell and Dop (2012) for adult men and women and WHO weight-for-age tables for children aged 0-9 years. For children aged 10-17 years, weight-for-age tables are not available. Therefore, we estimate body weight based on body mass index (BMI) and height at each age, using WHO reference tables. Note that the estimated weights (based on BMI) for age 17 would be higher than the adult weights given by Weisell and Dop (2012). Therefore, we truncate weights at 64 kg for males and 55 kg for females. **BMR equations:** BMR equations are provided in Schofield (1985) for adults and Table 5.2 of FAO (2004) for children. **PAL:** We assume a PAL value of 1.75 based on Weisell and Dop (2012).**TEE equations:** The equations for TEE are from Section 4.2 of FAO (2004) for children and from Section 5.3 of FAO (2004) for adults.

Exhibit 6-6: Regional Average Consumption of Maize and Groundnuts in Tanzania (2008–2009)





Risk Characterization involves estimating the population cancer risk, which is equal to the aflatoxin exposure as calculated above times the HCC potency, which is an average of HBV status-specific HCC potencies weighted by HBV prevalence in Tanzania:

Population Risk (cancers/year/100,000) = Exposure ×
(Share of HBV-positive × HBV-positive HCC Potency +
Share of HBV-negative × HBV-negative HCC Potency)

To derive the annual number of HCC cases that occur due to aflatoxin exposure, we multiplied the estimated population risk by the region-specific population (expressed in 100,000s).[8]

Disability Adjusted Life Years (DALYs) Lost. Under the assumption that all estimated HCC cases result in death within the same year, we estimated annual Disability Adjusted Life Years (DALYs) lost due to aflatoxin contamination-related HCC cases. DALY is an epidemiological measure of disease burden expressed in the number of healthy life years lost due to death or disability caused by disease. We used regional estimates of total liver cancer deaths and total liver cancer DALYs from the Global Burden of Disease project (WHO, 2008) to derive a DALY value for an HCC case in Tanzania.[9]

Monetized Health Impact. The health impact estimates assume that that all estimated HCC cases result in death within the same year. The estimates do not include any morbidity or illness related costs particularly because access to treatment is limited in developing countries; in that sense they are a lower bound estimate. We monetized the total aflatoxin-related liver cancer burden by extrapolating values from the United States, with adjustments for differences in income between the two regions using a transfer approach proposed by Hammitt and Robinson (2011). Specifically, we started with an estimate of willingness to pay for small changes in mortality risk—i.e., the value of a statistical life (VSL)—developed for the U.S at 8.9 million U.S. dollars.[10] This value was adjusted for differences in income per capita between U.S. and Tanzania.[11] Following recommendations in Hammitt and Robinson (2011), we used several income elasticity values (1, 1.5, and 2) for the transfer and bound the derived VSL estimate (from below) using the present value of future consumption (at 3% discount rate). We estimate a high VSL estimate of $169,000 per HCC death (using income elasticity of 1) and a low VSL estimate of $32,000 per HCC death (based on the present value of future consumption).[12]

---

8 Note that in each region, population risk was characterized separately for males and females by estimating sex-specific maize and groundnut consumption, HBV prevalence, and population.

9 We derived sex-specific HCC DALY estimates using WHO's AFR D region data. The estimated value for males was 12.3 DALYs per HCC case, and the estimated value for females was 13.8 DALYs per HCC case.

10 This U.S. VSL is 4.8 million of 1990 U.S. dollars at 1990 income levels (US EPA, 2010). It was adjusted for inflation and income growth between 1990 and 2010. The updated U.S. VSL value used in our calculations was 8.9 million in 2010 U.S. dollars.

11 The Purchasing Power Parity (PPP) based GNI per capita for 2010 (from the World Development Indicators Database, http://data.worldbank.org/indicator) was used in all calculations. The U.S. PPP-based GNI per capita was $47,360 (in 2010 U.S. dollars) and the Tanzania PPP-based GNI per capita was $1,430 (in 2010 U.S. dollars).

12 All values are in 2010 U.S. dollars.

These estimates assume that the willingness to pay for to avoiding risk of death in Tanzania differ from U.S. only in scale because of differences in the level of incomes and income elasticities. In reality it is possible, where level of income is lower, health is considered a luxury and is undervalued so that willingness to pay avoid risk of deaths is lower. To this extent, our estimates may be an upper bound.

Health Impact Estimates. In Tanzania, the prevalence data that has been gathered thus far imply that there is a great degree of variability in aflatoxin contamination across the country, and within zones. A large percentage of the samples tested had aflatoxin contamination below the minimum level of detection. Yet there were samples with aflatoxin contamination well above regulated levels. This suggests that there is significant uncertainty in determining mean aflatoxin contamination. Therefore, we have conducted a sensitivity analysis of impacts for different levels of aflatoxin prevalence, using the current maize and groundnut consumption patterns, HBV prevalence rates, and 2010 regional population estimates in Tanzania.

Following Shephard (2008), Exhibit 6-7 shows the number of HCC cases at different levels of aflatoxin B1 prevalence given the regional consumption of maize and groundnuts, the 2010 regional population estimate, the age and sex distribution, and the sex-specific HBV prevalence. Note that the analysis assumes that the prevalence is the mean contamination levels for food consumed through an individual's lifetime. In reality, there will be seasonal and regional variation in the contamination. Secondly, the contamination levels are related to the food that is ready for consumption and not maize on the field. There is potential for reduction in prevalence levels between maize that leaves the field and the form that it is consumed (e.g., *ugali).*

We find that even at the regulated level of aflatoxin B1—5 ppb— of contaminated maize and groundnuts, the total annual cancer cases attributable to aflatoxin contamination are estimated to be 546, which is more than a third of the total estimated liver cancer cases in Tanzania in 2010. Of these cases, the West, which has one of the highest maize consumption levels, accounts for the largest number of these cases. *At even at low levels of aflatoxin contamination of key staples, there is measurable health impact because of high contribution of the staples in the Tanzanian diet.*

Exhibit 6-7 also presents the regional estimates of HCC cases at different prevalence levels accounting for regional differences in consumption and population levels. In the Eastern zone and West zones the recent data suggests found aflatoxin B1 above 5 ppb in 43 percent and 40 percent of the samples with average contamination of 50ppb and 28ppb. These regions are likely to have higher average aflatoxin contamination. At average aflatoxin contamination of 10 ppb, 115 liver cancer cases can be attributed to aflatoxins in the Eastern zone and 277 in the Western zone. At 10 ppb, the national annual cancer cases attributable to aflatoxin contamination would be 1,092, accounting for more than 90 percent of the total liver cancer cases in Tanzania.

Exhibit 6-7: Estimated HCC Cases Attributable to Aflatoxin B1 Contamination in Tanzania for Ranges of Aflatoxin Prevalence Levels

Zone	Maize and Groundnut Consumption (g/person(60kg)/day)	Aflatoxin B1 Contamination (ppb) 2	5	10	20	50	100
Central	367	18	45	90	181	452	903
East	261	23	58	115	230	575	1150
Lake	278	30	75	149	298	746	1491
North	362	34	85	171	342	854	1708
South	299	16	41	81	162	406	812
Southern Highlands	495	41	102	203	406	1015	2030
West	508	55	139	277	554	1385	2770
Zanzibar	66	1	3	6	11	28	55
National	**521**	**218**	**546**	**1,092**	**2,184**	**5,460**	**10,920**

Estimated number of liver cancer cases in Tanzania is 1,209 (derived using the 2010 Tanzania population estimate and 2004 liver cancer incidence rate – 2.8 deaths per 100,000 population-- estimated for Tanzania by the Global Burden of Disease Project, WHO, 2008).

Exhibit 6-8 presents the equivalent DALY and the monetized value of aflatoxin-related liver cancer burden, at different contamination levels. At prevalence rates of 5 ppb, the monetized burden is between $18 million and $147 million (in 2010 U.S. dollars), while at 10 ppb the monetized burden is between $35 million and $294 million (in 2010 U.S. dollars).

Exhibit 6-8: DALY and Monetized Burden of Liver Cancer Cases by Contamination Levels

	Aflatoxin Contamination level (ppb) 2	5	10	20	50	100
DALY	2,851	7,127	14,253	28,507	71,267	142,534
VSL-Low ($1,000)	6,989	17,472	34,945	69,890	174,724	349,448
VSL-High ($1,000)	58,751	146,877	293,755	587,509	1,468,773	2,937,547

Analysis of Sensitivity to Assumptions about HBV Prevalence. We also assessed the impact of reducing HBV prevalence on the number of aflatoxin-related liver cancer cases. We find that if the HBV prevalence is reduced to zero, at the same levels of aflatoxin contamination as well as maize and groundnut consumption, the number of aflatoxin-related liver cancer cases from aflatoxin contamination could be three times smaller (at 5 ppb, 188 HCC cases per year as compared to 546 HCC cases per year).

In summary, the core concern of aflatoxin contamination of maize in Tanzania is the high dependence on maize in food intake. At these levels of consumption, even a low level of aflatoxin contamination can mean a measurable health impact. The prevalence data suggests that aflatoxin contamination in maize is a concern mainly in the Eastern and Western zones. In other zones majority of the samples did not have aflatoxins above 5 ppb. There is significant uncertainty in the extent of aflatoxin contamination in Tanzania, and the prevalence of contamination in 2012 is variable both across and within regions.

7 Opportunities for Aflatoxin Control in Tanzania

This section considers the regulatory framework governing aflatoxin control, which is key to setting a compelling tone and useful direction for central- to field-level prevention and mitigation strategies involving both public and private stakeholders and straddling the health, agriculture, and trade sectors. The section highlights viable control strategies that have either already gained traction or have promise in Tanzania, with particular emphasis given to those that were prioritized in the multi-stakeholder workshop held on December 3 and 4, 2012 in Dar es Salaam. The workshop was convened as the final step of the country assessment to disseminate the findings on the prevalence of aflatoxin, its risks, its impacts, and the potential control strategies, with the final objective of identifying key control strategies and supporting action plans. More than 50 stakeholders came together at this workshop, which was co-organized with TFDA to identify priority control strategies in the three sectors—agriculture and food security, trade, and health.[13] Action plans that support adoption of the priority control strategies were sketched out by small groups in this workshop for five topic areas: Agriculture (Pre-Harvest), Agriculture (Post-Harvest), Trade, Health, and the cross-cutting area of Policy Reforms. These are provided in Appendix A. The workshop was a critical step for translating the country assessment into actionable recommendations through cross-sectoral collaboration and enhanced country ownership.[14]

The National Forum for Mycotoxins Control, with a supporting steering committee (the National Steering Committee for Mycotoxins Control) was also formed at the workshop, with its secretariat in TFDA. This steering committee will meet in the beginning of 2013 to flesh out the skeletal action plans formulated during the workshop; to recommend how to allocate roles and responsibilities between and within relevant ministries and academic, private, and civil society organizations; and to mobilize and organize resources needed to implement the action plans.

The priority control strategies for Agriculture (Pre- and Post-Harvest), Trade, Health, and the cross-cutting area of Policy Reforms prioritized at the workshop are also summarized in this section.

---

[13] The stakeholders included **Government Institutions:** Ministry of Health and Social Welfare, MoAFC, Ministry of Industry and Trade, Ministry of Livestock Development, TFDA, Tanzania Food and Nutrition Centre, Government Chemist Laboratory Agency, Small Industries Development Organisation, Tanzania Bureau of Standards, Tanzania Trade Development Authority, National Food Reserve Agency, and Tanzania Women Chamber of Commerce, Crop Boards (Tanzania Cashewnut Board); **Local Government Authorities:** Kongwa district council, Njombe town council, Bukombe district council, Kibaigwa market, Lihobaika village; **Research and Academic Institutions:** Naliendele Research Centre, Uyole Agricultural Research Centre, Sokoine University of Agriculture, Open University of Tanzania, and Nelson Mandela Africa Institute of Science and Technology**; Development Partners:** Abt Associates Inc., IITA, Tuboreshe Chakula Project, Tanzania, Centre for Disease Control, NAFAKA, , Mwanzo bora Nutrition Program – COUNSENUTH, BecA-CSIRO aflatoxin project, Capacity and Action for Aflatoxin Reduction in Eastern Africa (CAAREA); **Private Sector:** Food Processors, Tanzania Animal Feed Processors Association (TAFMA), Professional Board (Tanzania Institute of Food Scientists and Technologists), and the East African Community secretariat; **Farmers Groups:** KIFFISACCOS and AMCOS.

[14] All workshop materials can be found at http://abtassociates.com/Tanzania-Aflatoxin-Stakeholders-Conference.aspx

7.1 Aflatoxin Control Strategies for Agriculture

As noted above, control strategies at the pre-harvest stage can prevent contamination from ever entering the food supply. However, control strategies must either be directly affordable to the poor, or subsidized in the name of the public good, since much of the subsistence farming subsector is not currently affected by formal quality control mechanisms.

Develop and use bio-controls such as the IITA-developed Aflasafe that can reduce aflatoxin levels in soil and among treated crops, even after poor storage.[15] IITA's investigation of atoxigenic fungi strains in Tanzania that can be used in developing an Aflasafe-like product of Tanzanian origin as well as investigation of farmers' willingness and ability to pay for the product are good steps toward development of a bio-control strategy for Tanzania.

Scale public and private sector initiatives to increase access and adoption of agricultural inputs and continue to scale targeted input vouchers for the poorest farmers. Demand for inputs is high, but access and affordability often prohibit adoption. Farmers indicated that pests were among the biggest threats to crop loss. Factors that allow for increased use need to be replicated in other areas to improve ease of access and use of agricultural inputs.

Use national data on agricultural stressors to inform market-based solutions to address localized threats. Stress-resistant seeds may have significant demand in all agricultural zones other than the Southern Highlands, where only 15 percent of the farmers reported having drought or floods. In all other zones, between 27 to 38 percent of the households reported being severely affected by climate shocks. The market demand for insecticide is likely to be highest in the West, where pest invasions affect the highest proportion (40 percent) of farmers (see Exhibit 7-1).

Exhibit 7-1: Shocks to Household Welfare (Percentage of Households Severely Affected by Each Shock)

Zone/Income Group	Crop Disease/Pests	Drought/Floods
By Zone		
Central	33%	25%
East	12%	27%
Lake	34%	27%
North	27%	38%
South	23%	32%
Southern Highlands	19%	15%
West	40%	34%
Zanzibar	16%	3%
National	**27%**	**28%**

Data Source: LSMS-ISA 2008-2009

Capitalize on mobile technologies and banking services to design business models for agricultural inputs that serve the poor. Currently, only 15 percent of farmers access government extension services. The advent of mobile technologies combined with public-private partnerships

15 Several studies have found significant levels of aflatoxin reduction from the competitive use of fungus including a 60–87 percent reduction (Dorner et al., 1999), a 70–91 percent reduction (Dorner and Horn, 2007), and an 80 percent reduction (Cline, 2005).

(PPPs) with agro-dealers promises to fill this gap innovatively, although scaling up, blanketing rural areas, and incentivizing uptake all remain challenges. One project that capitalizes on both PPPs and mobile technologies to reach the poor includes the government's subsidy program, which subsidizes half the cost of seed and fertilizers to impoverished farmers using agro-dealers and vouchers for distribution. For these initiatives to be successful, however, farmers also need extended, affordable credit to purchase the inputs needed to cope with natural stresses such as drought and pests. To date, the initiative is small, but it represents one innovative way in which effective inputs (e.g., bio-controls, drought-resistant seeds), could be commercially distributed on a scale that surpasses the reach of conventional extension.

Use the global research agenda on aflatoxins to inform and complement domestic research, and vice versa. Finally, international investigations of other control strategies such as aflatoxin-resistant planting materials, including conventional and transgenic breeding and ammoniation, can inform Tanzania's own research agenda.[16,17]

Priority Control Strategies for Agriculture: Pre-Harvest and Post-Harvest

- Use good agricultural practices for planting, harvest, and post-harvest handling. Evaluate how these recommendations affect labor burdens on men vs. women and recommend labor-sharing strategies for both.
- Use and promote affordable sale of bio-controls such as Aflasafe™, which has been proven to reduce aflatoxin levels in soil.
- Incorporate messages about aflatoxin mitigation into the national agricultural extension messages. Emphasize the importance of sorting and discarding crops with physical flaws and deformities (e.g., visible mold or damaged shells). This can be an effective way of removing some of the contamination, particularly in groundnuts where physical flaws are more visible (Turner et. al 2005)
- Promote use of insecticides to help keep plants healthy and able to resist fungus, especially in aflatoxin-prone areas. If resources are available also promote use of irrigation, fungicides and herbicides.
- Adopt moisture-control measures such as tarp drying, drying with natural fibers rather than humidity promoting materials (plastic bags), and promote above-ground storage and improved community storage.
- Promote research on safe disposal and alternative use of unsafe commodities, such as biofuels or blended feeds (which in the aggregate conform to safe maximum levels) and finishing feeds, which can have slightly higher levels (300 ppb) of aflatoxins without harming the animal.
- Conduct further research on processes such as use of aflatoxin-resistant planting materials including conventional and transgenic breeding, ammoniation, and commercial processing techniques for mitigating aflatoxin contamination.
- Ensure that information and aflatoxin-mitigating inputs are distributed with channels, times and locations that are accessible to female and male farmers.

The priority control strategies identified at the stakeholder workshop were:

- Measure, test, and assess the scale of the problem for use in public awareness campaigns and to target delivery of control strategies.
- Promote and make available good agricultural practices.
- Develop bio-control approaches for Tanzania, keeping in mind the cost implications for poorer farmers.

16 Conventional seed breeding for aflatoxin resistance has reduced aflatoxins by >70 percent and 82–93 percent. Transgenic breeding for aflatoxin resistance has reduced aflatoxins by 47 percent in maize (Khlangwiset, 2011).

17 Placing maize crops in a sealed container for 1–2 weeks and applying ammoniation gas could reduce aflatoxin levels by 90 percent (Nyandieka et al., 2009).

- Continue research efforts for breeding maize, groundnuts, and other crops for mycotoxin resistance, for availability in the longer time horizon.
- Improve storage facilities at the community level.
- Develop and implement good management practices.
- Improve the transportation system for food and feed crops as well as processed foods.

7.2 Aflatoxin Control Strategies for Trade

Use economic incentives to shift behaviors. Experienced livestock traders report significant economic impacts on their animals from aflatoxin exposure, which greatly affects productivity, growth, and reproduction. Yet because the symptoms of aflatoxin exposure are often attributable to other diseases, small-scale farmers require educational campaigns on aflatoxins. In Tanzania some animal feed traders have demonstrated that they can manage feeds to control aflatoxins if they are made aware of the signs of contamination.

A poultry farmer stated that when purchasing animal feeds she chooses feed that is sound and does not smell damp. She determines dampness by smelling. In case she finds dampness after buying, she returns it to suppliers because chicks would not eat it, and if they did they would get an infection or egg production would be reduced. She further stated that most feed suppliers respond promptly when informed of feed problems and recall as soon as they find the problem. She said that the problem of damp feed is common during winter because at this time millers cannot dry raw materials effectively. She reported an incident that happened in previous years where pigs fed with damp and smelly bran died. However, she was not aware of any national standard for animal feeds.

Explore alternative uses for aflatoxin-contaminated crops. In Tanzania, food crops are rarely discarded. When contaminated crops are rejected by one type of buyer, another, poorer kind of player is usually ready to buy and use the crop at a lower cost. Recognizing the importance of alternative uses, the United States Food and Drug Administration (U.S. FDA) has set regulations on the use of contaminated products that can be blended with uncontaminated products or other ingredients to make the composite feed safe for animal consumption (Dohlman, 2008; Rowe, 2007). This strategy could be adopted in Tanzania and used to reduce food losses.

Research from the U.S. Department of Agriculture (USDA) also shows that feeds with higher levels of contaminants can be used for finishing animals bound for slaughter. The USDA has set higher limits for aflatoxin contamination in finishing feed, which can be used up to 2 weeks before slaughter. Upper bounds for finishing feed can be safely set at 300 ppb for cattle; 200 ppb for swine; less than 100 ppb for breeding cattle, swine, and mature poultry; and less than 20 ppb for dairy cows and young animals (Dohlman, 2008; Rowe, 2007).

Evidence from the livestock and animal feed industry can inform quality control strategies in crops bound for domestic consumption. Social marketing campaigns that raise demand for higher quality commodities must be paired with input distribution and storage programs. These campaigns should enhance the reach and capacity of the inspection authorities, extending the authority of the newly formed commodities exchange board to certify grains as inspected.

Encourage the use of warehouse receipts and the commodities exchange board to enhance and regulate the quality and safety of food bound for domestic consumption. The government of

Tanzania is introducing a warehouse receipt system, which if well implemented can help reduce aflatoxins contamination in maize and groundnuts. Until this program is fully established, communities on a smaller scale can also launch their own warehouse receipt system to incentivize higher quality production. The programs should also include trader education via broader, free dissemination of commodities standards.

Priority Control Strategies for Trade

- Expand food safety and aflatoxin regulations to raw commodities bound for domestic production.
- Shape the marketplace to improve awareness of the presence and risks of aflatoxins in the food and feed system and create market-based incentives for safer food.
- Promote awareness campaigns to increase demand for aflatoxin-safe products and incentivize adoption of aflatoxin control strategies along the value chain.
- Widely, publicly disseminate specifications for acceptable aflatoxin limits by working with rural trade groups and commodities associations and through regional and international trade fairs.
- Educate/persuade retailers and consumers to demand and recognize safer practices by suppliers.
- Provide technical support to improve capacity of medium to large traders and enforcement agencies to recognize the national enforcement agency's "mark of quality."
- Collaborate with existing agriculture development projects, such as the Markets II project, to promote safe production through Aflasafe, improved seeds, and other agricultural inputs.
- Set standards for animal feed at higher levels than for commodities destined for human consumption; use a grading system to ensure safe levels for both.

The priority control strategies identified at the stakeholder workshop were:

- Shape the marketplace to improve awareness of the presence and risks of aflatoxins in the food and feed system and create market-based incentives for safer food.
- Improve the definition and application of standards relating to aflatoxins in domestic markets and import clearinghouses for aflatoxin-susceptible crops.
- Improve policies and procedures for product withdrawal.
- Improve suitability for commerce or trade of susceptible products by identifying and making available best practices for preventing or mitigating aflatoxin levels in priority crops (maize, groundnuts, and cassava) along the supply chains.

7.3 Aflatoxin Control Strategies for Health

Expand universal coverage of the HBV vaccine. Since there is co-morbidity between high aflatoxin levels in the body and hepatitis B, the HBV vaccine can serve as one of the most important public health interventions available for reducing the risk of cancer related to aflatoxin exposure. Reducing prevalence of HBV to zero in Tanzania could reduce liver cancer levels threefold. The HBV vaccine (which costs \$0.32 to \$0.90 per dose) (WHO, 2012) is now fully integrated into Tanzania's expanded immunization program, but vaccination coverage still has room to improve.

Improve dietary diversity, with emphasis on foods that are less likely to be contaminated, and are already a part of the Tanzanian diet. Improving demand for high-quality food while expanding consumption of diverse foods that are not susceptible would reduce overall exposure levels while improving the quality of the overall diet. The current efforts by the TFNC to ensure that aflatoxin management issues are incorporated into the Food and Nutrition Policy and to develop nutrition guidelines are steps in the right direction. TFDA plans to develop a database of aflatoxin exposure. This effort can provide information on regional dietary patterns and appropriate measures that can be promoted to minimize exposure to aflatoxins. The current dietary patterns suggest that bananas and cassava in the Lake region, rice in the Eastern region, and cassava in the south region are the other important staples.

Carry out joint campaigns between the MoHSW and MoAFC to raise consumer demand and incentivize good agricultural practices as well as better household practices for complementary feeding and food use/preparation. The MoHSW and MoAFC could promote joint behavioral change campaigns. Increasing the practice of exclusive breastfeeding among infants younger than 6 months can help reduce direct exposure to aflatoxins through the use of *ogi*, a local maize-based porridge, as a common complementary food. Further, reducing consumption of high-risk foods (e.g., *ugali* or *uji*, a maize-based beverage) that are susceptible to high concentrations of aflatoxins can be an important public health strategy, even when testing facilities are not available.

The MoHSW and MoAFC could promote joint behavioral change campaigns for minimizing aflatoxin exposure though dietary diversity as well as household farming and livelihood practices such as sorting, winnowing, dehulling of maize, drying above the ground, and using hermetic storage to reduce contamination levels in farm products for own use.

Improve the current surveillance and risk communication on food safety infringements. TFDA and TBS could collaborate to ensure that official food safety standards reflect the good manufacturing practices (GMP) and Hazard Analysis and Critical Control Points (HACCP) approach. Further, they could train private sector companies and public sector institutions to use the inexpensive rapid test kits to proactively withdraw contaminated products from the market. These rapid test kits can also be used more frequently by trained users in markets, at assembly points, at export points, and prior to processing to enhance the availability of quality control throughout the value chain.

Consider local food consumption levels in food safety standards. TBS should upgrade codes to reflect ranges of consumption of different commodities (e.g., Average Daily Intake) while considering the tolerance level of the consumer. TBS could write country-specific standards that account for consumption patterns, building on the FAO/WHO Codex Alimentarius, consistent with the World Trade Organization’s Sanitary and Phytosanitary Agreement.

Explore avenues for further research. Chemopreventive agents such as Oltipraz, green tea polyphenols, and sulforaphane can trigger detoxifying enzymes or inhibit enzymes required for the activation of procarcinogens. Enterosorbents such as Novasil® clay or calcium chlorophyllin can also be used to treat acute aflatoxicosis. They prevent absorption (and thus the toxic effects) of aflatoxins by capturing aflatoxins in the gastrointestinal tract and facilitating their elimination.[18]

[18] Some enterosorbents may be appropriate for treatment for acute outbreaks of aflatoxicosis, but not for chronic treatment due to cost and possible side effects (Khlangwiset, 2011). Chemopreventive agents may be more viable for preventive use, and further research is ongoing. Some enterosorbents may be more appropriate only to address acute aflatoxicosis and may not be suitable for daily or ongoing use. Continued research on side effects and long-term effects of chemopreventive agents and enterosorbents is ongoing. Green tea polyphenols, which have lowered contamination in human blood levels, are viewed as potentially viable and affordable dietary inhibitors (Khlangwiset, 2011). Studies have shown a 43 percent lower AFM1 in humans and > 15 percent lower aflatoxin albumin adducts at 500 mg dose at costs of approximately \$0.20−\$1 per day (Strosnider et al., 2006).

Priority Control Strategies for Public Health

- Reduce co-morbidity effects through achieving universal coverage of the hepatitis B vaccine.
- Reduce excessive caloric dependence on susceptible products by promoting dietary diversity.
- Conduct advocacy campaigns among major institutional representatives from the health field to shore up awareness and coordinated efforts that include the health sector.
- Conduct multi-sectoral behavioral change campaigns for food safety, especially among pregnant and lactating women, caregivers of infants, and immune-compromised individuals.
- Place special focus on monitoring foods used for pregnant women and infants/children (porridge, complementary foods).
- Carry out more regular testing of aflatoxin levels in major foods.
- Establish reference laboratories for mycotoxin studies in the eight geopolitical zones.
- For animal health: promote use of chemical toxin binders and anti-caking agent (e.g., Novasil) in animal feed and regulate aflatoxins in animal feed. Increase aflatoxin awareness through animal science associations.
- Conduct population mapping of the exposure to aflatoxins using biomarkers.
- Establish the relationship between the incidence of aflatoxins, levels of biomarkers, and incidence of primary liver cancer in the population.

The priority control strategies identified at the stakeholder workshop included:

- Promote proper food handling, processing, and preparation to reduce mycotoxin contamination.
- Achieve universal vaccinations for HBV since liver cancer risk is 30 times higher in HBV-positive populations.
- Address the mycotoxins issue in the Infant and Young Child Nutrition (IYCN) guidelines.
- Routinely monitor mycotoxins in cereal-based weaning foods.
- Detect and map aflatoxins in cereals to understand the extent of the problem in the country

7.4 Institutional, Policy, and Regulatory Environment and Related Opportunities for Policy Reforms

Tanzania’s regulatory structure for setting and enforcing aflatoxin standards spans several core ministries and institutions. TBS, a parastatal organization under MoIT, oversees the process of setting national standards for food products and processes, as well as food-related enterprises. TBS also oversees the processes for setting national standards for metrology, testing, and certification. Using mainly the national food standards, TFDA, a government agency under the Ministry of Health and Social Welfare (MoHSW), regularly inspects, tests, and certifies all foods sold for export regardless of destination. TFDA delivers these services through the Directorate of Food Safety which is organised in three departments; Department of Food Evaluation and Registration, Department of Food Inspection and Enforcement and Department of Risk Analysis. The department of Food Evaluation and Registration evaluates and registers all pre-packaged foods before are authorized for manufacture, import or export. The department of Food Inspection and Enforcement authorizes manufacture and monitors sale of such registered foods. Prior to authorizing manufacture of food the Department of Food Inspection and Enforcement inspects food processing for their Good Hygiene Practices and Good Manufacturing Practices (GMP), and asks manufacturers to apply Hazard Analysis and Critical Control Points (HACCP) principles in food manufacturing. The Department of Food Inspection and Enforcement, also issues import and export permits for foods, and monitors imports and exports of foods. TFDA inspectors collect samples for TFDA laboratory analysis before exports are permitted.

The department of Risk analysis is responsible for risk assessment of food. It also conducts post market surveillance for foods and performs surveillance of food-borne.

The **MoAFC** is currently formulating its national policy on agriculture, which will include GAP and has the potential to impact aflatoxin control. However, currently the policy does not explicitly discuss aflatoxins, which may have to be included as part of the guidance that is developed under the policy. Currently, GAP is also not recognized as being related to food safety concerns. Within MoAFC, the Directorate of Food Security and its focus on post-harvest management is also relevant to aflatoxin control but has not yet included aflatoxin explicitly in its strategy.

Recently, the parliament also established a **commodities exchange board** for cereals and other produce that will include marketing boards for maize and groundnuts. These boards have the potential to establish clear standards for quality control (including aflatoxin levels) for the commodities that they buy and sell.

The **Ministry of Livestock Development and Fisheries** has enacted a law on the quality of animal feed – the Grazing-Land and Animal Feed Resources Act. It is expected that through legislation under this law, animal feed manufacturers will be registered with the ministry for better compliance with the regulations and standards for manufacturing the feed. The specific details of these regulations are currently being formulated and may need to be completed in coordination with TBS and TFDA through a process that also engages animal feed manufacturers and farmer associations among others. Because these regulations focus on poultry feed only, there is potential to generate awareness on feed for other livestock that is supplemented by homemade products or maize bran.

TFNC is an independent parastatal organization that is the coordinating body for the Scaling Up Nutrition (SUN) Movement and Tanzania’s nutrition strategy and is therefore very relevant to aflatoxin control. TFNC has the mandate to work on aflatoxins and has laboratory capacity to test for them. The organization works on food quality, utilization of products in the context of fortification, testing of animal feed, and education and training on these topics. In particular, TFNC has been engaged in nutrition messaging for mothers and for IYCN practices. Therefore, the organization can play a key role not only in aflatoxin testing, but also in formulating nutrition guidance/curriculum for aflatoxin control, and implementing behavior change communications to promote the guidance.

Additional gaps and opportunities in the current institutional and regulatory framework governing aflatoxin control and mitigation are described below.

Set and publicize clear division of roles and responsibilities, which may yield greater regulatory efficiencies. Researchers and agricultural practitioners consulted in the field stressed confusing mandates and duplication of effort. Setting clear parameters such as assigning responsibility for standard setting and dissemination to TBS and for enforcement to TFDA may yield greater efficiencies and less confusion in mandates. Many agencies cite the need for expensive laboratory equipment that is not available under the current budgetary allocations.

Foster agreement among stakeholder agencies on a coordinated, risk-based surveillance strategy to communicate and isolate threats to the food system. The good agricultural practices approach to primary agriculture and incorporation of HACCP and GMP in manufacturing are often absent. Verification and dissemination of research data and information for the application of GAP and HACCP at relevant points of the food chain are poor. Research data are not widely disseminated, and the response to food-borne illnesses is poorly coordinated. These problems are partially due to constrained resources, which reduction in duplicative mandates can help address, as can enhanced systems for information sharing.

Explore alternative uses for contaminated products and incorporate the approach in the regulations for disposal and treatment of unfit foods. There are no reported procedures for directing aflatoxin-contaminated foods to other uses. Without guidelines or a market for alternative uses of aflatoxin-contaminated products, there will be large, avoidable losses of foods when the current regulations are strictly enforced.

Increase free, web-based public access to the codes and standards regulating food commodities, processes, and enterprises. Communication to consumers on the quality and safety features of the food system will better inform purchase decisions. Public awareness starts at the point of sale with proper labeling, but can be reinforced through industry promotion and media reporting. Even before that, government needs to publicize the existence of codes and standards, and make them readily available in hardcopy and digital form. Some countries make these standards freely available to the public via a national government website, which is a practice recommended in order to increase compliance among interested parties.

Strengthen the institutional mandate for cross-ministerial collaboration in producing aflatoxin-free food and stimulating consumer demand for better quality and safer food. The MoHSW through TFDA is crafting food safety and quality policy. This policy can be harnessed to increase the mandate for cross-sectoral collaboration for extension messaging, particularly at the rural field level. Currently, nutritional counseling does not actively promote GAP as a way to enhance food safety, nutritional, and health status. Especially in rural health outposts serving a large proportion of subsistence farmers, opportunities to advise patients on the health implications of food and crop safety should be increased. Increased collaboration between agro-dealers, health and extension workers, and rural community organizations can further strengthen the adoption of GAP, the accompanying agricultural inputs, and overall consumer demand for high-quality foods.

The stakeholder workshop considered these and other avenues where cross-cutting action is needed for aflatoxin control. The small group on policy, which included Dr. Claude Mosha from the African Union, Dr. Raymond Wigenge from TFDA, and Dr. Joyceline Kaganga from TFNC, proposed the following priority control strategies.

Priority Control Strategies for Policy Reforms

- Recommend review and finalization of various policies that are important for food safety and mycotoxin control: (1) National Food Security Policy, (2) National Food Safety Policy, (3) National Nutrition Policy, and (4) Draft Regulations under the Grazing-Lands and Animal Feed Resources Act.
- Mainstream GAP and other food safety-friendly measures within agricultural extension efforts.
- Coordinate with relevant ministries and institutions and propose mycotoxin levels for feed.
- Ensure that dairy legislation recognizes the official national standards for mycotoxins.
- Ensure that priority strategies and action plans are included in the business plans of relevant departments and institutions within line ministries.
- Raise awareness from the community level up to the decision makers, using a coordinated strategy with the trade and agriculture sector. The awareness-raising campaign should include information on control strategies.
- Support more research to fill the current gaps in aflatoxin prevalence in Tanzania—in the field and in foods—

to increase information on producing and consuming aflatoxin-free foods.

- Develop and agree on a data collection protocol and require that results from research conducted in Tanzania be shared with the national government and entered into a centralized database, to be managed by the newly formed Secretariat of the National Forum for Mycotoxins Control.

8 Avenues for Further Action and Conclusion

This report demonstrates that the cost of inaction related to aflatoxin control in Tanzania can be high because of the high dependence on maize in the average daily diets, as well as high prevalence of contamination in groundnuts. The sensitivity analysis of estimates assuming different contamination levels (see Section 6.3) suggests that even at aflatoxin contamination of 10 ppb (which is the regulatory limit in Tanzania), given the current consumption levels of maize and groundnuts, the estimated population in 2010, and current HBV prevalence rates, 1,092 liver cancer cases can be attributed to aflatoxins. These amount to a monetized burden between $35 million and $293 million (in 2010 U.S. dollars). Since cancer risk from aflatoxin exposure is sensitive to HBV prevalence, focusing efforts on HBV immunizations could reduce liver cancer cases from aflatoxins threefold.

While a range of solutions for aflatoxin control are readily available at all stages of food production, resources are scarce in comparison to the many development challenges that Tanzania faces. Thus it makes most sense to prioritize interventions based on country-led perceptions of risk to vulnerable populations, reward in terms of prevention or mitigation, capacity to pay, and degree of political and institutional support. The process of prioritization and action began with the stakeholder workshop that was co-organized with TFDA. There was agreement at the workshop that mitigation strategies should be multi-sectoral in nature, supported by relevant public and private sector institutions and respected professionals that represent plant and animal agriculture, human and animal health, commerce, and trade. Ideally, their actions should be coordinated through an entity that can meld and reconcile competing interests, champion the cause, and provide continuity of attention over time. The recent stakeholder workshop held in Dar es Salaam, which concluded the country and economic assessment effort undertaken by Abt Associates Inc. and TFDA, formed such an entity—the **National Forum for Mycotoxins Control.**

The workshop participants overwhelmingly agreed on **creating broad-based awareness** about mycotoxins generally and aflatoxins in particular, while simultaneously embarking on **prevention, control, and mitigation strategies appropriate to each affected sector**. If consumers' awareness increases, resulting in changes in effective demand and price penalties for contaminated product, **both retailers and suppliers will try to respond to the resulting market signals**. However, because some interventions depend on the existence and enforcement of suitable regulatory controls, it is important to establish and maintain a regulatory framework that is backed by political support and adequately resourced to enforce it. The workshop identified key areas for **policy reform that will create a proper enabling environment** for aflatoxin control.

It is also important to recognize that **raising awareness about aflatoxins may have unintended consequences on sensitive segments of the population.** These might include an increase in the relative price of safe food for consumers, decreases in farmer income, diversion of contaminated product back into rural households that have nowhere to sell it and too much caloric need to destroy it, and differential impacts on source areas that are prone to high levels of prevalence. It follows that **careful consideration of winners and losers under conditions of tighter or broader control is necessary, coupled with compensatory actions to balance different public objectives.**

Based on evidence compiled and analyzed under the new country and economic assessment framework, which was then interpreted during a significant two-day workshop in which stakeholders from government, industry, the farming community, civil society organizations and academia all participated actively, **Tanzania has now reached a collective high-level understanding of the complex challenges associated with aflatoxins that is unique within Africa**. Under the guidance of the new National Steering Committee for Mycotoxins Control, with broad support from the nascent National Forum for Mycotoxins Control, and with official backing from TFDA as host agency and governmental coordinator, **Tanzania is poised to assert leadership not only for its own citizenry and economy, but for Africa as a whole**.

Abt Associates and Meridian Institute, with support from the Bill and Melinda Gates Foundation as well as DFID, were honored and pleased to have the opportunity of participating in this innovative and important process.

Finally, this country assessment, as well as another pilot carried out in parallel in Nigeria, points the way toward a new methodology for assessing the situation, outlook, and needs of any developing country, in order to establish the evidentiary basis for policy and institutional reform; regulatory improvement; concerted action by both public and private stakeholder groups; and, ultimately, behavioral change by actors within value/supply chains as well as consumers.

9 References

Cline, H. Arizona cotton growers successful in aflatoxin control program. Western Farm Press [serial on the Internet]. 2005 [accessed 10/5/2012]: Available from: http://westernfarmpress.com/news/3-24-05-Arizona-cotton-aflatoxin/.

CountrySTAT (2012). Home page. Retrieved April 30, 2012, from www.countrystat.org.

Dohlman, E. 2008. Mycotoxin Hazards and Regulations Impacts on Food and Animal Feed Crop Trade. Economic Research Service/USDA International Trade and Food Safety / AER-828.USDA Economic Research Service.

Dorner J, Cole R, Wicklow D. Aflatoxin reduction in corn through field application of competitive fungi. J Food Prot. 1999;62(6):650–6.

Dorner JW, Horn BW. Separate and combined applications of nontoxigenic *Aspergillus flavus* and *A. parasiticus* for biocontrol of aflatoxin in peanuts. *Mycopathologia.* 2007;163(4):215–23.

European Union (EU). 2012. Rapid Alert Systems for Food and Food portal. [Accessed August 30, 2012.]

Food and Agriculture Organization (FAO) (2004). *Worldwide regulations for mycotoxins in food and feed in 2003* (Food and Nutrition Paper 81). Rome, Italy: FAO.

Gong, Y. Y., Cardwell, K., Hounsa, A., Egal, S., Turner, P. C., Hall, A. J., & Wild, C. P. (2002). Dietary aflatoxin exposure and impaired growth in young children from Benin and Togo: cross sectional study. *BMJ, 325*(7354), 20-21. doi: 10.1136/bmj.325.7354.20.

Hammitt, James K. and Robinson, Lisa A. 2011. The Income Elasticity of the Value per Statistical Life: Transferring Estimates between High and Low Income Populations," Journal of Benefit-Cost Analysis: Vol. 2: Iss. 1, Article 1.

International Agency for Research on Cancer (IARC) (2002). *Some traditional herbal medicines, some mycotoxins, napthalene and styrene* (IARC monographs on the Evaluation of Carcinogenic Risks to Humans, 82), pp. 171-300.

International Institute of Tropical Agriculture (IITA), 2012, GIS maps developed by IITA using Ministry of Agriculture, 2008 data for Abt Associates Inc.

Khlangwiset, P., Shephard, G. S., & Wu, F. (2011). Aflatoxins and growth impairment: A review. *Critical Reviews in Toxicology, 41*(9), 740-755. doi: 10.3109/10408444.2011.575766

Kuniholm, M. H., Lesi, O. A., Mendy, M., Akano, A. O., Sam, O., Hall, A. J., Whittle, H., Bah, E., Goedert, J. J., Hainaut, P., & Kirk, G. D. (2008). Aflatoxin exposure and viral hepatitis in the etiology of liver cirrhosis in the Gambia, West Africa. *Environ Health Perspect, 116*(11), 1553-1557.

LSMS-ISA, "2008-2009 Tanzania National Panel Survey." Part of the World Bank's Living Standards Measurement Study (LSMS) Integrated Surveys on Agriculture project. Data available at: http://go.worldbank.org/407HPUE790

Ministry of Agriculture, Food Security and Cooperatives (MoAFC), The United Republic of Tanzania "Investment Potential and Opportunities in Agriculture (Crop Sub-Sector)," January 2009

Neufeld, L.M., Omar Dary, Barbara Macdonald, and Kimberly B. Harding "Measurement of Food Consumption to Inform Food Fortification and other Nutrition Programs: Methods and Applications, " Proceedings of a workshop organized by the Monitoring, Assessment, and Data Working Group of the Ten Year Strategy for the Reduction of Vitamin and Mineral Deficiencies. 2012 Food and Nutrition Bulletin, vol. 33, no. 3 (supplement)

Nyandieka, H. S., Maina, J. O., & Nyamwange, C. (2009). Detoxification of aflatoxin in artificially contaminated maize crop by ammoniation procedures. *Discovery and Innovation*, 21(1–2).

Robens, J. and K. Cardwell (2003). The Costs of Mycotoxin Management to the USA: Management of Aflatoxins in the United States. *Journal of Toxicology TOXIN REVIEWS*. Vol. 22, Nos. 2 & 3, pp. 139–152.

Rowe, Christina (2009). DNA Markers for Resistance to Post-Harvest Aflatoxin Accumulation in Arachis hypogaea L. [Accessed 10/5/2012]. http://www.lib.ncsu.edu/resolver/1840.16/1533

Sanders, T.H., Blankenship, P.D., Cole, R.J., Hill, R.A., 1984. Effect of soil temperature and drought on peanut pod and stem temperatures relative to Aspergillus flavus invasion and aflatoxin contamination. Mycopathologia 86, 51–54.

Schofield, W.N. (1985). "Predicting basal metabolic rate, new standards and review of previous work." *Clin Nutr.* 39C (supplement 1): 5-41.

Shephard, G. S. (2008). Risk assessment of aflatoxins in food in Africa. *Food Addit Contam Part A Chem Anal Control Expo Risk Assess, 25*(10), 1246-1256.

Strosnider, H., Azziz-Baumgartner, E., Banziger, M., Bhat, R. V., Breiman, R., Brune, M. N., et al. (2006). Workgroup report: public health strategies for reducing aflatoxin exposure in developing countries. *Environ Health Perspect 114:*1898–1903.

Turner, P C. Sylla, Gong, Diallo, and Sutcliffe, Hall, Wild. " Reduction in Exposure to Carcinogenic Aflatoxins by Postharvest Intervention Measures in West Africa: a Community-based Intervention Study. Lancet 2005; 365: 1950–56

United States Environmental Protection Agency. 2010. Guidelines for preparing economic analysis. Appendix B: Mortality Risk Valuation Estimates. December.

Weisell, Robert, and Marie Claude Dop. (2012). "The Adult Male Equivalent concept and its application to Household Consumption and Expenditures Surveys (HCES)." *Food & Nutrition Bulletin* 33 (supplement 2): 157S-162S(6).

Whitlow, L. W., & Hagler, W. M. (2006). *Mycotoxins in dairy cattle: Occurrence, toxicity, prevention and treatment.* Raleigh: North Carolina State University.

Widstrom, N. W., Guo, B. Z., & Wilson, D. M. 2003. Integration of crop management and genetics for control of preharvest aflatoxin contamination of corn. *J. Toxicol.-Toxin Rev.* 22:199-227.

Williams, J. H., Phillips, T. D., Jolly, P. E., Stiles, J. K., Jolly, C. M., & Aggarwal, D. (2004). Human aflatoxicosis in developing countries: a review of toxicology, exposure, potential health consequences, and interventions. *The American Journal of Clinical Nutrition, 80*(5), 1106-1122.

World Bank (2011). Living standards measurement study. Retrieved from http://go.worldbank.org/TNOUO6ZE40.

World Health Organization (WHO) (1998). Safety evaluation of certain food additives and contaminants. Geneva: WHO.

World Health Organization. The global burden of disease: 2004 update. Geneva, World Health Organization, 2008. Available at http://www.who.int/evidence/bod

World Health Organization (WHO). 2012. Child Survival Factsheet on Immunizations, www.childsurvivalnetwork.info/resources/Immunizations+Factsheet.pdf. [Accessed 10/27/2012.]

Wu, F., Narrod, C., Tiongco, M., & Liu, Y. (2011). *The health economics of aflatoxin: Global burden of disease.* Aflacontrol Project. Facilitated by IFPRI.

Appendix A – Action Plans

The control strategies and the action plans for Agriculture (Pre- and Post-Harvest), Trade, Health, and the cross-cutting area of Policy Reforms prioritized at the workshop are presented below.

Priority Control Strategies for Agriculture: Pre-Harvest			
Control Strategy	**6-Month Goal**	**1-3 Year Goal**	**Institutional Actor Responsible**
Measure, test, and assess the scale of the problem for use in public awareness campaigns and to target delivery of control strategies	• Identify partners (including farmer groups) and responsibilities • Develop proposals • Consolidate existing procedures	• Country-wide profiling in target value chains • Groundnuts: Develop appropriate diagnostic methods for use in the field and laboratory; screen available varieties; standard breeding procedures • Longitudinal studies in on hot-spot areas	National and International Research Institutions (e.g. IITA, International Livestock Research Institute), TFDA, TFNC, MoAFC, Government Chemistry Laboratory
Promote and make available good agricultural practices	• Meet with relevant MoAFC staff, and present to relevant committees and meetings • Collect and harmonize procedures	• Training of farmers/extension officers Recognition of the role of GAP in food safety • GAP included as part of a set agenda of extension messaging by MoAFC • Mycotoxin control mentioned as part of GAP and extension messaging	MoAFC, Cereal Crop Boards
Develop bio-control for Tanzania, keeping in mind the cost implications for poorer farmers	Characterize strains of *Aspergillus* from maize and groundnuts as potential bio-control agents	• Identify hot-spots for preliminary field tests/control efficacy in food/feed value chains • Assess demand through participatory methods • Achieve registration • Develop production facility; commercialize Aflasafe supply • Expand applications to all hot-spots • Assess/control efficacy • Develop quality systems for bio-control product • Produce bio-control product • Assess demand through participatory methods to refine implementation	IITA, TFDA

Priority Control Strategies for Agriculture: Pre-Harvest			
Control Strategy	**6-Month Goal**	**1-3 Year Goal**	**Institutional Actor Responsible**
Continue research efforts for breeding maize, groundnuts, and other crops, for mycotoxin resistance, for availability in the longer time horizon.			
Create public awareness campaigns about the aflatoxin problem using a coordinated strategy with the trade and agriculture sector	• Identify partners • Identify target audiences • Develop messages/content • Identify channels for distributing messages • Develop tools to evaluate effectiveness of awareness campaigns	• Build capacity among implementers to deliver messages • Conduct aflatoxin public awareness campaign	TFNC, Institute of Food Science and Technology, Department of Prevention, MoAFSC, TFDA

Priority Control Strategies for Agriculture: Post-Harvest			
Control Strategy	**6-Month Goal**	**1-3 Year Goal**	**Institutional Actor Responsible**
Improve storage facilities at the community level	• Conduct awareness campaign on best storage practices as a measure of aflatoxin control – moisture content, pest control • Conduct training at all levels – farmers, traders	• Increased use of moisture meters and other techniques for controlling moisture • Improved individual & community storage facilities • Community warehouse with GMP • Traders come to get a marketable product. • Capital market system in place	Farmers associations , MoAFC – PHMS; MIT – Warehouse & TBS, NGOs, Local government
Develop and implement good management practices	• A harmonized GMP available • Awareness campaign on GMP to agents of change, farmers, traders	• Improved threshing, drying technologies and other processing machines adopted • Processing machines conducting GMP, packaged products available • Diversified products found in a trade hub	Manufacturers and farmers, health officers, agricultural extension officers, trade officers, community development officers
Improve transportation system for food crops and feeds	• Lobby the government for enforcement of regulation • Increase awareness among transporters	• Lobbying for enforcement of regulation • Food crops carriages in place	Policy enforcers, traders

Priority Control Strategies for Trade
• Shaping the marketplace to improve awareness of the presence and risks of aflatoxin in the food and feed system and create market-based incentives for safer food. • Improve the definition and application of standards relating to aflatoxins in domestic markets and import clearinghouses for aflatoxin-susceptible crops. • Improve policies and procedures for product withdrawal. • Improve suitability for commerce or trade of susceptible products by identifying and making available best practices for preventing or mitigating aflatoxin levels in priority crops (maize, groundnuts, and cassava) along the supply chains.

Priority Control Strategies for Public Health

Control Strategy	6-Month Goal	1-3 Year Goal	Institutional Actor Responsible
Promote proper food handling, processing, and preparation to reduce mycotoxin contamination	• Identify the key players/institutions • Understand the current practices, the motivations for those practices, barriers/opportunities for behavior change • Develop demonstrations/ materials describing proper food preparation	• Prioritize target regions for first year according to magnitude of the problem, expand to other regions second year onwards • Use peer groups, farmer groups, women's groups, teachers, etc., to pass knowledge to those who will share safe practices • Begin delivering content to a few regions	Food scientists, post-harvest processing unit, MoAFC, SIDO, extension workers, nutritionists, community development officers, local government
Achieve universal vaccinations for HBV since liver cancer risk is 30 times higher in HBV-positive populations			
Routinely monitor mycotoxins in cereal-based weaning foods.			
Detect and map aflatoxins in cereals and weaning cereals to understand the extent of the problem in the country	• Identify foods that need to be tested for aflatoxins and add these foods to the regulation • Identify funds • Begin process to acquire test kits	• Build capacity to carry out testing (training)	• TFDA, TBS, Government Chemistry Laboratory, local government

Priority Control Strategies for Policy Reforms			
Control Strategy	**6-Month Goal**	**1-3 Year Goal**	**Institutional Actor Responsible**
Recommend review and finalization of various policies that are important for food safety and mycotoxin control: • National Food Security Policy • National Food Safety Policy • Draft Regulations under Grazing-Lands and Animal Feed Resources Act • National Nutrition Policy	• Summarize the meeting minutes and develop outcomes and actions for each line ministry • Raise awareness among policy makers, members of parliament, and key committees such as the National Plant Protection Advisory Committee, National Food Safety Coordination Committee, Nutrition Steering Committee, National Nutrition Technical Working Group		Steering Committee along with Line Ministries
Mainstream GAP and other food safety-friendly measures within agricultural extension efforts			MoAFC, Farmer Associations, Local Government
Coordinate with relevant ministries and institutions and propose mycotoxin levels for feed			Ministry of Livestock and Fisheries Development, TFDA, and TBS
Ensure that dairy legislation recognizes the official national standards for mycotoxins			
Ensure that priority strategies and action plans are included in the business plans of relevant departments within line ministries	• Ensure resource commitment from all relevant institutions to support the newly formed National Forum for Mycotoxins Control and its action plans • Ensure that resources are allocated for implementing the priority strategies identified by the stakeholder workshop with the Forum leadership		

Priority Control Strategies for Policy Reforms			
Control Strategy	**6-Month Goal**	**1-3 Year Goal**	**Institutional Actor Responsible**
Raise awareness from the community level up to the decision makers, using a coordinated strategy with the trade and agriculture sector. The awareness raising campaign should include information on control strategies.			
Create public awareness campaigns about the aflatoxin problem using a coordinated strategy with the trade and agriculture sector	• Identify partners • Identify target audiences • Develop messages/content • Identify channels for distributing messages • Develop tools to evaluate effectiveness of awareness campaigns	• Build capacity among implementers to deliver messages • Conduct aflatoxin public awareness campaign	TFNC, Institute of Food Science and Technology, Department of Prevention, MoAFSC, TFDA
Develop and agree on a data collection protocol and require that results from research conducted in Tanzania be shared with the national government and entered into a centralized database, to be managed by the newly formed Secretariat for the National Forum for Mycotoxins control.	• Develop protocols for aflatoxin research that it will be submitted to a centralized database • Develop a research fund	• Establish the database	National and International Research Institutions, National Forum for Mycotoxins Control, TFDA, TFNC, Government Chemistry Laboratory

08/01/2013

Country and Economic Assessment for Aflatoxin Contamination and Control in Tanzania - Preliminary Findings

ABT Associates

ABT Associates