Aflatoxin Contamination and Potential Solutions for Its Control in Tanzania

A summary of the country and economic assessment conducted in 2012 and the aflatoxin stakeholder workshop held on December 3 and 4, 2012, in Dar es Salaam.

What are aflatoxins and how do they occur?

Aflatoxins are naturally occurring toxins produced by certain fungi, mainly *Aspergillus flavus and Aspergillus parasiticus.* Several types of aflatoxins (B1, B2, G1, and G2) are produced by these fungi. The B1 form is recognized by the International Agency for Research on Cancer as one of the most toxic and carcinogenic substances found in nature.[1] These aflatoxin-producing fungi can contaminate several dozen food commodities, including many of Africa's important staple crops: maize, sorghum, millet, rice, oilseeds, spices, groundnuts, tree nuts, and cassava.[2]

Countries such as Tanzania that are located between 40ºN and 40ºS latitude offer suitable growing conditions for the fungi. Since *Aspergillus spp*. originates in the soil, the biochemical risk of aflatoxin contamination begins with planting, and can be worsened later through inappropriate harvesting, handling, storage, processing, and transport practices. Contamination during crop development and after harvest depends on environmental conditions that are optimal for the growth of fungi. Damage by pests (birds, mammals, and insects) or the stress of hot, dry conditions can contribute to significant *Aspergillus* infection. Drought stressors (elevated temperature and low relative humidity) increase the number of *Aspergillus* spores in the air, increasing the chance of contamination. Heavy rain can cause spores to splash onto fruit and grain. After harvest, high crop moisture coupled with warm temperatures, inadequate drying, and poor storage can further increase the risk of contamination.

What are the adverse impacts of aflatoxin contamination?

Aflatoxin contamination can affect the entire supply chain for susceptible crops. Control measures (or their absence) taken along the supply chain can directly affect the availability of aflatoxin-free crop to households both for their own consumption and for sale to the consuming public. The sum total of action and inaction can impact all four pillars 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).

Aflatoxin contamination impacts three sectors: agriculture, trade, and health. If crops with very high levels of aflatoxin contamination are consumed by humans, poisoning (i.e., aflatoxicosis) and even death can occur. Chronic exposure to low levels of contamination in crops consumed regularly increases liver cancer risk and can suppress the immune system, particularly for populations that test positive for the hepatitis B virus (HBV). Aflatoxins can also enter the human diet through livestock products if the livestock are given contaminated feed. Children can be affected through breast milk or direct consumption of weaning foods. Some experts suspect association of aflatoxin exposure with child stunting and greater susceptibility to human immunodeficiency virus (HIV), tuberculosis, and malarial infection.

Aflatoxin contamination can also lead to rejection of specific export shipments and increased inspection and sampling rates. If plant quarantine authorities perceive the contamination as chronic, they can

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1 Hussaini Anthony Makun, Michael Francis Dutton, Patrick Berka Njobeh, Timothy Ayinla Gbodi, and Godwin Haruna Ogbadu, "Aflatoxin Contamination in Foods and Feeds: A Special Focus on Africa," Chapter 10 in *Trends in Vital Food and Control Engineering* (InTech, 2012).

2 Heather Strosnider, Eduardo Azziz-Baumgartner, Marianne Banziger, Ramesh V. Bhat, Robert Breiman, Marie-Noel Brune, et al., "Workgroup Report: Public Health Strategies for Reducing Aflatoxin Exposure in Developing Countries," *Environmental Health Perspectives* 114, no. 12 (2006):1898–1903.

curtail the right of countries to export susceptible products. These effects on trade result in lost revenues. Economic losses to producers and traders can also occur in the domestic market if either consumer awareness about the problem rises, leaders in marketing channels begin to pay more attention, or regulations are tightened or more strictly enforced. Thus, aflatoxin contamination can adversely affect both individual livelihoods and agricultural sector output.

***Aflatoxins disproportionately impact women and the poor*.** Food-insecure households are more likely to consume contaminated food rather than sell it at lower prices or discard it. The poor may also not be able to adopt costly control strategies. Even a well-intentioned awareness campaign can reduce prices for aflatoxin-contaminated food, resulting in direct market losses for the poor and more severe health impacts because of farmers' own consumption of low-price-yielding, contaminated grain. Women are also less likely to have access to information and resources for aflatoxin control and mitigation. Lack of decision making power with women may inhibit adoption of mitigation strategies even if information and resources are not a constraint.

How prevalent is aflatoxin contamination in Tanzania?

The Tanzania Bureau of Standards (TBS) sets standards on many food commodities, taking into account global standards as well as national production and consumption patterns. While it is generally recognized globally that there is no "safe" level of aflatoxin exposure, TBS has set the maximum acceptable limit for maize grain and groundnuts at 10 ppb for total aflatoxins and 5 ppb for B1.[3]

Aflatoxin contamination of key staples—maize, groundnuts—is above regulated levels for both total aflatoxins and B1 in some parts of Tanzania. Focusing on the strain that is most toxic and for which liver cancer impacts are identified, aflatoxin B1 prevalence data from 2012 indicated contamination above regulated levels (5 ppb) in two zones (see Figure 1).[4]

- In the Eastern zone (Morogoro), 43% 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% of the samples were above 5 ppb; in the Southern Highlands (Iringa, Mbeya, and Rukwa), only 4% 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. Percentages of samples from the Northern, Southern (Mtwara), and Western zones with aflatoxin B1 contamination above 5 ppb were 20%, 20%, and 8%, respectively, with mean contamination at 20 ppb, 18 ppb, and 20 ppb.
- In summary, prevalence data from 2012 suggest that aflatoxin contamination is a major concern only in the Eastern and Western zones. Prevalence testing is needed in other areas where data are not currently available to establish a fuller picture for the country.
- Since environmental conditions determine aflatoxin prevalence, testing in several years is needed to confirm whether aflatoxin prevalence can be a concern in other regions and to ensure that 2012 was not an atypical year.

The economic and country assessment conducted in 2012 by Abt Associates in collaboration with TFDA concluded that the largest impact of aflatoxins in Tanzania is on health, especially human health. The assessment found little awareness about aflatoxins among farmers, traders, and consumers. Despite

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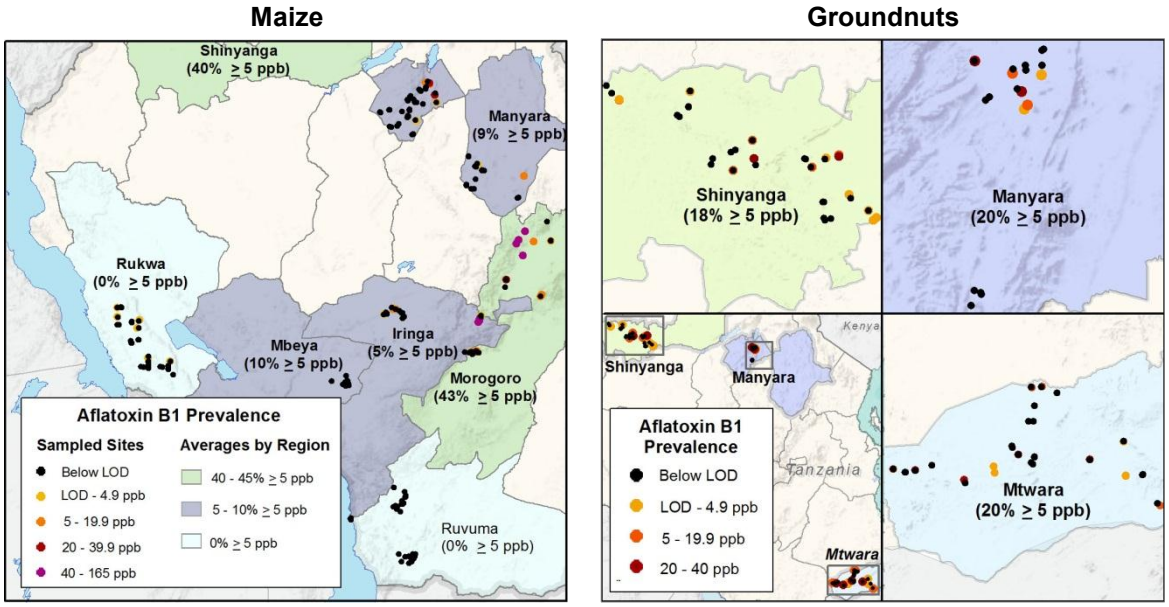
[3] The level of contamination of aflatoxins is measured in parts per billion or microgram per kilogram. This is often denoted as ppb or µg/kg. The weight of one microgram per kilogram is proportional to the weight of one grain of rice in a 50 kg bag. Small measurements must be used to detect aflatoxins because of their high level of toxicity.

[4] The prevalence data were generated by the Tanzania Food and Drugs Authority (TFDA), Ministry of Agriculture, Food Security and Cooperatives (MoAFC), and International Institute of Tropical Agriculture (IITA) in collaboration with the country assessment.

aflatoxin standards, unpackaged food is largely unregulated. This means that aflatoxin-contaminated grain can easily enter the Tanzanian consumption stream.

Figure 1: Aflatoxin B1 Contamination in Maize and Groundnuts



How serious are the risks of aflatoxin exposure in Tanzania?

Risk Characterization for Agriculture and Food Security

Notwithstanding *objective findings* of prevalence and contamination, 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 crops. 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. The market does not differentiate between aflatoxin-free and aflatoxin-contaminated food; therefore, farmers do not incur any costs for mitigating aflatoxins. This in turn results in increased risk that aflatoxin-contaminated grains leave the farmers' fields and enter the food and feed supply.

Farmers are not aware of aflatoxins, nor of measures to control aflatoxins in the field, which begin with good agricultural practices (GAP). There is no set "agenda" for agricultural extension services to include aflatoxins, mycotoxins, food safety, or GAP in their messaging, nor is there a strategy or guidelines for crop-specific GAP.

Although the use of quality seed is a fundamental means to mitigate aflatoxins, the country and economic assessment found that nationally, only 18 percent of agricultural households use improved seeds for maize, and 3 percent use improved seeds for groundnuts. Since healthy plants can better resist disease, the use of irrigation, fertilizers, and crop protection chemicals also matters in aflatoxin control. Yet only 2 percent of the area cultivated under maize is irrigated, and the area irrigated for groundnuts is negligible. Use of fertilizer is at 17 percent for maize and 1 percent for groundnuts. Use of pesticides is at 11 percent for maize and 3 percent for groundnuts.

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.

Farmers do basic sorting, culling out visibly damaged and moldy crops in order to realize the price premium associated with cleaner, unspoiled maize and groundnuts. However, these practices cannot

guarantee aflatoxin reduction. Nor do farmers necessarily incur losses for aflatoxin-contaminated grain (or realize premiums for aflatoxin-free grain). Lack of awareness among growers and buyers, combined with the often unobservable effects of aflatoxins, make it very difficult to incentivize and inform farmers of the risks associated with aflatoxins.

There are no standards yet for aflatoxins in feed, but standards are likely to be defined by the guidance issued under the Grazing Lands and Animal Feed Resources Act. The focus of this guidance will be on the poultry feed sector, which is to some degree aware of the issue. Livestock feed and feeding practices are not covered by agricultural extension messaging, and are only weakly addressed by the private feed industry, which gives rise to concern that there may be aflatoxin contamination in milk produced in urban and peri-urban areas where maize chaff makes up a large part of the utilized feed.

Risk Characterization for Domestic Commerce and International Trade

Aflatoxin-contaminated grain can enter the domestic markets and the informal international markets (e.g., Kenya and Zambia for maize) because of lack of awareness and difficulty faced in enforcement of existing standards. TFDA enforces commodity standards but only for packaged foods and foods bound for the formal export market; thus, the vast majority of foods consumed by the Tanzania population are not regulated for aflatoxin.

Country assessment field research in Kongwa, Njombe, and Bukombe found no evidence of testing for aflatoxins in the domestic maize and groundnut markets in Tanzania. There is low awareness about aflatoxins and their health impact among most farmers, traders, and market sellers.

In the animal feed sector, there is aflatoxin control even though there are no regulations on aflatoxins in this sector. However, since there is no mandate for withdrawal and destruction of contaminated commodities, grain deliveries rejected by large commercial operations are likely to be sold by a trader to smaller feed manufacturers that do not test for aflatoxins. Maize chaff generated by large millers is used by the feed industry as raw material and is not regulated or tested for aflatoxins, which raises concern for aflatoxin contamination in animal products, particularly milk and possibly eggs.

Risk Characterization for Human Health

Consumers' level of aflatoxin knowledge is still very low in Tanzania, while the contribution of maize to calorie intake is very high. Although groundnuts do not account for a large share of calorie intake, they are widely promoted as ingredients for weaning foods. This implies that even small levels of aflatoxin contamination in maize and groundnuts could present a high risk of aflatoxin exposure, particularly in mainland Tanzania.

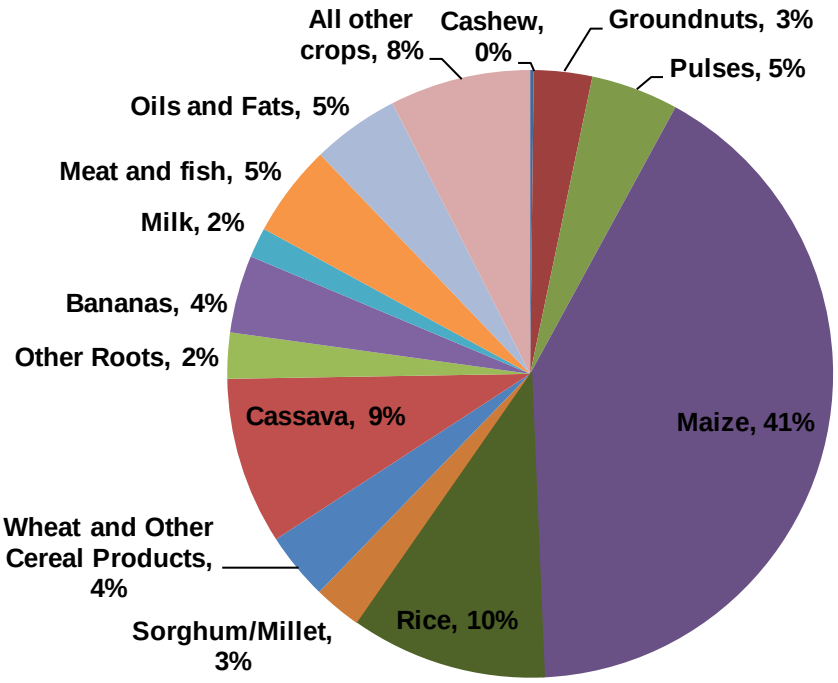
Maize and groundnuts together account for 44 percent of the calorie intake (see Figure 2). There is some regional variation in diets: In the Eastern zone, maize constitutes 31 percent of the calorie intake, while in the Southern Highlands the contribution of maize is as high as 55 percent. In other zones 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 intake on the island. Across the board, groundnuts account for a small percentage of calorie intake, ranging from 1 percent in Zanzibar and the Northern and Eastern zones to 8 percent in the Central zone.

What is the impact of aflatoxins in Tanzania?

In Tanzania, maize comprises 41% of the weekly calorie intake of households. On average Tanzanians eat 521 grams of maize and groundnuts per person per day. This implies that *even at low levels of aflatoxin contamination of key staples, there is measurable health impact because of the high contribution of the staples in the Tanzanian diet.* For example:

- Even at average contamination of 5 ppb (the regulated level in these crops), the current maize and groundnut consumption levels, population (projected for 2010), age distribution of the population, and HBV prevalence imply that 546 annual liver cancer cases can be attributed to aflatoxin contamination, with an associated annual cost ranging from $17 million to $147 million.[5]

Figure 2: Calorie Contribution of Maize in Tanzanian Diets (weekly household consumption)



- The World Health Organization estimates that in 2010 there were 1,209 liver cancer cases in Tanzania. This implies that at average contamination of 5 ppb, in 2010 as many as 45% of annual liver cancer cases in Tanzania could be attributed to aflatoxins.
- Sensitivity analysis of estimates indicates that if there were 100% immunization for HBV, the liver cancer cases attributable to aflatoxin contamination would drop by 65%.

What are the potential solutions for aflatoxin control?

- The Tanzania country and economic assessment helped identify opportunities for aflatoxin control in Tanzania in the three sectors of concern—agriculture, trade, and health.
- Tanzanian stakeholders came together at the aflatoxin stakeholders' workshop (co-organized by TFDA and Abt Associates) to identify priority control strategies in these three sectors.[6]

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[5] Age- and sex-specific HBV prevalence rates are estimated for Eastern Sub-Saharan Africa for 2005 in J. J. Ott, G. A. Stevens, J. Groeger, and S. T. Wiersma, "Global Epidemiology of Hepatitis B Virus Infection: New Estimates of Age-Specific HBsAg Seroprevalence and Endemicity," *Vaccine* 30, no. 12:2212-9 (March 9, 2012). Epub January 24, 2012.

[6] 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.

- Actions 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.
- 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 at the end of January to organize resources 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 presented below.

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

- 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 for Tanzania, keeping in mind the cost implications for poorer farmers.
- 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 crops and feeds.

Priority Control Strategies for Trade

- Shape 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

- Promote proper food handling, sorting, 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 guidelines.
- Routinely monitor mycotoxins in cereal-based weaning foods.

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.

Conclusion

This brief was designed to share the results in Tanzania of a country and economic assessment based on a new methodology for assessing the situation, outlook, and needs of any developing country. Its purpose was to establish the evidentiary basis for policy and institutional reform, then stimulate regulatory improvement and concerted action by both public and private stakeholder groups, and ultimately foster behavioral change by actors within value/supply chains, as well as consumers.

While solutions for aflatoxin control are readily available at all stages of food production, resources are scarce given competing priorities of the many development challenges that Tanzania faces. **Interventions must be prioritized** 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.

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, domestic commerce and international trade, and human and animal health. 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 aflatoxin 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 the UK Department for International Development, were honored and pleased to have the opportunity to participate in this innovative and important process.