Building an Aflatoxin Safe East African Community

Technical Policy Paper 10

Aflatoxin: Economic Impacts on Trade

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Situational Analysis for East Africa Region

Aflatoxin: Economic Impacts on Trade

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Foreword

Agribusiness comprises a significant proportion of the gross domestic product (GDP) for all countries across the African continent, with agriculture by far the largest sector for employment. The value chain is characterized by a network of formal and informal traders that has evolved over centuries. Vast expanses of land and porous borders between countries pose numerous challenges to regulatory enforcement that is generated outward from the urban hubs. Nascent efforts to comply with standards for maximum limits on aflatoxin contamination of staple foods and commonly traded crops exemplify these challenges.

As a first step to policy-making, it is important to better understand the gains and losses, winners and losers, that will likely emerge when contaminated commodities and processed foods that presently flow freely through the marketplace are subsequently removed. In the absence of a sound policy regime reinforced by the rapid implementation of programs addressing health, agriculture, trade, and environmental issues associated with aflatoxin contamination, losers would be many.

Consumers win when unsafe foods are removed from their diet, assuming adequate and affordable replacement supplies. And farmers win when they are paid a premium for aflatoxin safe crops.

However, farmers lose if their crops are confiscated; consumers lose if the staple food supply contracts and prices rise as contaminated commodities are suddenly removed from the marketplace. Traders and processors could lose due to the increased cost burdens of testing and compliance with aflatoxin standards--though they could win by expanding their market shares and upgrading to higher value product lines. In other words, the process is dynamic and needs to be guided to ensure positive rather than negative outcomes.

To establish a baseline we have analyzed the impact of aflatoxin contamination on the trade of commonly traded products in Burundi, Kenya, Rwanda, Tanzania, and Uganda, as well as the likely impact of harmonizing regulatory standards for aflatoxin contamination in export crops across Africa. We have focused on impacts on human heath, export volumes, and regional food security implied through the enforcement of standards. We hope this knowledge base and situational analysis toll make an important contribution to planning and pacing the strengthening of the food and feed safety regulatory environment while also protecting regional and national food security.

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Executive Summary

Contamination of crops by aflatoxins—naturally occurring toxins—results in serious health impacts in humans, including aflatoxicosis, hepatocellular carcinoma (HCC), immune suppression, and nutritional interference. Livestock—poultry, pigs, and cattle—are also affected. In addition to the direct impacts associated with the disease burden, controlling aflatoxins in agriculture, where the problem originates, is costly and has an subtantial economic impact. Regulations on trading contaminated crops can affect both domestic and international trade. In this paper, we assess the potential trade impacts for the East African Community (EAC) partner states (Burundi, Kenya, Rwanda, Tanzania, and Uganda). To assess these potential impacts, we reviewed the relevant literature[1] and analyzed publicly available data (Table 1). We focused the analysis on crops that have high aflatoxin susceptibility and at the same time are produced and/or traded in large quantities by each country. Specifically, we identified the following crops: maize, groundnuts, cashew, sesame, and rice.

Table 1: Data requirements and sources for estimating international trade impacts.

Data Requirement	Source
Export Volume and Value by Importer and Exporter	UN Comtrade (http://comtrade.un.org/db/)
Production Quantity, Area Harvested, Yield	FAOSTAT (www.faostat.org)
Export Rejection, Barriers to Trade	EU Rapid Alert System for Food and Feed (http://ec.europa.eu/food/food/rapidalert/rasff_portal_database_en.htm).Data on rejection from other countries are not available from formal sources. Requires interview with trade, export, and food and drug safety officials.
Aflatoxin Standards	*Worldwide Regulations for Mycotoxins in Food and Feed*—1995 (FAO 1997) and 2003 (FAO 2004)

Market losses in trade from aflatoxin contamination can be separated into losses in the domestic market and thoe in the international market. In the domestic market, the direct economic impact of aflatoxin contamination in crops results mainly from a reduction in marketable volume (and hence a potentially higher price), revenue loss by domestic producers or distributors, and losses incurred from livestock disease and mortality. In the international market, impact results from inadmissibility or rejection of products by the international market, and from inability to participate in the international market. The contribution of market losses to the total economic impact depends on the extent to which the domestic market differentiates aflatoxin contaminated

[1] Information from the literature included: aflatoxin standards (Keyser 2012), informal trade within the EAC (Ogalo 2010; Karugia 2009), and barriers to trade (Rios and Jaffee 2008; Munasib and Roy 2012).

products. If the domestic market does not differentiate aflatoxin contaminated products, market losses from the contamination will be minimal. Among EAC partner states, in Kenya, awareness about aflatoxins is high, signaling that domestic market impact will likely be higher than in other countries.

In the remaining EAC partner states, we postulate that currently it is unlikely that aflatoxin would have large impacts on domestic trade. The lack of awareness and poor regulation of domestically traded products (at least those that are not sold in packages) in these countries means that market differentiation does not occur and neither short- nor long-term domestic market impacts are likely to be realized.

We also examine trade among EAC nations, where standards for most aflatoxin susceptible products are harmonized. However, even where standards exist, if they are not effectively enforced, shipments rejected formally can still cross borders informally. Such evasion of standards is ry likely, given the significant amount of informal trade among the EAC partner states. Thus, we anticipate that the trade impact of aflatoxin among these countries would be limited. The trade impact will be greater as a market develops for aflatoxin safe commodities, resulting in smaller health impacts.

When considering impact on trade outside the EAC partner states, we examine the long-term export volumes for the EAC partner states and assess whether key changes in regulations of aflatoxins resulted in a decline in trade. The first major change in European Union (EU) regulations to control aflatoxins in commodities occurred in 1980, when the Codex Alimentarius established standards for food and feed use in 1995 (although not for maize). The EU harmonized its standards in 2002.[2] The long-term trends in exports for maize and groundnuts from the EAC fluctuate over time but did not show any marked dips when the regulations were enforced. Maize is often subject to domestic bans and is important for food security, so other factors affect international trade of maize. Exports of sesame, cashew, and rice show an uptrend for some EAC partner states. We agree with the overall consensus in the literature that aflatoxins alone have not caused significant trade impact despite some trade rejections.

An important contribution of our paper is assessing the potential impact of harmonizing aflatoxin standards across all African countries in the three communities: Market for Eastern and Southern Africa (COMESA), EAC, and the Southern African Development Community (SADC). We contend that there should be no significant adverse social impact of harmonizing aflatoxin standards across Africa.

[2] The Codex Alimentarius Commission, established jointly by the Food and Agricultural Organization (FAO) and the World Health Organization (WHO), provides international guidelines for aflatoxins. The European Union (EU) has more stringent guidelines than those specified by the Codex Alimentarius. In addition, the United States, Canada, and some other countries have also specified their own standards.

As we discuss in our conceptual framework, if aflatoxin contamination is a threat to crops, there will be an economic impact from that threat. It will be borne as costs to control it in agriculture if the issue is addressed at its origin (as is the case in developed countries). If Africa-wide aflatoxin regulations are harmonized and effectively enforced, there will be impact resulting from crop rejections and reduction in export revenue; if the regulations are not harmonized (or weakly enforced), the aflatoxin contaminated crop will be consumed, resulting in adverse health impacts.[3]

The policy and regulatory environment therefore determines whether the impact will be in agriculture, trade, or health; the impact does not go away. Of course, the benefit from the avoided health impact is borne by the importing country, and the trade impact is borne by the exporting country. Furthermore, as one would expect, we find that the trade-off between trade impact and health impact varies depending on the average consumption of the traded commodity in the importing country, the reliance on imports for consumption, and the aflatoxin contamination level of the rejected commodity. If the contaminated commodity is rejected by a country where there is high consumption of the commodity, the health impacts are greater. For example, we find that, if 15% of maize imports are contaminated at 20 parts per billion (ppb) in a country with high maize consumption and a large proportion of consumption from imports, the risk of hepatocellular carcinoma (HCC) is 0.19 cases per 100,000 population. That is, if the country's population is 40 million, then there will be 76 more HCC cases that could be avoided if there were effective aflatoxin standards at 20 ppb.

It is important to note though that if the trade standards are harmonized but not effectively enforced, creating conditions that allow the contaminated commodities to enter the consumption stream, then the benefits of health impact will not be realized; and negative health impacts could disproportionately affect the poorer households.

The paper concludes with a discussion on the potential gains that EAC partner states could realize by controlling aflatoxins. We argue that aflatoxin control will be a necessary but not sufficient condition to gain a larger share of the international market in commodities where EAC partner states have a comparative advantage. Other factors that affect quality standards that limit iexports need to be addressed. A more detailed analysis is needed that compares the cost of investments required to make EAC partner states competitive in exporting, and the resulting impact on the cost of production of the crops against the cost of production in countries that are the leading exporters.

[3] Narayan, et al., A Conceptual Framework to Conduct Country and Economic Assessment of Aflatoxins, Abt Associates, Inc. December 2012.

Aflatoxins are a family of extremely toxic, mutagenic, and carcinogenic compounds that can contaminate crops; they are produced mainly by the fungi *Aspergillus flavus* and *Aspergillus parasiticus*, both of which are widely found in the soil. (Diener et al. 1987; Kurtzman et al. 1987). Toxigenic *A. flavus* isolates produce aflatoxins B1 and B2, and toxigenic *A. parasiticus* isolates produce aflatoxins B1, B2, G1, and G2 (Abbas et al. 2006). These fungi can colonize a wide variety of food commodities, including maize (corn), sorghum, millet, oilseeds, spices, groundnuts (peanuts), tree nuts, and dried fruit (Strosnider et al. 2006), as well as rice in storage. *Aspergillus* species depend on environmental conditions in order to thrive: *Aspergillus* growth is optimal in temperatures between 80° and 100° Fahrenheit with a relative humidity around 85 percent (corresponding to 18 percent grain moisture) (LSU AgCenter 2011). Thus, aflatoxin disproportionately affects food in the tropical and subtropical regions of the world.

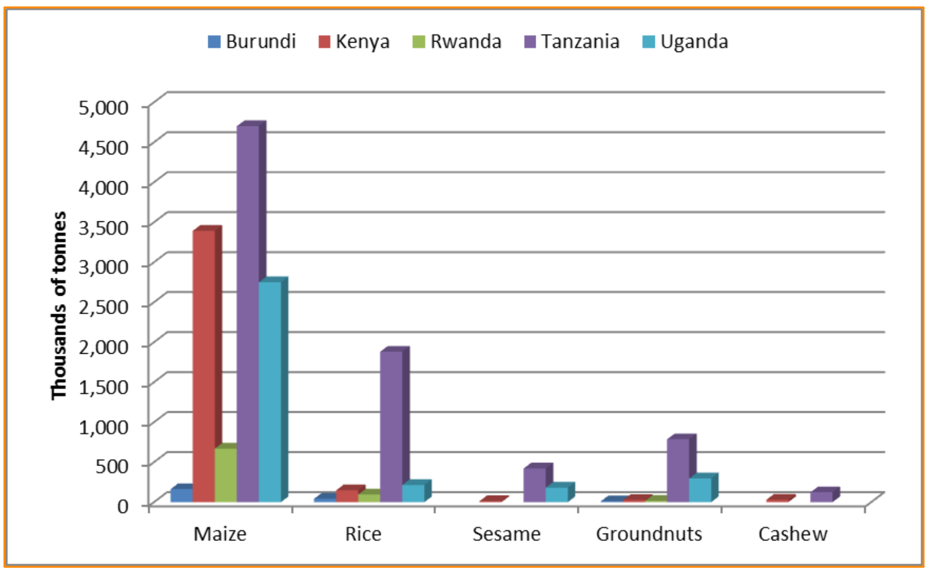
The purpose of this paper is to identify and characterize the impacts of aflatoxin contamination on trade for the East African Community (EAC) countries (Burundi, Kenya, Rwanda, Tanzania, and Uganda) and the impact of harmonizing regulations setting standards for acceptable levels of aflatoxin in export crops for trade across Africa. The assessment includes a review of relevant literature and analysis of publicly available data. Then, having described the trade impacts of aflatoxin under current standards, we assess the potential economic benefits and consequences of enforcing aflatoxin standards within the proposed tripartite trade agreement among the EAC, the COMESA, and SADC.

Introduction

Crops of Concern

The crops commonly affected by aflatoxins include cereals (maize, sorghum, millet, rice wheat), oil seeds (groundnuts, cottonseed, sesame) root crops (cassava) and nuts (cashews, Brazil nuts, pecans, walnuts, pistachio nuts), and spices (particularly chilies).

This study focused on maize, groundnuts, cashew, sesame, and rice. Of the key crops of concern for aflatoxin in the EAC, maize was produced in the highest quantity in 2013 (see Figure 1). Tanzania also produced rice and groundnuts in quantities exceeding 500,000 tons in 2013.



Source: FAOSTAT. Note that production data for cashew is for 2012.

Figure 1: EAC production of key crops in 2013.

Table 2 presents the crops in each country that are important in production quantity and export value. Based on these data, we identified the key crops of concern for EAC partner states, focusing on crops known to have high aflatoxin susceptibility that are produced and/or traded in large quantity by each country. Specifically, we focused on the following crops: maize, groundnuts, cashew, sesame, and rice.

Table 2: Production quantity and export value of key crops by EAC partner states.

Crop[a]	EAC partner states				
	Burundi	Kenya	Rwanda	Tanzania	Uganda
Production Quantity (tons)					
Cassava	2,233,790	1,112,420	2,948,121	5,400,000	5,228,000
Cottonseed	2,238	7,750	0	160,000	40,000
Groundnuts	10,243	25,000	14,414	785,000	295,000
Maize	162,417	3,390,941	667,833	4,700,000	2,748,000
Millet	11,200	64,102	9,000	297,000	228,000
Rice	41,454	146,696	93,746	1,880,000	214,000
Sesame seed	-	12,200	-	420,000	180,000
Sorghum	31,453	138,533	157,492	850,000	299,000
Wheat	6,423	485,846	70,129	117,500	20,000
Export Value (thousands of US$)					
Brazil nuts	-	$0	-	$241	$0
Cashew nuts	-	$6,135	-	$123,158	$5
Chilies and peppers, dry	$0	$296	$0	$125	$161
Cottonseed	$0	$0	-	$604	$230
Groundnuts	$0	$43	$6	$1,125	$136
Maize	$94	$6,567	$127	$2,181	$17,096
Millet	-	$26	$1	$254	$498
Rice	$14	$2,531	$120	$12,719	$18,442
Sesame seed	-	$4,069	-	$73,077	$17,296
Sorghum	$25	$8,844	$0	$909	$346
Spices	$3	$3,496	$0	$147	$205
Walnuts	-	$0	-	$1	-
Wheat	$0	$1,300	-	$5,918	$2,472

Source: FAOSTAT. Production data for 2013; export data for 2011.

a. **Production data for these countries were not available for specific nuts (e.g., Brazil nuts, cashews, walnuts) or spices.**

Domestic Trade

In the current environment of low enforcement of regulations and low consumer awareness, it is unlikely that aflatoxin has large impacts on domestic trade. For domestic markets to be affected, there must be awareness, regulation, and enforcement in domestic commerce, leading to a segmented market with lower, or no, demand for aflatoxin contaminated products. Later in this paper, though, we present a hypothetical analysis of potential impacts with full enforcement and regulations. In the short run, the supply of aflatoxin-free food is determined largely by weather outcomes. When producers cannot adjust the quantity of aflatoxin-free food they produce and in-country regulations exist and are enforced, aflatoxin contaminated food is discarded, resulting in revenue loss. In the long run, the market adjusts, with production shifts toward less-susceptible crops or through adoption of technology to control aflatoxins, as it has in the developed countries.

The lack of awareness in most sub-Saharan African countries means that such market differentiation does not occur and neither the short- nor long-term domestic market impacts are realized. Accordingly, Abt Associates, Inc.'s January 2013 assessment of aflatoxin contamination and control in Tanzania found essentially no effects of aflatoxin on domestic markets. However, awareness in EAC partner states is growing, and condemnation of aflatoxin contaminated crops is becoming more widespread. This is particularly true in Kenya, where millions of bags of maize have been discarded due to aflatoxin contamination in recent years.[4] The Kenyan poultry industry, which is aware of aflatoxins, uses clay binders or finds other ways to control aflatoxin in poultry feed because the chickens respond immediately to aflatoxin contamination. Therefore, while there is some limited impact on domestic trade, there are alternative points of sale and alternatives for poultry feed. As a result, the poultry industry's awareness does not imply a significant impact.

Trade within the EAC

The EAC has harmonized standards for most aflatoxin susceptible products (cashews is an exception). Keyser (2012) listed 42 staple foods with harmonized EAC standards. The products include those most commonly traded by EAC partner states, such as maize and rice, setting the limit for total aflatoxins at 10 ppb and for aflatoxin B1 at 5 ppb.

However, it is very likely that these standards are not actively enforced, and the porous borders imply a significant amount of informal trade among the EAC partner states. Ogalo (2010) described informal trade across borders in the EAC, and noted that such trading occurs for almost all types of goods, particularly for staple foods such as maize, rice, and groundnuts. While informally traded goods are traded in small quantities, they can account for a large portion of imports. For example, Ogalo (2010) estimated that informal imports to Uganda from other EAC partner states were $80.6 million in 2006, or 16% of total imports from those countries. In addition, Karugia et al. (2009) noted that informal trade accounts for up to 60% of trade in staple grains in Kenya, Tanzania, and Uganda. Any crops that are rejected formally due to aflatoxin contamination can make it across borders informally. Given

[4] We are aware of warehouses that contain large volumes of aflatoxin contaminated commodities, but the exact value and volume is not known. There has been no systematic condemnation or regulation of any of the commodities, but the commodities have not been discarded.

the amount of informal trade within the EAC partner states, we expect that the trade impacts of aflatoxin among these countries are limited.

Based on UN Comtrade data for 2009-2013, cashew nuts are traded among all five EAC partner states. The average annual value of intra-EAC trade of cashews during 2009-13 was approximately $83,000--not particularly significant. All EAC partner states import cashews from other EAC partner states; Kenya, Tanzania, and Uganda export cashews to other EAC partner states.

International Trade

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 are now shifted to the production of the good(s) a country produces best, resulting in improved welfare in the country and all trading nations. 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, and the commodity may instead be sold domestically.[5] Thus, in the long run, as the market adjusts to the new knowledge about aflatoxin, the welfare losses may not be significant, and may only be incurred in the short run.

For economies where certain crops are grown largely for internal consumption and form a significant part of the diet, markets may not adjust in the long run, and there may be some realized losses resulting from the inability to sell in the international market.

The literature thus far measures the impact of aflatoxin standards on trade volume and uses it as a proxy for the impact of aflatoxin contamination on trade, without discussing the impact of trade on gross domestic product (GDP) (Otsuki et al. 2001a; Otsuki et al. 2001b; Munasib and Roy 2012). The authors rely on the variability in mycotoxin standards across the European countries to estimate the international trade impacts on Africa. However, the analysis does not take into account other factors that could affect trade volume, such as additional food safety or labor standards. In addition, as pointed out by Munasib and Roy

[5]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 aflatoxins by establishing and enforcing regulations, testing for aflatoxins, and controlling for them. Robens and Cardwell (2003) assess the impact of managing mycotoxin and the cost of testing in the United States. Since this conceptual framework is written in the context of developing countries, it will not go into further detail in estimating these costs.

(2012), they do not model the inability of countries to enter the export market (or zero trade volume), which results in selection bias in their estimates. They control for bilateral costs rather than multilateral resistance, which is used by recent papers that model trade flows.

Rios and Jaffee (2008) argue that the trade impact may be overstated in the literature because these papers do not account for the high trade barriers to entry. They instead use the interception and rejection data from the EU Rapid Alert System for Food and Feed (RASFF) and UN Comtrade data to calculate the impact of EU regulations on the value of exports. However, their analysis is relevant to estimating the losses of trade to the EU, which has the strictest aflatoxin standards, and does not account for the losses associated with the barrier to entry—the cost of being excluded from international trade.

Wu (2004) uses a very different approach from the trade models and develops a simulation model to estimate the trade impact on Africa (and other regions). She models export loss as a function of price of the commodity, the total volume of that crop exported by a particular nation, and the fraction of that nation's food export crop that is rejected as a result of a given worldwide mycotoxin standard. Specifically, she uses the following equation to model the export losses:

$$\boldsymbol{Export\ Loss_{i,j,k} = P_{i.}W_{ij}\ (1 - \int PDF_{i,j,k}dk)} \qquad [0\text{-}1]$$

Where W_{ij} is the total export weight of crop i to nation j, Pi *is* the price of crop i and $PDF_{i,j,k}$ is probability of rejection of export for crop i to nation j given the aflatoxin standard k, so that $(1 - \int PDF_{i,j,k}\,dk)$ is the fraction of the export volume for crop i to nation j, given the aflatoxin standard k, that is rejected. The study uses a log-linear functional form for the probability distribution with lower- and upper-bound aflatoxin contamination rates for crops in different countries using individual studies that report prevalence; these studies are not necessarily representative of an entire country. For Africa, Wu (2004) just uses an estimate for prevalence without a survey. In addition, the prevalence of aflatoxin contamination in crops selected for export is likely to be lower than the general prevalence of aflatoxin because of sorting of better products for exports. Therefore, this is a data gap, and interviews with relevant regulatory authorities for trade are required to estimate the prevalence in products for the export market.

We also reviewed publicly available data on export rejections from EAC partner states to European Union (EU) countries. The RASFF did not indicate any export rejections in the EU of food products from the EAC due to aflatoxin from 2010-14. Rios and Jaffee (2008) found that sub-Saharan Africa accounted for 11.3% of RASFF information notifications concerning groundnuts between 1999 and 2006; most of these were for non-EAC partner states, but some exports from Uganda were affected. Therefore, export rejections do not appear to be a significant factor in the export of aflatoxin-susceptible crops to the EU for EAC partner states. Similarly, Rios and Jaffee (2008) examined economic losses in sub-Saharan Africa's groundnut industry and concluded that the EU's strict standard for aflatoxin is not a major barrier to trade. Instead, more important factors include cost, reliability, quality, and lack of incentives to invest in improved production and quality control measures (Rios and Jaffee 2008). Further analysis is needed to compare the cost of investments to improve competitiveness of countries in trading in these commodities, the resulting impact on cost of production, and how it compares to cost of production in leading exporters. There have been changes over time in EAC exports of key crops, but the Codex standards established in 1995 have not had a major impact on international trade. For example, Tanzania, Kenya, and Uganda are active exporters of maize, and their export values have fluctuated over time. Maize is often subject to domestic bans and is an important crop for food security, so there are other factors affecting international trade of maize. For groundnuts, Tanzania's exports decreased prior to the 1995 regulations and have since increased. The long-term trends in exports for maize and groundnuts from the EAC fluctuate over time but do not show any marked dips when the regulations were enforced. Exports of sesame, cashews, and rice show an uptrend for some EAC partner states.

Figure 2 through Figure 6 show the trends in EAC exports since 1961. Overall, there have been changes over time in exports of the key crops, but no clear effect of the Codex standards established in 1995. Kenya's maize exports dropped in the mid-1990s but have since increased. Tanzania and Uganda are active exporters of maize, which is often subject to domestic bans and is an important crop for food security. For groundnuts, there have been sharp increases and decreases in Tanzania's exports since the early 1990s. Uganda and Tanzania's rice exports have increased recently, while Kenya's rice exports have decreased since a peak in the early 1990s. Tanzania is the largest exporter of cashews and sesame in the region, with some exports from Kenya and Uganda as well.

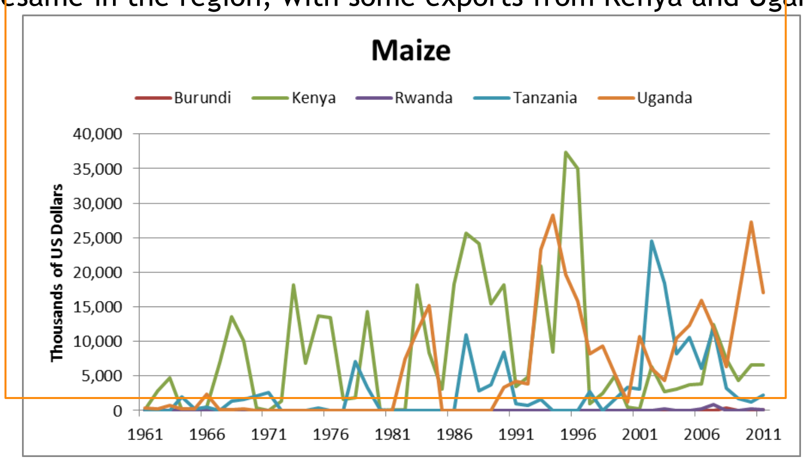


Figure 2: EAC exports in 2013: maize. **Source: UN Comtrade**

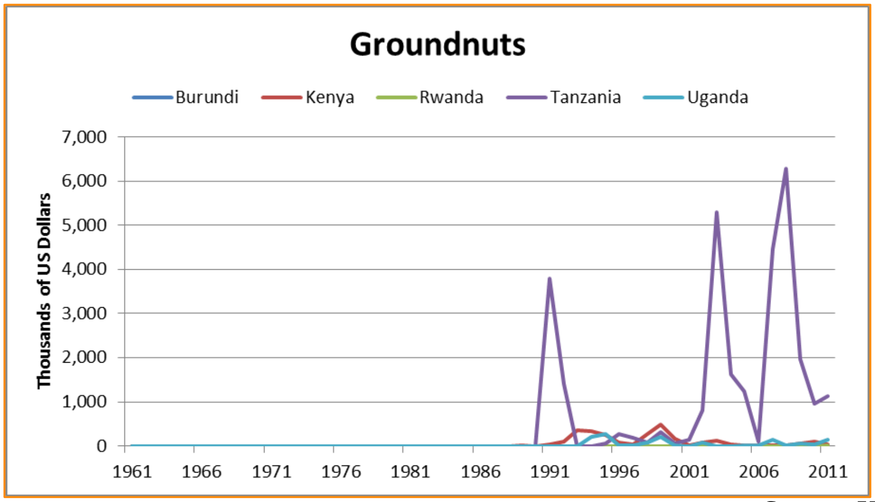


Figure 3: EAC exports in 2013: groundnuts. **Source: UN Comtrade**

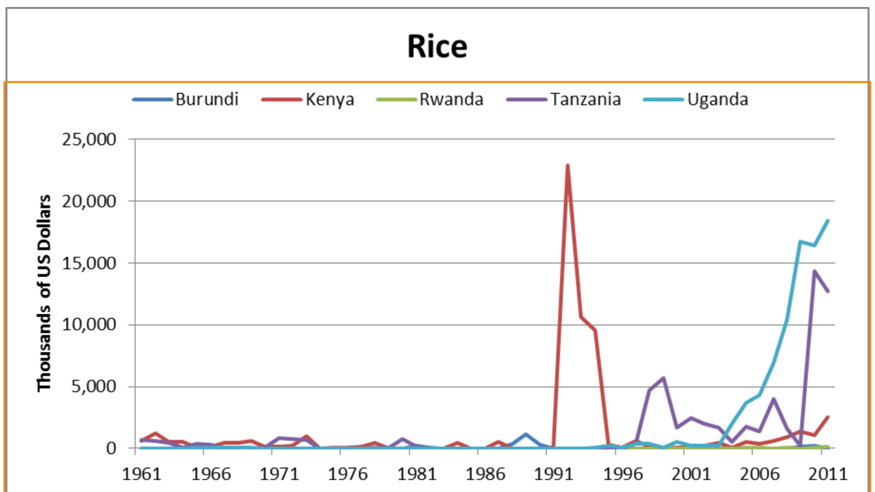


Figure 4: EAC Exports in 2013: rice. **Source: UN Comtrade**

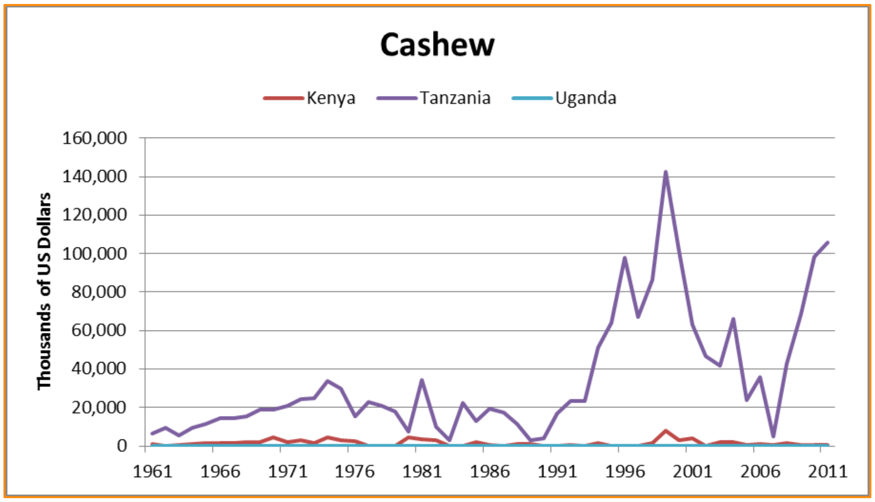


Figure 5: EAC Exports in 2013: cashew. **Source: UN Comtrade**

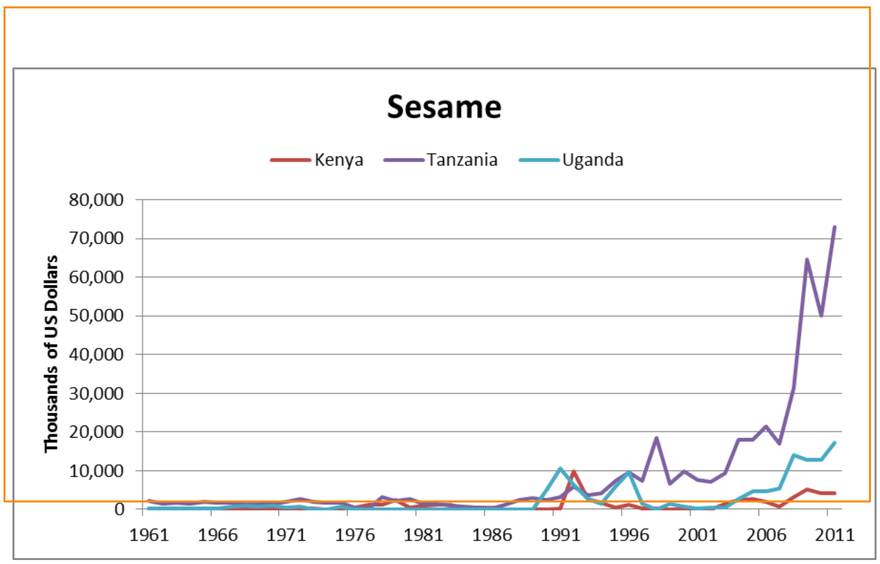


Figure 6: EAC Exports in 2013: sesame. **Source: UN Comtrade**

Impacts of Harmonizing Regulations Across Africa

There is a clear trade-off between trade and health impacts. Harmonization of regulations across Africa has the potential to have a negative trade impact on the EAC, because of potential rejection of exports from countries that do not have any regulations established, or currently have higher limits than the EAC. However, without harmonization, the contaminated commodities will affect health in the importing countries.

Below we assess this trade-off under different hypothetical scenarios. We conduct the analysis under the assumption of full enforcement of regulations in all trading countries in Africa. Without enforcement of regulations that remove the contaminated commodity from the market, trade regulations will result in an economic impact without the benefits of avoided health impact--a lose-lose proposition.

To set the stage, we analyzed available trade data to identify EAC partner states' key African trading partners for maize and groundnuts: Sudan, South Sudan, Democratic Republic of the Congo, and Angola (see Table 3).

Table 3: EAC partner states' African trading partners for exports in 2013.

Crop Name	#1	#2	#3	#4
Maize	Sudan	Democratic Republic of the Congo	South Sudan	–
Groundnuts	Sudan	Angola	South Sudan	Democratic Republic of the Congo

Source: UN Comtrade.
Notes: For both maize and groundnuts, a large amount of EAC exports are sold to other countries within the EAC. However, this table lists the non-EAC partner states where the highest values of exports are sent. Beyond Africa, the UK and Vietnam are trading patterns in the top four for maize and groundnuts, respectively.

We consider the relative trade-off between health and impacts using the example of maize, an important food-security crop and consumed widely in Africa (with large variation in its relative share in daily calorie requirements). Table 4 presents the results of our analysis. We calculated the trade impact, assuming that the regulated levels are 5 ppb and that 15% of EAC's maize exports are contaminated (11,412 tons) above this level. In the case where there are no harmonized regulations, there will be no trade impact. With regulation, these exports would be rejected. Given a maize price of $0.20 kg, the value of rejected maize would be $2.3 million.

Keeping the trade impact constant, we considered the avoided health impact from removing the contaminated commodity from human consumption for two different types of countries--one that relies heavily on imports (imports comprise 25% of the consumption) and another where imports comprise only 5% of consumption. For each, we estimated the avoided health impact at different levels of contamination of the rejected commodity, and for two different levels of consumption: one that relies heavily on maize consumption and another that relies less on maize consumption. In effect, we developed scenarios for four types of countries:

1. High import reliance but less share in calorific consumption in diets
2. High import reliance and high share in calorific consumption in diets

3. Low import reliance and less share in calorific consumption in diets, and
4. Low imports but high share in calorific consumption in diets.

For the analysis, we assume that the contaminated commodity enters the consumption basket of the importing country. As is well documented, aflatoxin exposure increases the risk of HCC, liver cancer. Therefore we calculated the HCC risk that results from ineffective aflatoxin standards, following the approach described by Abt Associates, Inc. (2013). We developed this scenario for all four cases mentioned above. For example, we find that if 15% of maize imports are contaminated at 20 ppb in a country with high maize consumption, and a large proportion of consumption from imports, the risk of HCC is 0.19 cases per 100,000 population. That is, if the country's population is 40 million, then there will be 76 more HCC cases that could be avoided if there were effective aflatoxin standards at 20 ppb.

In addition to risk of HCC cases, we estimated margins of exposure (MOE), which is calculated as the ratio of the benchmark dose lower limit (BMDL) and exposure. We used a BMDL of 170 nanograms (ng) per kg of body weight per day (ng/kg bw/day), which was calculated for aflatoxins (European Food Safety Authority 2007). Exposure levels for each scenario (high/low consumption and large/small contributions of imports to overall consumption) vary by the concentration level of rejected maize. Any MOE less than 10,000 is a health concern, according to the United National Food and Agriculture Organization (FAO) and World Health Organization (WHO) (2005). In most cases, regulation did not change the determination of whether there is a health concern (i.e., the MOE does not "switch" from being lower than 10,000 without regulation to being higher than 10,000 with regulation). The only cases where the MOE switches are for very high concentrations (200 and 500 ppb) of rejected maize in a country where there is low consumption but a large proportion of consumption is obtained from imports.

Table 4: HCC risk due to maize contamination.

Trade Impact [a]							
Imported volume		76,081 tons					
Volume of contaminated maize imports		11,412 tons (15% of total imports)					
Maize price		$0.20/kg					
Value of maize discarded due to contamination		$2.3 million					
Health Impact[b]							
Maize Consumption Level[c]	**HCC Risk**	**Concentration level of rejected maize (ppb)**					
		5	**10**	**20**	**50**	**200**	**500**
Large proportion (25%) of consumption from imports							
High consumption	Cases avoided per 100,000	0.05	0.09	0.19	0.47	1.90	4.73
	Percentage decline in baseline risk [d]	1%	2%	4%	9%	38%	95%
	MOE without regulation [e]	7,552	7,036	6,189	4,570	1,974	924
	MOE with regulation [e]	8,118	8,118	8,118	8,118	8,118	8,118
Low consumption	Cases avoided per 100,000	0.01	0.03	0.06	0.14	0.55	1.39
	Percentage decline in baseline risk [d]	0.3%	1%	1%	3%	11%	28%
	MOE without regulation [e]	31,657	29,514	25,954	19,166	8,281	3,879
	MOE with regulation [e]	34,068	34,068	34,068	34,068	34,068	34,068
Small proportion (5%) of consumption from imports							
High consumption	Cases avoided per 100,000	0.01	0.02	0.04	0.10	0.38	0.95
	Percentage decline in baseline risk [d]	0.2%	0.4%	1%	2%	8%	19%
	MOE without regulation [e]	7,763	7,640	7,437	6,838	4,915	3,139
	MOE with regulation [e]	7,885	7,885	7,885	7,885	7,885	7,885
Low consumption	Cases avoided per 100,000	0.003	0.01	0.01	0.03	0.11	0.28
	Percentage decline in baseline risk [d]	0.1%	0.1%	0.2%	1%	2%	6%
	MOE without regulation [e]	32,567	32,015	31,193	28,668	20,631	13,168
	MOE with regulation [e]	33,074	33,074	33,074	33,074	33,074	33,074

a. The imported volume is equal to the EAC's total maize exports in 2013. Maize price is based on farmgate prices of $0.17 in Tanzania and $0.21 in Nigeria, as estimated from the Living Standards Measurement Study (LSMS).

b. We assumed an average contamination of 2.5 ppb for both domestically produced maize and non-discarded maize imports. We assumed that contaminated maize imports that are discarded will be replaced by other food that has zero contamination.

c. High maize consumption is based on Tanzania's consumption patterns (363.65 g/day), while low maize consumption is based on Nigeria's consumption patterns (95.90 g/day), as estimated from LSMS.

d. Assuming an average baseline risk of 5 cases per 100,000, based on risks of 5.6 and 6.5 per 100,000 in Tanzania and Nigeria, respectively (data from WHO).

e. MOE = margin of exposure. MOE is calculated as the ratio of the benchmark dose lower limit and exposure. We used a BMDL of 170 ng/kg bw/day, calculated for aflatoxins (European Food Safety Authority, 2007). Any MOE<10,000 is a health concern, according to FAO/WHO (2005).

Trade Potential

Assessing trade potential for the crops of concern requires a full analysis that compares the cost of investments needed to make EAC partner states competitive in exporting, and the resulting impact on the cost of production of the crops, against the cost of production in countries that are the leading exporters. While this analysis is outside the scope of this paper, we present the current volume and value of trade in these crops, and the key exporters and importers, to facilitate such an analysis.

Trading partners for exports are important, since trade with some countries (such as those in the EU) is likely to produce higher export values than trade with other African countries. Table 5 shows the top countries where exports go, from the largest worldwide and African exporters in 2013 and from the EAC partner states.

The top worldwide exporters were: USA for maize and groundnuts, and India for rice, cashews, and sesame.

The top sub-Saharan African exporters included South Africa for maize and rice, Malawi for groundnuts, Ghana for cashews, and Burkina Faso for sesame. For both rice and groundnuts, the top destination for both the largest African exporter and the EAC partner states are within Africa, while the top worldwide exporters sell these crops to Iran and Vietnam, respectively.

For maize, the EAC partner states' largest trading partner is Sudan, while a large portion of South Africa's export value comes from trade with Japan; the USA's largest trading partner is Mexico.

Table 5: Top trading partner for exports in 2013.

Crop	Worldwide	African	EAC partner states (total)
Top Exporters[a]			
Maize	USA	South Africa	All EAC partner states combined
Rice	India	South Africa	All EAC partner states combined
Groundnuts	USA	Malawi	All EAC partner states combined
Cashews	India	Ghana	All EAC partner states combined
Sesame	India	Burkina Faso	All EAC partner states combined
Top Exporters' Trading Partners [b]			
Maize	Mexico	Japan	Sudan
Rice	Iran	Botswana	Dem. Rep. of the Congo
Groundnuts	Vietnam	Zambia	Sudan
Cashew	USA	India	India
Sesame	Rep. of Korea	Singapore	China

Source: UN Comtrade.

a. Top worldwide and sub-Saharan African exporters were identified using data on the value of countries' exports to all countries in 2013.

b. In some cases (e.g., maize, groundnuts), a large amount of EAC exports are sold to other countries within the EAC. However, this table lists the non-EAC country where the highest value of exports is sent.

None of the EAC partner states have an EU country as their largest trading partner. Since the EU is a major market that African countries could access, we examined the current value and volume of imports to the EU. For each key crop, Table 6 shows EU import values and volumes: in total, for the top three countries from which they obtain these commodities, and for the top exporter from sub-Saharan Africa to the EU. For all crops except sesame, the top African exporter's trade value is much lower than the overall top exporters to the EU. Note that Tanzania is the top African exporter of cashews to the EU.

Table 6: Value and volume of EU imports in 2013.

Crop / Country	EU Import Value (US$)	EU Import Volume (kg)
Groundnuts		
Total	**$1,067,765,284**	**642,778,954**
Argentina	$457,644,325	289,099,400
USA	$265,043,543	163,291,000
China	$154,669,160	83,543,000
South Africa	$9,964,539	4,169,300
Maize		
Total	**$3,391,327,452**	**11,116,313,199**
Ukraine	$1,930,286,147	6,853,668,300
Brazil	$691,857,157	2,418,466,448
Argentina	$133,708,194	342,611,800
South Africa	$29,966,314	58,184,300
Rice		
Total	**$1,207,353,870**	**1,447,547,720**
India	$377,907,412	365,644,300
Thailand	$237,397,643	209,593,932
Cambodia	$165,694,457	226,997,400
Malawi	$55,578	35,000
Cashew		
Total	**$563,262,408**	**80,887,780**
Vietnam	$287,537,645	42,744,600
India	$193,641,195	25,985,000
Brazil	$38,926,324	5,848,500
Tanzania	$9,112,334	1,287,311
Sesame		
Total	**$270,058,688**	**125,057,973**
India	$127,281,959	53,236,900
Nigeria	$42,776,448	23,732,068
Sudan	$28,336,220	15,897,200

Source: UN Comtrade

Another way to identify markets that could be accessed is to consider the largest importers of the key crops (see Table 7). EAC partner states already export sesame to China and cashews to India, which are top worldwide exporters (as shown in Table 5). There may be potential to realize trade gains by trading maize, rice, and groundnuts with the major importers in the EU, such as Spain, the United Kingdom, and the Netherlands.

Table 7: Top importers in 2013, by value and volume.

Crop Name	Top Worldwide Importer	Top EU Importer	Top African Importer
By Value			
Maize	Japan	Spain	Zimbabwe
Rice	Saudi Arabia	United Kingdom	South Africa
Groundnuts	Netherlands	Netherlands	South Africa
Cashew	USA	Netherlands	South Africa
Sesame	China	Germany	South Africa
By Volume			
Maize	Egypt	Spain	Madagascar
Rice	Madagascar	United Kingdom	Madagascar
Groundnuts	Netherlands	Netherlands	South Africa
Cashew	India	Netherlands	South Africa
Sesame	China	Greece	South Africa

Source: UN Comtrade

Scenarios for Enforced Aflatoxin Regulations

If we assume that aflatoxin regulations for maize are fully enforced, there are no human health impacts, since the contaminated grain is taken out of consumption. However, there will be substantial impacts on trade (both formal and informal), as well as domestic production and the availability of food. Since accurate data on informal trade are not available, we focus on formal trade, but our results likely underestimate actual trade losses and their effects. However, our estimates from domestic production represent the overall loss, whether it is consumed, domestically traded, informally exported, or formally exported. The analysis is based on maize production, consumption, and trade for the year 2011 because it is the most recent year that is available across all sources from FAOSTAT (in particular, the latest food balance sheets are from 2011).

The current EAC harmonized standard for maximum tolerable levels of aflatoxin in maize is 10 ppb. We assume the following scenarios for the prevalence of maize that is contaminated with aflatoxin above 10 ppb: 10%, 15%, 45%, and 60%. These scenarios are based on estimates of the prevalence of contaminated maize samples in Tanzania and Kenya. In Tanzania, the Tanzania Food and Drugs Authority (TFDA) estimated an overall prevalence of 14%, and zone-specific estimates ranging from 4% to 43%.[6] In Kenya (as well as subpopulations studied elsewhere), elevated serum aflatoxin levels indicate high levels of chronic aflatoxin ingestion, suggesting that more than 45% of the maize is contaminated (see Table 8).

[6] Aflatoxin testing by TFDA, 2012.

These levels can be considered representative of the past five years with some upward adjustments for extreme climatic events, which could have elevated aflatoxin contamination in specific zones.

Table 8: Aflatoxin contamination in maize in the EAC above the 10 ppb standard.

Crop	Study year	EAC maize production (mMT)	Quantity above 10 ppb (mMT)	% of maize above 10 ppb	Reference
Maize	1990	5.6	1.7	30	Kaaya et al. 2005
Maize	2004	8.5	4.3	51	Lewis et al. 2005
Maize	2005	7.4	3.0	41	Daniel et al. 2011
Maize	2006	8.1	4.1	51	Daniel et al. 2011
Maize	2006	8.0	6.7	83	Okoth & Kola 2012
Maize	2007	8.0	1.3	16	Daniel et al. 2011
Maize	2013	11.0	5.0	45	Kilonzo et al. 2014

Formal Trade

In Table 9, we summarize the trade volume and value that would be lost in each EAC country under the four scenarios of aflatoxin prevalence above the maximum tolerable standard of 10 ppb if regulations were enforced at EAC trade borders. In 2011, maize prices in EAC countries ranged from $283 to $406 per metric ton (data from FAOSTAT). Of these countries, the largest impacts are seen for Uganda, which had the highest maize exports in 2011, followed by Kenya. Trade values lost in Uganda range from $1.7 million to $10.3 million across the four scenarios. In Kenya, trade values lost range from $656,700 to $3.9 million across the four scenarios. In the 15% scenario (which is similar to the overall prevalence estimate for Tanzania), trade volumes lost would exceed 1,000 metric tons in three countries: Kenya, Tanzania, and Uganda.

Table 9: Formal trade volume and value (USD) lost due to aflatoxin regulations.

	Maize Prevalence Scenario (Percentage above 10 ppb)							
	10%		15%		45%		60%	
Country	**Volume Lost (MT)**	**Value Lost (USD)**	**Volume Lost (MT)**	**Value Lost (USD)**	**Volume Lost (MT)**	**Value Lost (USD)**	**Volume Lost (MT)**	**Value Lost (USD)**
Burundi	112	$9,400	168	$14,100	504	$42,300	672	$56,400
Kenya	1,085	$656,700	1,628	$985,050	4,883	$2,955,150	6,510	$3,940,200
Rwanda	169	$12,700	254	$19,050	761	$57,150	1,015	$76,200
Tanzania	744	$218,100	1,116	$327,150	3,349	$981,450	4,465	$1,308,600
Uganda	5,498	$1,709,600	8,247	$2,564,400	24,740	$7,693,200	32,987	$10,257,600

Source: UN Comtrade 2011

Overall Loss

If regulations are enforced domestically and for trade, we can estimate the overall loss for the countries based on the overall domestic production, whether it is exported, consumed or sold, and accounting for losses from aflatoxin contamination (Table 10). Kenya and Tanzania each produce large quantities of maize (3.4 and 4.3 million metric tons, respectively). In the highest scenario of maize prevalence, over 2 million metric tons of maize would be lost in each of these countries.

Table 10: Domestic production lost due to enforced aflatoxin regulations.

		Maize Prevalence Scenario (Percentage above 10 ppb)			
Country	Production in 2011 (MT)	10%	15%	45%	60%
Burundi	128,483	12,848	19,272	57,817	77,090
Kenya	3,376,862	337,686	506,529	1,519,588	2,026,117
Rwanda	525,679	52,568	78,852	236,556	315,407
Tanzania	4,340,823	434,082	651,123	1,953,370	2,604,494
Uganda	2,551,000	255,100	382,650	1,147,950	1,530,600
Total	10,922,847	1,092,285	1,638,427	4,915,281	6,553,708

Note: Data for 2011 from FAOSTAT

Calorie Consumption

Given the production losses described in Table 10, aflatoxin regulations would also have an impact on consumption in the short run, since calories that now come from maize would need to be replaced with food from another crop. As shown in Table 11, Kenya, Tanzania, and Burundi have the heaviest reliance on maize for daily calories (over 20%). In the highest scenario of maize prevalence, over 10% of calories would need to be replaced in each of these three countries.

Such a substitution would have implications for nutrition and food security. Since maize currently comprises 23-31% of per capita calories in these countries, households would likely face difficulties in finding available and economically accessible substitutes that adequately satisfy energy needs. Maize is also a key contributor of fiber, lysine, and vitamin B6 in the diet, and, when combined with a legume product, comprises a balanced protein comparable to animal products. In other words, downward adjustments in maize consumption are likely to have multiple negative impacts on the nutritional wellbeing of individuals residing within the East Africa region.

		Maize Prevalence Scenario (Percentage above 10 ppb)			
Country	**Calorie Share from Maize**	**10%**	**15%**	**45%**	**60%**
Burundi	23%	2.3%	3.4%	10.3%	13.7%
Kenya	31%	3.1%	4.6%	13.8%	18.4%
Rwanda	6%	0.6%	0.9%	2.6%	3.4%
Tanzania	24%	2.4%	3.5%	10.6%	14.1%
Uganda	15%	1.5%	2.3%	6.8%	9.1%
Average	**20%**	**2.0%**	**2.9%**	**8.8%**	**11.8%**

Source: FAO Food Balance Sheets, 2011

Conclusion

In summary, this paper finds that in the absence of enforcement of regulations in domestic trade within the EAC and in trade among African countries, the impact of aflatoxin regulations is likely to be very low. Large informal trade flows among the African countries make it hard to enforce regulations currently, resulting in insignificant trade impact from aflatoxin regulations. Since informal trade data are not all available, it is also possible that accounting for the rejections in the formal market may overstate the actual impact (because the commodity would have made its way informally). Historic data on export volumes from EAC partner states in key commodities—maize, groundnut, sesame, rice, and cashews—also do not suggest that aflatoxin regulation resulted in large losses in international trade. In fact, sesame and rice exports from Tanzania have increased recently.

Overall, itis more likely that other factors limit EAC country's ability to export than the aflatoxin levels in the commodity.

We conclude by noting that it is limiting to consider the question of the impact of aflatoxin contamination of food stuffs only from the perspective of its economic impact resulting from rejections or reduction in trade volume. It is also important to consider the positive impacts that result from aflatoxin regulations on the avoided negative health impacts. Poor enforcement of regulations means there are no trade impacts, but this also means that the contaminated crops are being consumed. For example, if 11,400 tons of maize (15% of EAC exports), valued at $2.3 million, is contaminated at 20 ppb in a country with high maize consumption and a large proportion of consumption from imports, the increased risk of HCC from not removing that maize from the diet is 0.19 additional cases of HCC per 100,000 population. That is, if the country's population is 40 million, then there will be 76 more HCC cases that could be avoided given effectively enforced aflatoxin standards.

Policy Recommendations

1. The full benefits of harmonized aflatoxin standards for agricultural commodities, and food and feed within the East Africa region can only be realized with adequate enforcement of these standards, both at the borders and within domestic markets. Therefore, adequate human and financial resources should be focused on establishing and enforcing aflatoxin standards in conjunction with other sanitary and phytosanitary standards regulations within EAC partner states.
2. A secondary and parallel approach to regulation and enforcement is needed for the informal trade, processing, and marketing sectors. Without this, over half of domestic and cross border trade will continue to flow unregulated. This will undermine efforts to address the detrimental public health impacts of aflatoxin.
3. Emphasis should be placed on the design of a decentralized, multi-tiered testing protocol in tandem with making affordable and reliable testing technologies readily available and economically accessible for farmers, traders, artisanal food and feed processors, customs and borders officials, government regulators, and consumers.
4. Safe and rapid disposal systems for contaminated commodities and products need to be established within the domestic value chains, and at international trading points.

5. The flow of animal feeds that may be the result of new alternative-use programs for aflatoxin contaminated commodities needs to be newly addressed within domestic and regional trade regulations.
6. A modernized regulatory environment that shifts the responsibility for compliance from the public sector to the private sector (traders) should be pursued.
7. Development of a credible “aflatoxin safe” certification will be a necessary condition to support the development of such products and as enforcement becomes efficient. This can also play a role in expediting the movement of intra-regionally traded aflatoxin-prone commodities and products by reducing time spent transiting borders.
8. Harmonization of standards across Africa will bring impetus to the overall efforts to generate awareness about aflatoxin, strengthen the legal and regulatory environment, and increase Africa’s trade shares in the global marketplace. The EAC and COMESA should play a leadership role with SADAC, MENA, and ECOWAS to establish such standards. The PACA can also be used as a vehicle for this initiative.
9. Until agricultural production, processing, and markets become fully responsive to new demand for aflatoxin safe crops and products, and aflatoxin contaminated commodities are transparently and swiftly removed from markets, there will be an interim period of transition where there are dual markets–one for higher premium aflatoxin safe commodities, foods and feed, and another for contaminated products. For the short- to medium-term during this transition period, attention should be focused on protecting poorer households and other vulnerable groups, which are more likely to consume contaminated products.
10. Programs that address the region’s high levels of on-farm consumption must be integrated into the larger trade and regulatory initiatives to ensure these households are not marginalized, and to promote equitable consumer protection.

List of Abbreviations and Definitions

Term	Definition
BMDL	Benchmark dose lower limit
COMESA	Common Market for Eastern and Southern Africa
EAC	East African Community
ECOWAS	Economic Community Of West African States
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
HAV	Hepatitis A virus
HBV	Hepatitis B virus
HCC	Hepatocellular carcinoma
MENA	Middle East and North Africa
MOE	Margin of exposure
ng	Nanograms
PACA	Perishable Agricultural Commodities Act
ppb	Parts per billion
PLWA	People living with AIDS
ppm	Parts per million
RASFF	Rapid Alert System for Food and Feed
SADC	Southern African Development Community
SPS	Sanitary and Phytosanitary Standards
WHO	World Health Organization

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