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Low Levels of Genetically Modified Crops in International Food and Feed Trade: FAO International Survey and Economic Analysis

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TABLE OF CONTENTS

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ABSTRACT

The low level presence (LLP) and adventitious presence (AP) of Genetically Modified Organisms (GMO) in internationally traded food crops have been a major issue of discussion recently. The production (research and commercial use) of GM food crops is increasing in both developed and developing countries. On the other hand, many countries have quite diverse GMO regulations. Asynchronous Approvals (AA) and zero tolerance policy have been reported to have trade diversion effects by some of the exporters. Therefore, FAO conducted a survey to evaluate the issue and examine the impact of LLP on trade flow. The survey was sent to national government organizations through FAO Representations (FAORs), Codex contact points, and individual contacts in early 2013. The survey results provided useful information on the current situation of GM food crops, regulations, and other related issues. Almost half of the respondents (47 percent) indicated that they produce GM crops for research or commercial use. 78 percent of respondents indicated that they have a GMO regulation; however, 22 percent either don't have or are planning to have regulations in the future. This situation may give a rise to uncontrolled import of GM crops especially for developing countries. High level of regional guidelines is a critical issue in food safety regulations worldwide. 37 percent of the respondents indicated that they have a LLP threshold at least for one group of product (feed). The remaining 63 percent do not have any threshold limit for LLP related imports. Only 33 percent of the respondents indicated that they have a technical capacity to detect GMOs in imports. Therefore, capacity development is a particularly an important issue for developing countries. 37 percent of the respondents indicated that they faced LLP/AP in their imports in the last 10 years. The main crops that are subject to LLP/AP incidents are linseed, rice, maize, and soybean. The US (73 incidents), China (62), and Canada (44) were the main exporters whose consignments were involved in LLP/AP incidents in the survey. The most important factors that contribute to the trade risk are indicated as different policies on GMOs existing between trading partners, unintentional movement of GM crops, and different timing for approvals. The economic analysis section of the study found some evidence regarding the deterrent impact of regulation restrictiveness, including zero tolerance for the maize trade. The restrictive LLP threshold itself has a somewhat ambiguous impact such that it is found insignificant in an ad hoc model, while a theoretical model indicates a slight deterring effect on bilateral export flows. On the other hand, the FAO survey reveals that there are some incidents reported by the importing countries related to the LLP/AP. Most of the time the situation is handled through rejection or market withdrawals by the importers of developed countries, and in some cases it was accepted by some developing countries. These incidents may have several welfare impacts on producers, consumers, and agribusiness firms. A certain level of incidents can lead to income loss for exporters and consequently for producers. Consumers in importing countries can potentially face higher domestic prices when import is deterred from one country and directed to a trading partner. Therefore, GM crop producing countries, either for research or commercialized production, should take all the necessary measures in the stages of production, harvesting, transportation, storage, and marketing to eliminate low level of presence in conventional crops. More international collaboration is needed in this area. When evaluating the impacts of related regulations and standards a holistic approach that covers consumer safety and environmental effects should be considered together with the trade effects.

INTRODUCTION

Low level presence (LLP) and adventitious presence (AP) of Genetically Modified Organisms (GMOs) in internationally traded crops are leading to concerns for both the private and public sectors. The land area under GM cultivation has grown steadily over the last two decades and many of the GM crops are important in international trade, such as soybean, maize, and canola. In addition, available information suggests that there are a number of new GM crops under development and that a growing number of countries are involved in developing these crops. Current systems of production, handling and transportation lead to unintentional low level presence of GMOs in non-GMO consignments. A number of trade-related problems have been reported due to such unintentional mixing. On the other hand, national policies and regulations that govern the acceptability of genetically modified (GM) crops vary.

FAO carried out a study to better understand the extent of trade-disruption due to LLP and AP. As an outcome of the survey, the paper aims to examine the impact of LLP incidents on agricultural trade flow utilizing both international trade flow and survey data. The study consists of three main sections. The first section aims to evaluate the overall situation by examining the current production, trade issues, and regulations of GM crops worldwide. The second section of the study is concerned with the analysis of the FAO survey carried out in 2013. The questions in that part will help us understand the current issues related to regulations, LLP/AP incidents and trend of these incidents related to GM crops in the future. The third section examines the impact of GMO regulations and LLP on trade flows.

Objectives

The main objective of this paper is to review current production, trade, and regulation of GM food crops, and estimate the impact of LLP on trade flow. Specifically:

1. To provide an overview of the current production and trade of GM crops;
2. To provide an overview of current GMO regulations and international agenda;
3. To evaluate the responses in the FAO survey on LLP/AP;
4. To estimate the impact of GMO regulation and LLP on trade flows on a product basis.

Method

This study firstly reviews the current situation of GM crops in terms of production, trade and related regulations. In addition a comprehensive literature review is made for the impacts of GM and LLP on trade and welfare. The FAO survey was sent to national government organizations through FAORs, Codex contact points, and individual contacts. The responses were then evaluated and classified in figures and tables. The economic analysis section utilizes trade flow data and employs a bilateral trade flow model to examine the impact of GM related regulations and LLP on trade flow. Detailed information on the methods is explained in each section.

1. REVIEW OF CURRENT SITUATION

1.1 Genetically modified crops

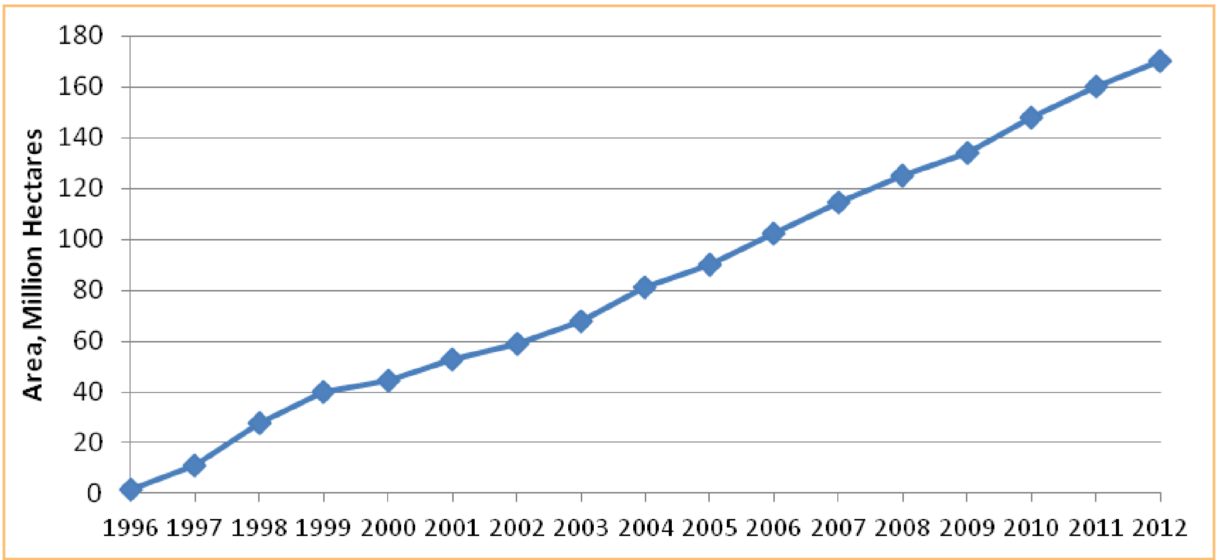
Biotechnology involves a wide range of technologies which can be applied for a range of different purposes, such as the genetic improvement of plant varieties and animal populations to increase their yields or efficiency, genetic characterization and conservation of genetic resources, plant or animal disease diagnosis, vaccine development, and improvement of feeds (FAO, 2011a). One of these biotechnologies is genetic modification and it is used to produce genetically modified organisms (GMOs). GMO refers to an organism that has been transformed by the insertion of one or more transgenes (FAO, 2001). In line with the rapid advances in biotechnology, a number of genetically modified (GM) crops have been developed and released for commercial agriculture production (see FAO, 2011b). In addition, a recent FAO e-mail conference indicated that in the near future the new GMOs likely to be released would continue to centre around four crops (soybean, maize, cotton, and canola) and two traits (herbicide tolerance and insect resistance) but that they would also involve a broad range of additional species by trait combinations (Ruane, 2013).

The increasing cultivation of GM crops has raised a wide range of concerns related to food safety, environmental effects and socio-economic issues. From the food and health perspective, the main concerns are related to possible toxicity and allergenicity of GM foods and products. Concerns about environmental risks include the impact of introgression of the transgenes into the natural landscape, impact of gene flow, effect on nontarget organisms, evolution of pest resistance and loss of biodiversity. The social and ethical concerns about restricting access to genetic resources and new technologies, loss of traditions, such as saving seeds, private sector monopoly and loss of income of resource-poor farmers (FAO, 2012).

1.2 Production

The total area of GM crops amounted to 170 million hectares by at the end of 2012 (Figure 1). The main growers of GM crops are the US, Brazil, and Argentina, while India, Canada and China also are important producers (Table 1).

Figure 1. Global Area of GM crops, 1996-2012



Source: Compiled from James, 2010-2013.

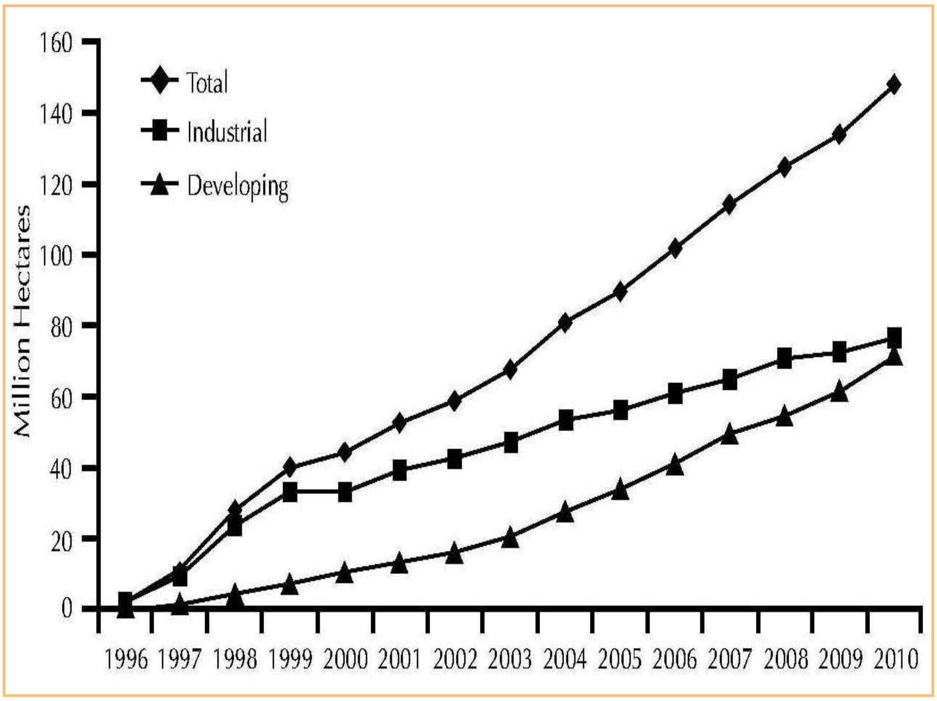
Table 1: Global status of commercialized GM crops, 2010

Country	Area (Million Hectares)	Share %
USA	66.8	45
Brazil	25.4	17
Argentina	22.9	16
India	9.4	6
Canada	8.8	2
China	3.5	2
Paraguay	2.6	2
Pakistan	2.4	2
South Africa	2.2	2
Uruguay	1.1	1
Bolivia	0.9	1
Australia	0.7	<1
Philippines	0.5	<1
Myanmar	0.3	<1
Burkina Faso	0.3	<1
Spain	0.1	<1
Mexico	0.1	<1
Colombia	<0.1	<1
Chile	<0.1	<1
Honduras	<0.1	<1
Czech Republic	<0.1	<1
Poland	<0.1	<1
Egypt	<0.1	<1
Slovakia	<0.1	<1
Costa Rica	<0.1	<1
Romania	<0.1	<1
Sweden	<0.1	<1
Germany	<0.1	<1

Source: Compiled from James, 2010.

Developing countries have decreased the gap with developed countries in 2010 (Figure 2), and according to the most recent ISAA report (James, 2013), developing countries account for 52 percent of global area planted for GM crops while developed countries account for 48 percent in 2012.

Figure 2. Global Area of GM crops by Developed and Developing Countries, 1996-2010



Source: Compiled from James, 2010.

Soybean ranks first (50 percent) in total GM crops planted followed by maize and cotton. The share of GM crops to the total area planted is 81 percent for soybean and 64 percent for cotton (Table 2-3).

Table 2: Distribution of GM crops, 2010

Crop	Area (Million Hectares)	Share %
Soybean	73.3	50
Maize	46.0	31
Cotton	21.0	14
Canola	7.0	5
Sugar Beet	0.5	<1
Alfalfa	0.1	<1
Papaya	<0.1	<1
Others	<0.1	<1

Source: Compiled from James, 2010.

Table 3: GM crops area as percentage of global area of principal crops, 2010

Crop	Global Area (Million Hectares)	Biotech Area (Million Hectares)	Share, %
Soybean	90	73.3	81
Cotton	33	21.0	64
Maize	158	46.0	29
Canola	31	7.0	23
Others	-	0.7	-

Source: Compiled from James, 2010.

The ISAAA Report (James, 2010) estimates the global value of GM crop markets as US$ 11 billion in 2010.

Table 4: The global value of the GM crop market, 1996 to 2010

Year	Value (US$ Million)
1996	93
1997	591
1998	1.560
1999	2.354
2000	2.429
2001	2.928
2002	3.470
2003	4.046
2004	5.090
2005	5.714
2006	6.670
2007	7.773
2008	9.045
2009	10.607
2010	11.219

Source: Compiled from James, 2010.

1.3 GMO regulations and approvals

According to ISAAA (James, 2010) 29 countries planted commercialized GM crops in 2010 and an additional 30 countries have granted regulatory approvals for GM crops for import, food and feed use, and for release into the environment since 1996. It must be underlined that an estimated 75 percent of the world's population of 6.7 billion, equivalent to 4.4 billion people, live in the 59 countries which have approved planting or import of biotech crop products. A total of 973 approvals have been granted for 183 events for 24 crops. More specifically, GM crops are accepted for planting and import for food and feed use, and for release into the environment in 59 countries, including major food importing countries like Japan, which do not plant GM crops for commercial purpose. Of the 59 countries that have granted approvals for GM crops, USA tops the list followed by Japan, Canada, Mexico, Australia, South Korea, the Philippines, New Zealand, the European Union, and China. Maize has the most events approved (60) followed by cotton (35), canola (15), potato and soybean (14 each). The event that has received regulatory approval in most countries is herbicide tolerant soybean event GTS-40-3-2 with 24 approvals, followed by herbicide tolerant maize (NK603) and insect resistant maize (MON810) with 21 approvals each, and insect resistant cotton (MON531/757/1076) with 16 approvals worldwide.

1.4 Zero tolerance policy and LLP

In general zero tolerance policy states that any imported food or feed material cannot contain even trace amounts of GMO substances that have not been authorized in the importing country. Although there are no universally agreed definitions, in general LLP refers to low level presence of those GMOs that have been approved in at least one country on the basis of a food safety assessment according to the relevant Codex Guidelines. Adventitious Presence (AP) refers to the unintentional presence of GMOs that have not been approved in any countries on the basis of the international guidelines for safety assessment.

The most prominent zero tolerance policy is the one applied by the EU. Zero tolerance applies to all unauthorized GM crops in food and seed. GMO related regulations in the EU are: Directive 2001/18/EC on the deliberate release into the environment of genetically modified organisms and repealing Council Directive 90/220/EEC, in force since 2001. EU Food Safety Regulation, EC-178/2002, in force since 2002. Regulation (EC) No 1829/2003 on genetically modified food and feed, in force since 2003. Regulation (EC) No 1830/2003 concerning the traceability and labelling of genetically modified organisms and the traceability of food and feed products produced from genetically modified organisms and amending Directive 2001/18/EC, in force since 2003. EU Food Safety Regulation, EC-178/2002, in force since 2002. Article 4(2) of Regulation 1829/2003 states that "No person shall place on the market a GMO for food use or food referred to in Article 3(1) unless it is covered by an authorization".

In order to address the LLP issue, a partial solution was adopted by the EU. The regulation No 619/2011, in force since July 2011, lays down the methods of sampling and analysis for the official control for feed related to the GMO. This regulation basically sets the threshold level of 0.1 percent for feed, so called "technical solution". However, for food and seed this threshold is 0 percent. There are some arguments initiated by the GM crop exporters, on the adaptation of this zero tolerance policy by other neighbouring or food importing countries, and concerns were raised over the impact on trade flow caused by the LLP incidents. For instance in the FAO survey (2013) 46 of the respondents (72 percent) reported that they apply zero tolerance for unauthorized GM crops, although effectiveness of this policy is questionable for some countries based on technical capacities to detect and implement. In addition, another argument initiated by the exporters is the "Asynchronous Approvals" (AA), approvals granted by one importing country but still pending in another. The issue of AA is reportedly leads to delays and additional cost for traders.

1.5 International agreements, guidelines and relevant activities on food, feed, and environmental safety and trade

Codex Alimentarius Commission

The Codex Alimentarius Commission, established in 1963 by the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO), develops harmonized international food standards, guidelines and codes of practice to protect the health of the consumers and ensure fair practices in the food trade. While being recommendations for voluntary application by members, Codex standards serve in many cases as a basis for national legislation. The reference made to Codex food safety standards in the World Trade Organization's Agreement on Sanitary and Phytosanitary measures (SPS Agreement) means that Codex has far reaching implications for resolving trade disputes. WTO members that wish to apply stricter food safety measures than those set by Codex may be required to justify these measures scientifically (Codexalimentarius, 2013). In 1999 Codex established an Ad hoc Intergovernmental Task Force on Foods Derived from Biotechnology (TFFBT) to be tasked with developing standards, guidelines or recommendations, as appropriate, for foods derived from biotechnology or traits introduced into foods by biotechnology. The Codex Alimentarius Commission has adopted one document on principles for risk analysis of foods derived from modern biotechnology and three key guidelines. Codex TFFBT was dissolved by the 31st session of the Commission (2008). The following documents that TFFBT has developed have been adopted:

- Principles for the Risk Analysis of Foods Derived from Modern Biotechnology (CAC/GL 44-2003)
- Guideline for the Conduct of Food Safety Assessment of Foods Derived from Recombinant-DNA Plants (CAC/GL 45-2003, hereinafter referred as Codex Plant Guideline)

- Guideline for the Conduct of Food Safety Assessment of Foods Produced Using Recombinant-DNA Microorganisms (CAC/GL 46-2003)

- Guideline for the Conduct of Food Safety Assessment of Foods Derived from Recombinant-DNA Animals (CAC/GL 68-2008)

- The TFFBT has also developed a series of annexes to the Codex Plant Guideline and the following annexes have been adopted the Commission:

- Annex I: Assessment of Possible Allergenicity

- Annex II: Food Safety Assessment of Foods Derived from Recombinant DNA-Plants Modified for Nutritional or Health Benefits, and

- Annex III: Food Safety Assessment in Situations of Low-Level Presence of Recombinant-DNA Plant Material in Food (LLP Annex).

The Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS Agreement).

It is an international treaty of the World Trade Organization. It was negotiated during the Uruguay Round and entered into force with the establishment of the WTO in 1995. Main concerns for food safety are (WTO, 2013a):

- SPS issues are gaining more importance as tariff barriers decrease

- Food producers in developing countries are becoming increasingly concerned that their exports to markets of developed countries are being prevented by SPS measures

- Private sector exporters tend to assume that the real motive for importing countries' SPS measures is to protect producers rather than consumers.

The SPS Agreement indicates that measures either have to be based on scientific evidence of risk, or on recognized international standards. Countries are free to set their own standards based on science. The agreement says that (WTO, 2013a) the SPS measures should be based on:

- Recognized international standards, particularly those of the FAO/WHO Codex Alimentarius Commission, the World Organization for Animal Health (OIE), the International Plant Protection Convention (IPPC)

- Science, including scientific assessment of risk

- A temporary precautionary principle, which favours safety first approach in the absence of international standards or scientific evidence.

The WTO committee on SPS indicates that specific trade measures that are most frequently discussed are bovine spongiform encephalopathy (BSE, or mad cow disease), avian influenza (bird flu), foot and mouth disease, and various plant diseases and pests such as fruit flies. The most common complaints are that importing countries are not following the international standards. In addition, long delays in completing risk assessments or allowing imports is another frequent complaint. Recently some other barriers such as strict aflatoxin regulations and low level of presence in GMOs are gaining importance. According to the dispute settlement database (WTO, 2013b), there was a dispute titled "Approval and Marketing of Biotech Products" against the EU, and initiated by US (Third Parties: Argentina, Australia, Brazil, Canada, Chile, China, Chinese Taipei, Colombia, El Salvador, Honduras, Mexico, New Zealand, Norway, Paraguay, Peru, Thailand, Uruguay) in 2003. The mutually agreed solution with related parties provided for the establishment of a regular dialogue on issues of mutual interest on biotechnology applied to agriculture with some parties such as Argentina, Canada, and US in 2008 and 2009.

Agreement on Technical Barriers to Trade (TBT Agreement)-WTO:

It aims to ensure that product requirements and procedures that are used to assess compliance with those requirements do not create unnecessary obstacles to trade. It covers product requirements developed by governments or private entities at the national or the regional level. The TBT agreement promotes the development of international standards and encourages recognition of other countries' measures.

Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs)-WTO:

It is concerned with the protection and enforcement of all the main categories of intellectual property rights such as patents for inventions, copyrights, and trademarks for brand names. It lays down minimum standards that member governments should comply with in their national law. The TRIPS Agreement seeks to find an appropriate balance between interests of users of intellectual property and creators or producers of intellectual property.

OECD Task Force for the Safety of Novel Foods and Feeds

The work programme of the OECD Task Force for the Safety of Novel Foods and Feeds aims to promote international harmonization in the risk/safety assessment of novel foods and feeds. A number of non-OECD member economies and observer organizations are partners in this work. Biotechnology products, particularly commodities from new crop varieties, are increasingly moving into global trade. In this context, international harmonization of regulatory assessment of novel foods and feeds will ensure the protection of human and animal health. The programme aims to encourage information sharing, promote harmonized practices and common frameworks in safety assessment and regulation, and prevent duplication of efforts among countries. The major outputs of the programme are Consensus Documents that provide information on critical parameters of food/feed safety and nutrition. The documents gather, for each crop under consideration, common scientific elements on key nutrients, anti-nutrients, toxicants and allergens. A comparative approach focusing on similarities and differences between the novel food/feed and its conventional counterpart aids in the identification of potential safety and nutritional assessment. The outputs are intended to be used by governments (risk and safety assessors, regulators), industry (novel food/feed developers and producers), other stakeholders, as well as the wider scientific community (OECD, 2013).

OECD Working Group on the Harmonization of Regulatory Oversight in Biotechnology

The OECD's Working Group on Harmonization of Regulatory Oversight in Biotechnology deals with the environmental risk/safety assessment of transgenic plants and other genetically engineered organisms. The work aims to ensure that the types of elements used in biosafety assessment, as well as the methods to collect such information, are as similar as possible amongst countries. This improves mutual understanding and harmonized practice, which in turn, increases the efficiency of the biosafety assessment process, limits duplication of effort, while reducing barriers to trade. The publication of Consensus/Guidance Documents is a major output of the programme. They constitute a set of practical tools for regulators and biosafety assessors dealing with new transgenic plant varieties and organisms, with respect to environmental safety. The Working Group also deals with two key issues in the context of environmental risk assessment: 1) considerations for the release of transgenic plants, and 2) situations of low level presence of genetically-engineered plant materials in conventional seeds or commodities.

The Cartagena Protocol on Biosafety to the Convention on Biological Diversity:

The protocol is an international agreement which aims to ensure the safe handling, transport and use of living modified organisms (LMOs) resulting from modern biotechnology that may have adverse effects on biological diversity (CBD, 2013). It was adopted on 29 January 2000 and entered into force on 11 September 2003. The protocol lays down rules for international trade in LMOs, which are basically genetically modified organisms (GMOs) that have not been processed, and that could live if introduced into the environment, such as seeds. Under the protocol, a country which wants to export LMOs for intentional introduction into the environment (such as seeds for planting) must seek advance informed agreement from the importing country before the first shipment takes place.

The Biosafety Protocol requires parties to make decisions on import of LMOs for intentional introduction into the environment in accordance with scientifically sound risk assessments. It sets out methodological steps and points to consider in the conduct of risk assessment. The general principles include, among others, the following concepts: Risk assessment should be carried out in a scientifically sound and transparent manner; Lack of scientific knowledge or scientific consensus should not necessarily be interpreted as indicating a particular level of risk, an absence of risk, or an acceptable risk; Risks should be considered in the context of risks posed by the non-modified recipients or parental organisms; and that Risks should be assessed on a case-by-case basis. Under certain circumstances, importers can ask the exporter to carry out the risk assessment. In addition, the protocol contains provisions related to identification of LMOs in international trade. If a dispute is brought to the WTO, the panel can only judge compliance with WTO Agreements. In such circumstances, the Cartagena Protocol would presumably be taken into account as a relevant international treaty. However, the relationship of the protocol with the SPS Agreement and other international agreements is not clear.

Current Issues on Trade: The WTO committee on SPS (WTO, 2013a) identifies major areas of concern as follows:

Transparency: The Committee plays a key role in sharing information among the members. The members have to notify each other through the WTO when they are introducing new or changed import requirements. This notification is supposed to be made in advance for proper response from related countries. However, not all countries are providing advance warnings, and complaints about insufficient transparency are common.

Regionalization: Geographically larger members (the EU, Brazil, Canada, etc) object to covering of bans on all their exports when a problem exists only in some regions. The SPS Committee has developed guidelines to help governments implement this concept without much delay and setting out a process to follow.

Equivalence: Equivalence refers to recognition of other countries' measures as acceptable even if they are different from their own. This concept is a requirement in the SPS Agreement; however the implementation is difficult. There are still disputes on equivalence especially between developed and developing countries.

Private sector standards: Some developing countries have started to raise the question of standards set by the private sector, such as supermarket chains. The Committee has agreed to take some action to reduce potential negative effects of private standards. Private standards are often more rigid than international standards, causing small farmers to suffer. It has been discussed regularly since then.

Special treatment for developing countries: The debate concerning special treatment to poor countries such as providing more without endangering consumers and farming in importing countries still continues. The Committee has agreed on a procedure for developing countries to ask for special treatment or technical assistance when they face requirements they find difficult to meet. The discussion includes the question of technical assistance to help countries meet standards. To some extent the issue is related to equivalence accepting that alternative methods of testing and alternative measures can provide a level of protection that is equivalent to methods used in the importing country.

1.6 Related literature

An IFPRI study (Smale at al., 2007) examines existing studies according to stakeholders. The first category of study analyzes the adoption of GM crops and its impacts on farmers. The second examines the attitudes of consumers toward products made with transgenic ingredients. The third set considers the impact of GM crops on a given industry or sector, in terms of both producers and consumers. The last category examines the impacts of transgenic products on international trade.

In general, the research findings imply that GM crops do provide economic advantages for adopting farmers. However, there are several points to consider when evaluating the impacts. The first point is that only a limited range of GM crops has been studied because few have been released in developing countries. Most of the studies concentrate on specific crops such as studies of Bt cotton. A second general caveat is that there is considerable variation in gains. The magnitude of the economic gains advantages varies substantially according to the nature of the cropping season and the geographical location of the study. During the initial years of adoption, it makes sense that researchers have focused on the relative profitability of GM crops; if GM crops are not advantageous for farmers, they will not adopt them and there will be no measurable impact (Smale et al., 2007).

In terms of consumer studies, IFPRI classifies two main bodies of literature that address the influence of GM crops on consumer behaviour. The first consists of surveys designed to elicit the attitudes of consumers toward products made with GM crops. Findings are generally descriptive in nature. In the second set of studies, researchers exploit recent advances in stated-preference methods to estimate consumers' willingness to pay for products that are free of transgenic ingredients. All findings in this second set are based on hypothetical, rather than observed, choices. The findings generally indicate that attitudes of consumers change significantly as they absorb new information, and particularly negative messages. Framing of questions is therefore of great importance, and studies will have to be periodically updated as the market changes. Relative to their counterparts in developed economies, most consumers in developing economies have serious constraints on access to information about biotech food.

Trade interaction is researched in various methods such as partial and general equilibrium studies. The findings in general imply several points. They underline the importance of first-mover advantage. Countries that do not adopt GM crops lose if they stay behind. Second, a number of studies highlight the risk of productivity growth in markets with inelastic demand, which benefits consumers but hurts adopting producers. Third, many studies demonstrate that in developing economies, potential export losses resulting from the adoption of GM crops are unjustified relative to the potential gains from productivity enhancement. However IFPRI indicates that these studies have some deficiencies such as aggregation, assumption of perfectly competitive markets, imperfect market integration and imperfect price transmission in developing countries.

Anderson and Jackson (2005) employ the Global Trade Analysis Project (GTAP) model to estimate effects of other countries' GM policies without and with Australian and New Zealand farmers (ANZ) adopting GM varieties of various grains and oilseeds. The results indicate that the gross economic benefits to ANZ from adopting GM crops under a variety of scenarios could be positive even if the strict controls on imports from GM-adopting countries by the European Union are maintained.

Sobolevsky et al (2005) utilize a partial equilibrium four-region world trade model for the soybean complex in which Roundup Ready (RR) products are weakly inferior substitutes to conventional ones. RR seeds are priced at a premium, and costly segregation is necessary to separate conventional and biotech products. The findings illustrate that the United States, Argentina, Brazil, and the Rest of the World (ROW) all gain from the introduction of RR soybeans, although some groups may lose. The impacts of RR production or import bans by the ROW or Brazil are analyzed. U.S. price support helps U.S. farmers, despite hurting the United States and has the potential to improve world efficiency.

Gruere et al. (2007) study the potential effects of introducing GM food crops in Bangladesh, India, Indonesia, and the Philippines in the presence of trade-related regulations of GM food in major importers utilizing multi country general equilibrium model. They focus on GM field crops (rice, wheat, maize, soybeans, and cotton) resistant to biotic and abiotic stresses, such as drought-resistant rice. The results of their simulations show that the gains associated with the adoption of GM food crops largely exceed any type of potential trade losses these countries may incur. Adopting GM crops also allows net importing countries to greatly reduce their imports. GM rice is bound to be the most advantageous crop for the four countries. The opportunity cost of segregation is much larger for sensitive importing countries than for countries adopting new GM crops, which suggests that sensitive importers will have the incentive to invest in separate non-GM marketing channels if exporting countries like India decide to adopt GM food crops.

Vigani et al. (2009) examine the impacts GMO regulations on bilateral trade flows. A composite index of the complexity of such regulations for sixty countries is developed. Using a gravity model, they found that bilateral distance in GMO regulations negatively affect trade flows. Across GMO regulatory sub-dimensions, those that are more detrimental to trade are the approval process, labelling policies and traceability requirements.

Bouet et al. (2011) examine the global economic implications of the proposed strict documentation requirements on traded shipments of potentially genetically modified (GM) commodities under the Cartagena Protocol on Biosafety. The study evaluates the trade diversion, price, and welfare effects of requiring all shipments to bear a list of specific GM events in the maize and soybean sectors employing a spatial equilibrium model with 80 maize- and 53 soybean-trading countries. They found that information requirements would have a significant effect on the world market for maize and soybeans. The information requirements would have greater effects on trade, creating significant trade distortion that diverts exports from their original destination. The measure would also lead to significant negative welfare effects for all members of the Protocol and non-members that produce GM maize, soybeans, or both. While non-GM producers in Protocol member countries would benefit from this regulation, consumers and producers in many developing countries would have to pay a proportionally much heftier price for such a measure.

Although there is a large body of literature on economic impacts of GM crops, that cannot be asserted for the case of LLP. With the acceleration in the release of new GM crop varieties in major commodity exporters (like the United States, Argentina, or Brazil), these and other importers are becoming concerned with delayed import authorizations and the increasing risk of temporary trade disruptions due to the adventitious presence of unapproved GM products conflicting with their zero percent tolerance for unapproved GM products. To address this issue, members of the Codex Alimentarius have recently adopted a guideline (the Codex Annex) which proposes the use of a simplified risk assessment procedure for GM products approved at exporters but not yet at importers and potentially present in low levels in commodity shipments. However, this guideline does not specify what level of tolerance countries should apply and which products it should cover (Gruere, 2009).

In one of the few studies Gruere (2009) attempts to model the economic effects of different implementation options of low level presence (LLP) policies. A simple analytical model is used to identify factors for consideration in the design of regulations. The results imply that three factors will matter: the market effects, the risk avoidance effect and the implementation costs. Each of these factors will depend on the regulatory approach. A GM ban is the most costly option, and can only be justified if the country does not import crops that could be GM or if the perceived consumption risk of GM products exceeds any possible cost. A LLP policy with a 0 percent tolerance level is almost identical, and may generate issues of asynchronous approvals. It is only justified if the perceived risks exceed the temporary costs, and/or if there is no trust in the exporters regulation. A laissez-faire approach is only justified if prices and costs largely exceed perceived risks. Lastly, the use of a nonzero tolerance level LLP policy is the best from traders' perspective in that it balances risks and cost considerations. Gruere (2009) argues that LLP policies are valid intermediates between GM bans and no regulations. That may explain why all countries at the Codex approved such guideline. Gruere (2009) identifies three significant factors that will alter whether a LLP policy will be effective and efficient: the tolerance level, the delay for LLP approval, the delay for full approval and the degree of trust in exporters' regulations. If reducing regulatory delays and increasing confidence unambiguously increase total welfare, the choice of the tolerance level will balance perceived risks and costs, and needs to be selected based on local specificities. The developed model is applied to countries of the Asia Pacific Economic Cooperation (APEC), to assess the potential economic implications of different tolerance levels. The findings show that APEC economies would benefit from adopting LLP approaches, especially given that 63 million metric tonnes of imported maize and soybeans potentially subject to trade disruption (and with canola and cottonseed 67 million tonnes or 84 percent of total imports of these products). The study recommends that countries should choose a nonzero tolerance level, they should try to adopt harmonized levels with major trade partners, there should be a rapid information flow via workable and reliable database, and countries should try to use the same Codex guidelines.

In another study Gruere (2011) evaluates the economic effects of policy options on Low Level Presence (LLP) to manage the risk of trade disruption with asynchronous approval of genetically modified (GM) products, focusing on Vietnam, a significant GM feed importer in the process of introducing its biosafety regulations. An analytical model based on economic surplus is built and the results show that Vietnam's proposed rapid authorization of GM events approved in five developed country would cost $7 million more than if applied to three or fewer countries. Furthermore, maintaining a zero tolerance level for unapproved GM events would impose significant annual welfare costs for Vietnam, from $ 3.6 million for maize to $ 57 million for soymeals. Any non-zero tolerance level would reduce these costs significantly.

Kalaitzandonakes et al. (2011) examine the impact of restrictive LLP regulations on maize in Latin America, which is home to a large number of importers of agricultural commodities and trades with exporters in both North and Latin America. Employing a spatial equilibrium model, the paper shows that smaller importing countries, whose trade can be more easily shifted across alternative suppliers, would likely experience 2-8 percent price increases as a result of trade disruptions, whereas larger importers would experience price increases of 9-20 percent. The research recommends that countries in the region better adopt a non-zero tolerance level for LLP in order to balance safety objectives with the practical realities of commodity trade.

The overview of research findings is summarized in Table 5. As can be seen all of the studies examine mainly the impact on either welfare or trade. However, future trends and perceptions of related parties on the problem of LLP are not evaluated. Other than addressing these issues, the current FAO study will also identify the intensity of the LLP problem in the context of related commodities and parties.

Table 5: Selected Research Findings of GMO/LLP on Trade

GMO	Method	Commodity Analyzed	Findings
Anderson and Jackson (2005)	Global Trade Analysis Project (GTAP)	GM varieties of various grains and oilseeds	Gross economic benefits to farmers from adopting GM crops under a variety of scenarios could be positive even if the strict controls on imports from GM-adopting countries by the European Union are maintained.
Sobolevsky et al. (2005)	Partial equilibrium four-region world trade model	Roundup Ready (RR) soybean	The US, Argentina, Brazil, and the Rest of the World all gain from the introduction of RR soybeans although some groups may lose.
Gruere et al. (2007)	Multi country general equilibrium model.	GM field crops (rice, wheat, maize, soybeans, and cotton).	The gains associated with the adoption of GM food crops largely exceed any type of potential trade losses these countries may incur. Adopting GM crops also allows net importing countries to greatly reduce their imports.
Vigani et al. (2009)	Trade flow	Food trade	Bilateral variations in GMO regulations negatively affect trade flows. Main impeding factors are the approval process, labelling policies, and traceability requirements.
Bouet et al. (2011)	Spatial equilibrium model	Maize and Soybean	The information requirements would have greater effects on trade, creating significant trade distortion that diverts exports from their original destination.
LLP			
Gruere (2009)	Analytical model	Maize and Soybean	A GM ban is the most costly option, and can only be justified if the country does not import crops. A LLP policy with a 0percent tolerance level is almost identical. The use of a nonzero tolerance level LLP policy is the best from traders perspective in that it balances risks and cost considerations.
Gruere (2011)	An analytical model based on economic surplus	Feed	Vietnam's zero tolerance level for unapproved GM events would impose significant annual welfare costs for Vietnam, from $ 3.6 million for maize to $ 57 million for soymeals. Any non-zero tolerance level would reduce these costs significantly, especially a 5 percent tolerance level.
Kalaitzandonakes et al. (2011)	Spatial equilibrium model	Maize	Latin American smaller importing countries would likely experience 2-8 percent price increases as a result of trade disruptions, whereas larger importers would experience price increases of 9-20 percent caused by zero tolerance level for LLP.

2. FAO Survey on Accidental Presence of Low Levels of Genetically Modified Organisms (GMOs) in Internationally Traded Food Crops

2.1 Overview

Content and response rate

FAO has carried out this survey to better understand the extent of trade-disruption due to LLP/AP. The survey covers main points related to GM crops such as production, regulation, safety assessment, detection and quantification, LLP/AP incidents, and importance of factors contributing to the trade risks posed by LLP/AP. The FAO survey was sent to national government organizations through FAORs, Codex contact points, and individual contacts in early 2013; therefore the target population includes all the related countries. Since the aim of the survey is to obtain the information on the extent of overall LLP incidences and to include all available opinions, the responses can be classified as heterogeneity type nonprobability method of sampling. The FAO survey was sent to total of 193 member countries including 27 EU member states. 64 countries responding to the survey on the specified date (31 May 2013) were evaluated in the analysis; thus, response rate is 33.16 percent [1] (Table 6).

2.2 Distribution of regional responses

Out of 64 responses, the highest contribution to the survey came from Europe (21 responses, 33 percent) followed by the regions of Africa and Latin America & Caribbean. The regional classification is based on UN "Composition of macro geographical (continental) regions, geographical sub-regions, and selected economic and other groupings"[2]. The highest response rate is from North America followed by Europe (48 percent) and Latin America & Caribbean (39 percent). However it should be noted that there were only 2 countries in the region of N. America to which surveys were sent (Table 7, Figure 3).

Table 6: FAO-LLP survey response rate

Total Number of Surveys Sent	193
Total Number of Responses Received	64
Response Rate, %	33.16

[1] The list of responding countries: Argentina, Australia, Austria, Bahamas, Bangladesh, Barbados, Bolivia, Botswana, Brazil, Bulgaria, Cambodia, Canada, Cape Verde, Colombia, DR Congo, Congo Republic, Costa Rica, Croatia, Cuba, Cyprus, Czech Republic, Denmark, Dominican Republic, Ecuador, El Salvador, Estonia, European Union, Finland, France, Gambia, Germany, Grenada, Honduras, Hungary, Iran, Ireland, Italy, Jamaica, Japan, Lao PDR, Latvia, Lithuania, Luxembourg, Madagascar, Malaysia, Mali, Moldova, Mongolia, Morocco, Mozambique, Myanmar, Namibia, Netherlands, New Zealand, Niger, Norway, Pakistan, Philippines, Poland, Qatar, Samoa, Seychelles, Slovakia, Slovenia, Somalia, Spain, Sudan, Sweden, Syria, Thailand, Togo, Trinidad, Turkey, Uruguay, United States of America.

[2] http://unstats.un.org/unsd/methods/m49/m49regin.htm

Table 7. Distribution of regional responses

Regions	Number of responses	Ratio of response in each Region to total response, % (Regions' contribution)	Number of surveys sent to the Regions	Ratio of Response in each Region to total surveys sent to the Related Region, % (Regional Response Rate)
Africa	13	20.31	54	24.07
Asia	12	18.75	45	26.67
Europe	21	32.81	43	48.84
L. America &Caribbean	13	20.31	33	39.39
N. America	2	3.13	2	100.00
Oceania	3	4.69	16	18.75
Total	**64**	100	193	

2.3 Analysis of questions

GM crop production

Does your country produce GM crops? (Q.1)

53 percent of respondents indicated that they do not produce GM crops, 24 percent indicated research only production, and remaining 23 percent indicated both research and commercial production.

Among the regions, Europe ranks first in research only GM production, Latin America & Caribbean in commercial production, and Africa in no-GM production. Specifically, the region of Europe accounts for 53 percent of research only GM production, Latin America & Caribbean accounts for 40 percent of research and commercial production, and Africa accounts for 32 percent of no GM production).

Figure 3. Distribution of Regions' Contributions to the Survey

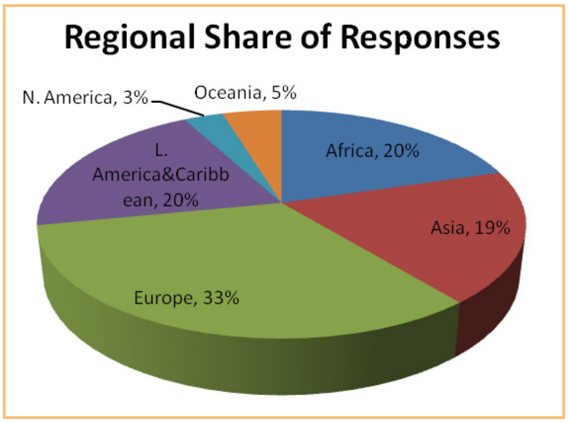


Figure 4. GM Crops Production

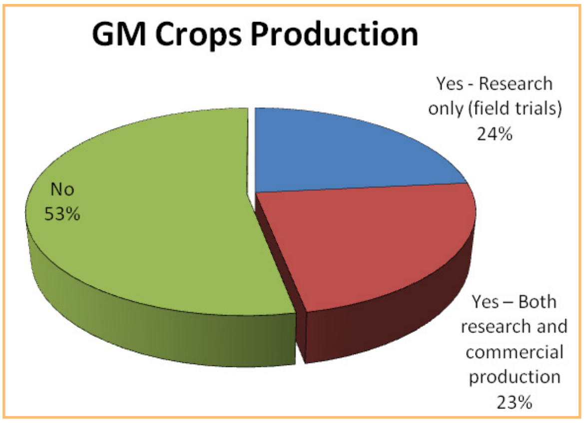


Figure 5. Regional distribution of research only GM production

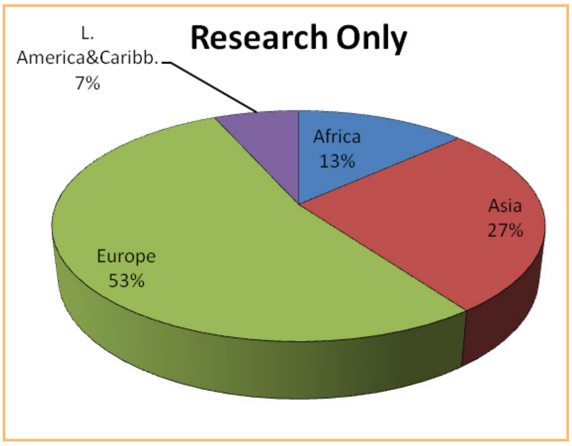
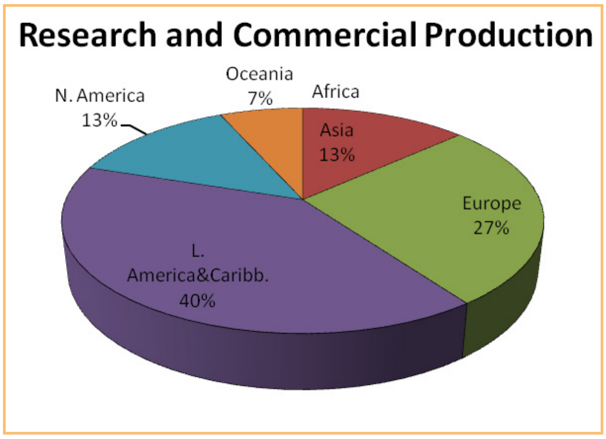


Figure 6. Regional distribution of research and commercial GM production



How many GM crops (the number of GM events) does your country produce (both research and commercial production)? (Q.2)

Among the countries which indicated the production of GM crops, 76 percent of countries indicated that the number of GM events production is less than 20. 10 percent of respondents indicated that it is between 21 and 50, 4 percent indicated that it is between 51-80. 7 percent indicated that it is over 80. Three percent of respondents indicated no data despite production.

Figure 7. Regional distribution of no GM production

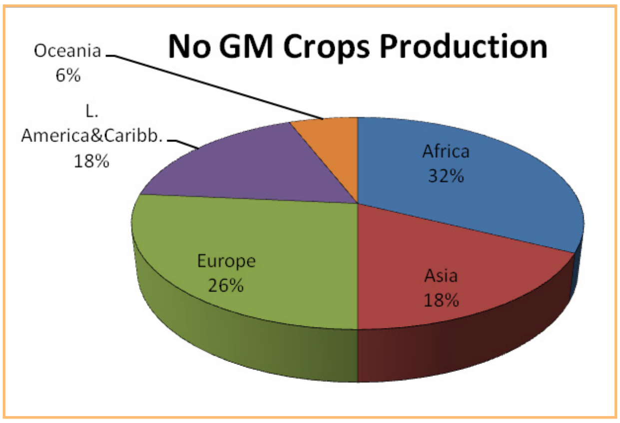
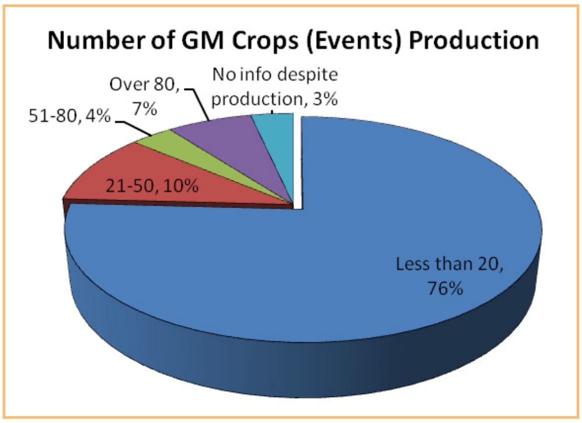


Figure 8. Number of GM crops (events) production



In your country, how many GM crops (the number of GM events) are currently in pipeline? (Q.3)
52 percent of respondents indicated that the number of GM crops in pipeline is less than 20; 20 percent indicated that they have no any GM events in pipeline; 3 percent indicated that the number of events in pipeline is between 51-80. 20 percent of the respondents provided no answer.

How many GM crops (the number of GM events) are authorized to be *commercialized* in your country? (Q.4)
38 percent of respondents indicated that number of GM crops authorized to be commercialized is less than 20; 20 percent indicate the number is 0; 5 percent indicated the number is over 80. 23 percent of the respondents indicated no answer.

GM crops trade

Please fill out table 8 for your country's export situation of some selected agricultural commodities. (Q.5)
Some respondents reported the proportion of GM crops exported in their related commodity trade. For instance, in Argentina, the share of GM crops is 90-99 percent of maize, soy, and cotton while 100 percent of cotton exported from Australia is GM. Major trading partners covers many different regions of the world.

Figure 9. Number of GM events in pipeline

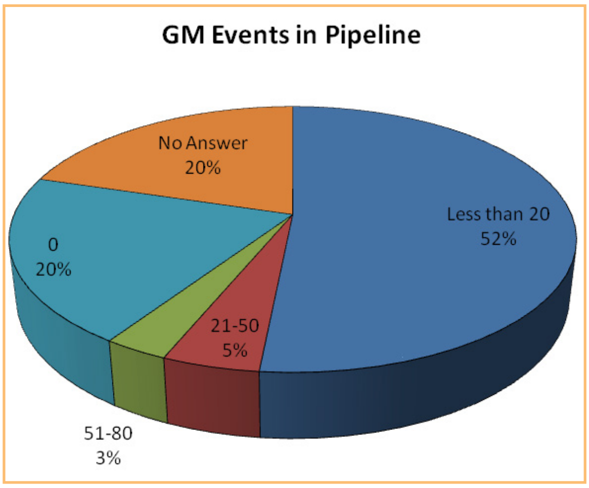
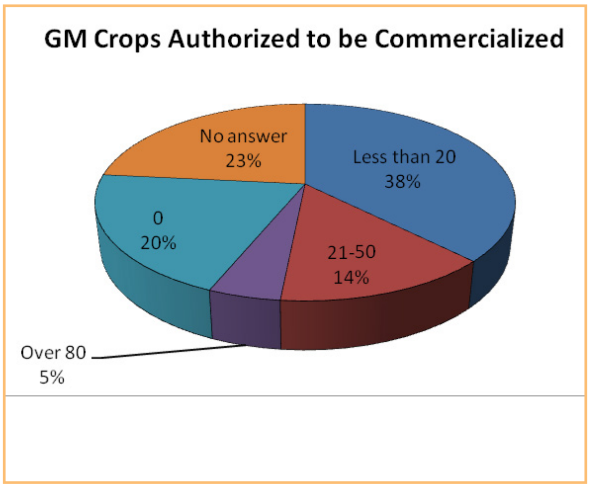


Figure 10. GM crops authorized to be commercialized



Please fill out table 9 for your country's import situation of some selected agricultural commodities (Q.6)

Some respondents indicated the proportion of GM crops imported in their related commodity trade. For instance, all of the cotton imported to Argentina and cotton seed imported to Australia is GM; 99 percent of maize and soy imported to Bolivia is GM.

Table 8: Proportion of GM crops in total export of related commodity by countries

Reporting Country	Commodity	Proportion of GM crops in total exports of this commodity	Major Trading Partners
Argentina	Maize	90	N. Africa, S. America, Asia
	Soy	99	Asia, Middle East, EU
	Cotton	95	S.E. Asia
Australia	Rapeseed	23	Pakistan, Japan, UAE, Bangladesh
	Cotton	100	China, Japan, Republic of Korea, USA
Bolivia	Soy	99	Peru, Colombia, Ecuador, Brazil
Brazil	Soy	-	China, EU, S. Korea, Japan
Canada	Maize	85	US, Spain Egypt, Iceland, Hong Kong
	Soy	50	China, Japan, U.S., Netherlands, Belgium, Egypt, Malaysia.
	Sorghum	-	Germany, Belgium, S. Korea Colombia
	Wheat	-	US, Japan, Indonesia, Mexico
	Rice	-	U.S.
	Rapeseed	95	China, Japan, Mexico, U.S.
Colombia	Cotton Lint	70	-
	Maize	-	-
US	Maize	-	Japan, Mexico, China, South Korea, Venezuela
	Soy	-	China, Mexico, Japan, Indonesia, Germany
	Cotton	-	China, Turkey, Mexico, Vietnam

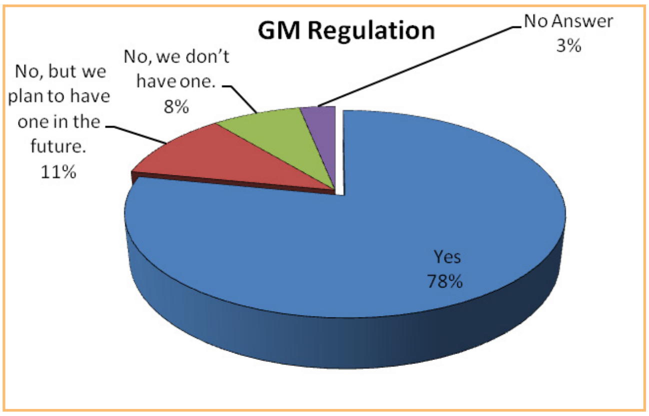
Table 9. **Proportion of GM crops in total import of related commodity by countries**

Reporting Country	Commodity	Proportion of GM Crops in Total Imports of this Commodity	Major Trading Partners
Argentina	Cotton	100	Brazil
Australia	Rapeseed	56	Canada, US
	Cotton seed	100	USA
Austria	Soy	81	US, Brazil
Bolivia	Maize	99	Argentina, Brazil
	Soy	99	Argentina
Brazil	Maize	-	Argentina, Paraguay
	Soy	-	Argentina, Paraguay
Bulgaria	Soybean Meal	90	Brazil, Argentina
Canada	Maize	95-100	US
	Soy	95-100	U.S.
	Sorghum	-	US
	Wheat	-	US
	Rice	-	U.S., Thailand, India
	Rapeseed	95-100	U.S.
Colombia	Maize, Soy	-	
Croatia	Soy	15	Brazil, Argentina
Cuba	Maize	70	US, Brazil, Argentina
	Soy	90	Brazil, Argentina
	Wheat	-	US
	Rice	-	-
Cyprus	Soy	99	Brazil, Argentina, Spain
Dominican Republic	Maize, Soy, Wheat	-	-
Finland	Soy	15	-
France	Maize, Soy, Colza	-	-
Honduras	Maize, Rice	-	US
Iran	Maize	-	Brazil, Argentina, Ukraine
	Soy	-	Brazil, Argentina, Ukraine
	Rapeseed	-	Canada
Ireland	Maize	37	US, Brazil, Canada
	Soy	94	Argentina, US, Brazil
	Rapeseed	20	Canada, US
Italy	Maize, Soy (feed)	-	US, Argentina, Brazil
Japan	Maize, Soy	-	United States, Brazil
	Rapeseed	-	Canada, Australia
	Cotton	-	Australia, US

Table 9 (cont.d) **Proportion of GM crops in total import of related commodity by countries**

Reporting Country	Commodity	Proportion of GM Crops in Total Imports of this Commodity	Major Trading Partners
Latvia	Soybean Meal	89	Argentina, US
Lithuania	Soy	74	China, Russia, Israel, S. Korea, India, Argentina, Ukraine
	Rice	24	USA, Cambodia, India, Pakistan, Vietnam, Thailand, South Korea, Canada
Luxembourg	Soy	80	Transit
Malaysia	Maize	-	S. Africa, US
	Soy	-	US
Netherlands	Maize	-	-
	Soy	75	Paraguay, Uruguay, Brazil
	Rapeseed	-	-
Philippines	Maize	90	US, Argentina
	Soy	90	Argentina, US
	Rapeseed	-	-
Samoa	Maize	-	N. Zealand
	Soy	-	Australia
	Sorghum	-	US
	Wheat	-	China
	Rice	-	Europe
	Rapeseed	-	American Samoa
Slovenia	Soy	80	Brazil, Argentina
Sudan	Maize, Soy	-	-
Thailand	Maize, Soy	-	-

Figure 11. Existence of GMO regulation by country

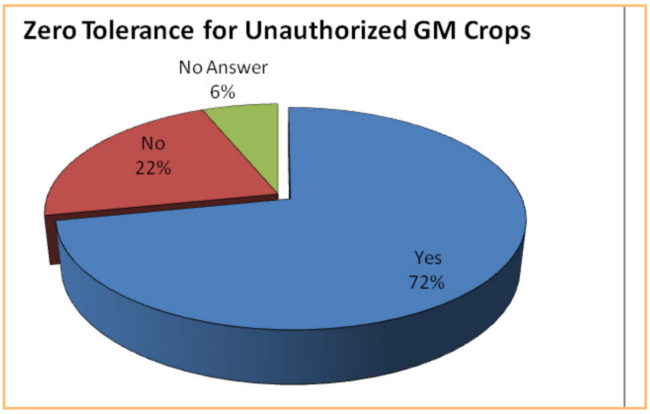


2.4. Regulations on GM crops

Does your country have any food safety, feed safety or environmental regulations on GM crops? (Q.7)

78 percent of respondents indicated that they have a GMO regulation, while 8 percent indicated that they don't have one.

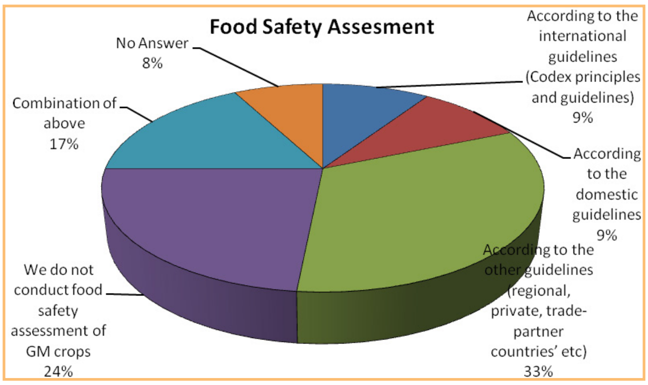
Figure 12. Zero tolerance for unauthorized GM crops



Does your country have a "zero-tolerance policy for unauthorized GM crops? (Q.10)

72 percent of respondents indicated that they have a zero tolerance for unauthorized GM crops, 22 percent indicated they don't have.

Figure 13. Food safety assessment

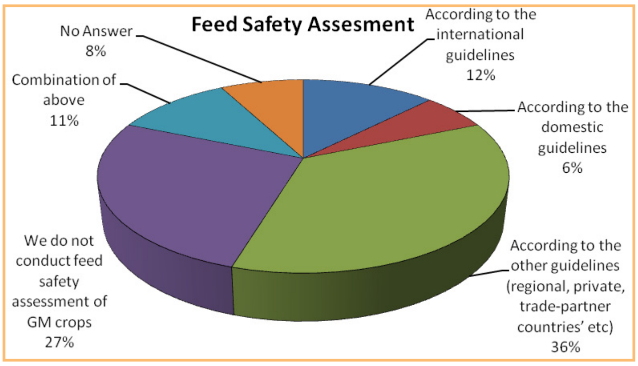


2.5 Safety assessment of GM crops

How does your country conduct food safety assessment of GM crops? (Q.11)

33 percent of respondents indicated that they follow regional, private guidelines in food safety assessment of GM crops; 24 percent indicated they do not perform any assessment; and only 9 percent indicated they follow international guidelines. 17 percent indicated they follow combination of guidelines, usually international and domestic.

Figure 14. Feed safety assessment

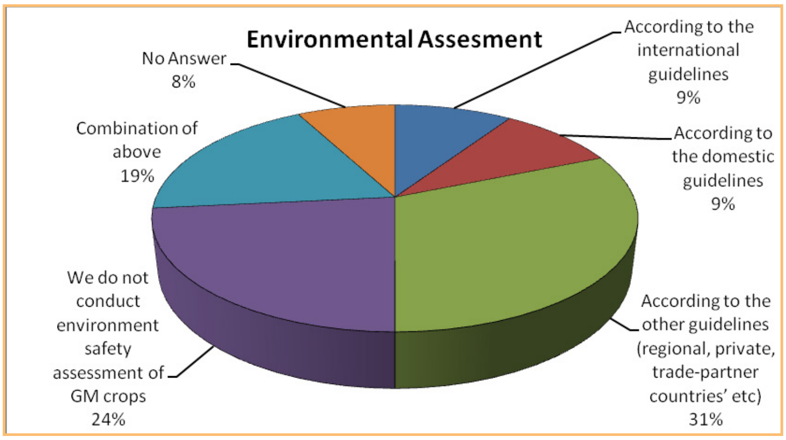


How does your country conduct feed safety assessment of GM crops? (Q.12)

36 percent of the respondents indicated that they follow regional-private guidelines; 27 percent do not perform safety assessment; and only 12 percent solely follow international guidelines for feed safety assessment.

How does your country conduct environment safety assessment of GM crops? (Q.13)

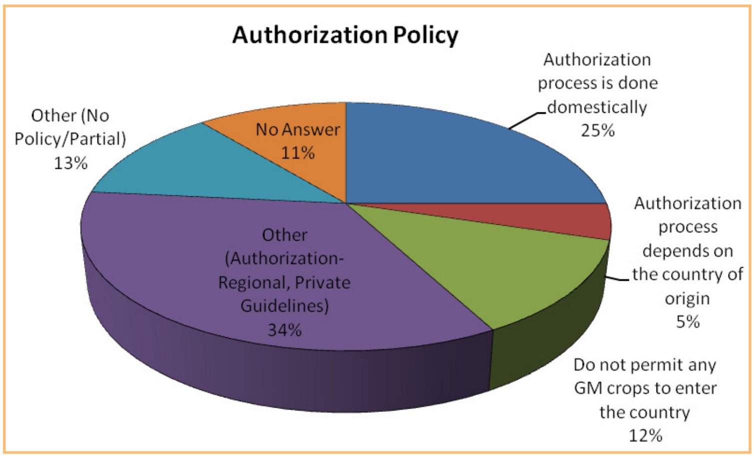
Figure 15. Environmental assessment



31 percent of respondents indicated that they follow regional-private guidelines, while 24 percent indicate they do not perform assessment for environment; and only 9 percent solely follow international guidelines.

What is the authorization policy for the imported GM crops in your country? (Q.14)

Figure 16. Authorization policy for imported GM crops



34 percent of the respondents indicated that authorization is done according to regional-private guidelines (mostly EU members); 25 percent indicated that it is done by domestic regulations; 13 percent indicated that they have no policy. 12 percent of the respondents indicated that they do not permit import of GM crops.

Figure 17 Existence of LLP threshold

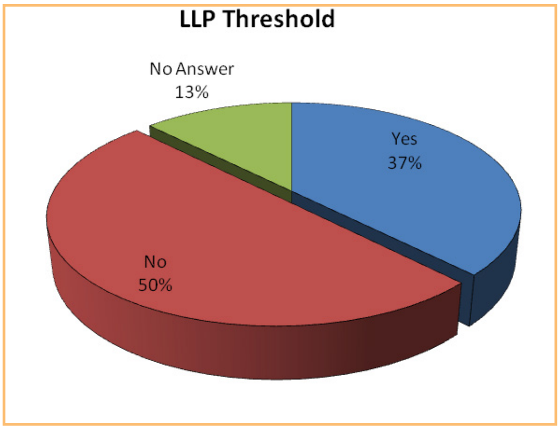
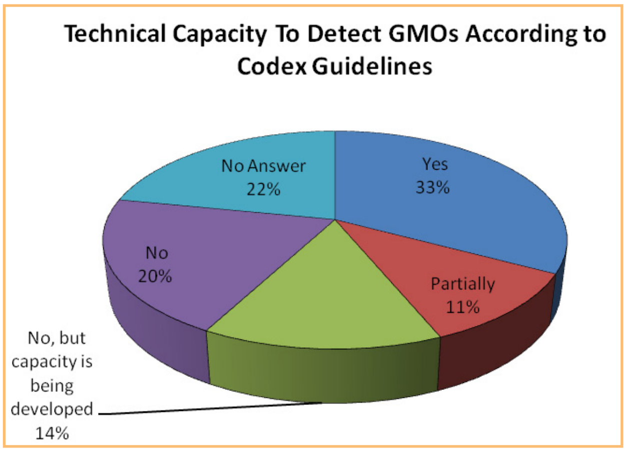


Figure 18.Existence of technical capacity to detect or quantify GMOs



2.6 Detection and quantification

Does your country have a threshold level for LLP/AP? (Q.15)

50 percent of respondents indicated that they do not have LLP/AP threshold, while 37 percent indicated yes (mostly for feed, EU technical solution).

Does your country's domestic (reference) laboratory have technical capacity to detect or quantify GMOs according to the Codex guidelines (CAC/GL 74-2010)? (Q.17).

33 percent of respondents indicated that they have a technical capacity to detect or quantify GMOs according to the Codex guidelines; 20 percent said no; 14 percent said no, but capacity is being developed; 11 percent said partially. 22 percent provided no answer.

2.7 LLP and AP incidents

Has your country faced situations of LLP or AP in imports in the last 10 years? (Q.19)

24 out of 64 countries (37 percent) reported that they faced LLP or AP in the last 10 years; 35 (55 percent), said no; and 5 (8 percent) indicated no answer.

If Yes provide the details below (Q.20)

The main crops that are subject to LLP/AP incidents are linseed, rice, maize, papaya, and soybean. Most of the time the situation is managed through consignment rejection, destruction, or market withdrawals, and fines. In the case of the EU, the member notifications are carried out through the Rapid Alert System for Food and Feed (RASFF). The US (73 incidents), China (62), and Canada (44) were main exporters whose consignments were involved in LLP/AP incidents in the survey. In addition following countries were reported by importers: Argentina (6), Thailand (5), France (3), Pakistan (3), Brazil (2), Chile (2), Colombia (2), Italy (2), Romania (2), S. Africa (2), Croatia (1), and India (1), Netherlands (1), Philippines (1), Serbia (1),

Figure 19 LLP/AP incidents in the last 10 years

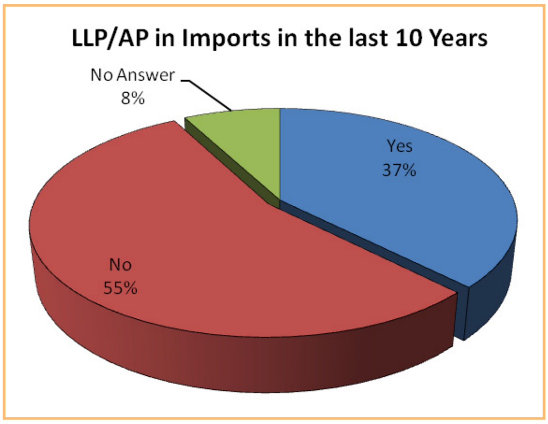
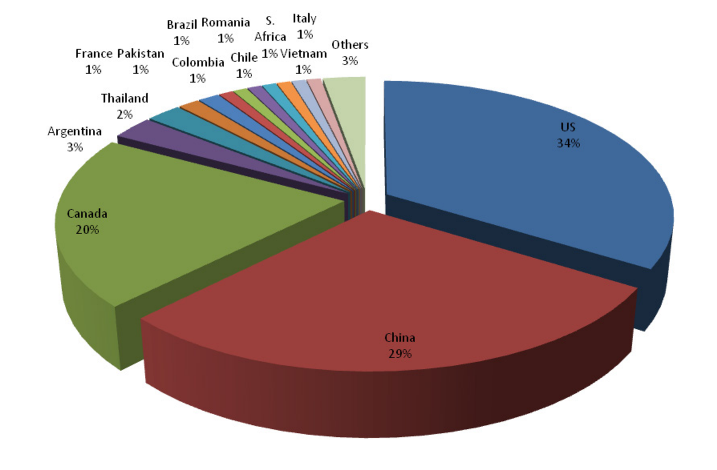


Figure 20. LLP/AP incidents by country of origin, percent, 2000-2012



Taiwan (1), Thailand (1). As shown, 34 percent of incidents originate from the US, followed by China (29 percent), and Canada (20 percent). Note that LLP/AP related transit imports via EU members but originating from non-EU exporters are not reported here. LLP/AP incidents reported by importing countries by commodity are: Linseed (55), Rice (39), Rice noodles, crackers etc. (37), Maize (32), Papaya (18), Pet food (10), Soybean meal and products (6), Soybean (2), Canola (1).

The number of LLP/AP incidents in general has an increasing trend. The number of incidents topped in 2009, and then levelled off afterwards. Based on the trend line, the forecast intervals are presented in Table 10. Accordingly, with the 95 percent confidence, the forecast interval for LLP/AP incidents is expected to be between 34 and 38 in 2020.

Table 10. Forecast of LLP/AP incidents

	Forecast Interval, α=0.05	
Year	Low	High
2013	28	32
2014	29	33
2015	30	34
2016	31	35
2017	32	36
2018	33	37
2019	33	38
2020	34	38

Figure 21. LLP/AP incidents by commodity, 2000-2012

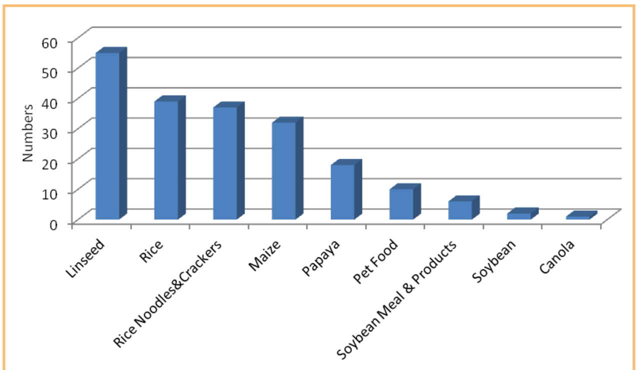


Figure 22. Number of LLP/AP ncidents and trend (2000-2012)

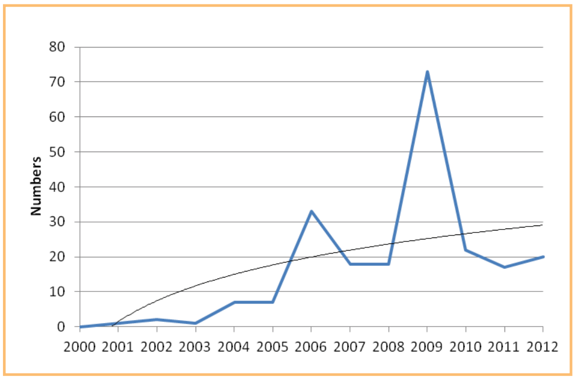


Table 11. LLP/AP incidents

Reporting Country	Year	Commodity	Amount (Tonne)	Imported from	How was the situation discovered?	How was the situation managed?*
Argentina	2008	Canola	100	Canada	Complaint farmer	Converted to biofuel
Brazil	2009	Flax	Not determined	Canada	Detection in the Port	consignment rejected
	2012	Maize	Not determined	US	Detection in the Port	consignment rejected
Bulgaria	2007	Unauthorized GM Soy protein	Two lots of 2.7 and 6.2 tonnes	Brazil	They were rejected by the Bulgarian authorities	Notification 2007.CBB was issued by Bulgaria via RASFF
Canada	2005	Corn (BT10)	86 acres worth of the event	US	Proponent informed the government	Proponent destroyed crop
	2006	Rice (LLRice601)	None in Canada, trace amount in USA	US	Proponent informed the government	Proponent removed crop from commercial seed production
Croatia		Food supplements			Official control (inspection and sampling)	Consignment held for testing
		Soy			Official control (inspection and sampling)	Consignment held while information was sought and then released (under 0,9 percent)
		Feed			Official control (inspection and sampling)	If it unauthorized GMO it would be destroyed or returned in country of origin
Cuba	2002	Rice		US	Review	
Cyprus	2007	Rice Protein	100	China/NL	Control on the Market	Returned to the dispatcher
	2007	Pet Food	19.5	US	Control on the Market	Returned to the dispatcher
	2007	Pet Food	2.16	US/Greece	Control on the Market	Returned to the dispatcher
	2009	Pet Food	19.7	US	Sampling B.IP	Seized, destruction
	2009	Pet Food	19.6	US	Sampling B.IP	Seized, destruction
	2010	Maize	0.74	Italy	After Laboratory test	Consignment was sent back to the country of origin
Denmark	2009	Linseed (feed use)	1.5 tonnes	Presumably originating from Canada (bought via supplier in Germany)	A sample of linseeds showing a low level of Flax CDC Triffid (FP967) was identified in the official control of feed	Affected batches were destroyed
	2009	Linseed (food use)	Different lots	Canada via other EU-Member States	Via the EU rapid alert system	Affected batches were withdrawn from the market

Table 11. LLP/AP incidents *(cont.d)*

Reporting Country	Year	Commodity	Amount (Tonne)	Imported from	How was the situation discovered?	How was the situation managed?*
France	2004	Maize GA21		US	RASFF of Member	Market Withdrawal
	2005	Maize Bt10		US	Information of US Authorities	EU Emergency Measures
	2006	Rice LL601		US	Information of US Authorities	EU Emergency Measures
	2006	Rice LL62		US	Official Control	Market Withdrawal
	2006	Rice Bt63		China	Greenpeace	EU Emergency Measures
	2009	Lin FP967		Canada	RASFF of Member	Market Withdrawal
	2009	Maize MON88017		US	RASFF of Member	Blocking, Pending EU Approval
	2009	Maize MIR604		US	RASFF of Member	Blocking, Pending EU Approval
	2012	Rice Kefeng6 et KMD		China	Official Control	Market Withdrawal + Consumer Recall
	2012	Rice OGM		Pakistan/India	Operator Auto control	Market Withdrawal + Consumer Recall
	2012	Papaya		Thailand	Official Control	Market Withdrawal + Consumer Recall
Germany *(Very detailed List-Appendix), Number of Incidents are in parentheses.*	2003-2012	Rice (24), Rice Noodles and Crackers (30), Linseed (45), Maize and Maize Floor (2), Papaya (16), Pet Food (4)		China (50), US(41), Canada (32), Thailand (3), Colombia (2), Pakistan (2), Italy (1), Philippines (1)		Recall, Withdraw, Destruction
Hungary	2007	Maize Seed	0.21			Fine
	2010	Maize Seed	21	Argentina	Check Sampling	Fine
	2011	Maize and Soybean Seed	376	Canada, US, Romania, Croatia, France, Chile	Check Sampling	Fine
	2012	Maize Seed	134	US, Romania, Chile, France, S. Africa, Serbia, Netherlands	Check Sampling	Destroyed
Iran	2005 - 2012	Maize and soy	Millions of tonnes	Argentina and Brazil	Research by Graduate students and random check by public research institutes.	Not managed

Table 11. LLP/AP incidents *(cont.d)*

Reporting Country	Year	Commodity	Amount (Tonne)	Imported from	How was the situation discovered?	How was the situation managed?*
Ireland	2007	Maize (Herculex-RW)	12.000	US	Laboratory tests	Product was stored until EU authorization of Herculex was approved and then released. There is ongoing disruption to trade due to asynchronous authorizations between EU and third countries. The current 'tolerance' of < 0.1 percent under Reg. 619/2011 is inadequate to facilitate trade between 3rd countries and the EU. Trade problems are likely to increase in future, as more GM events enter the pipeline, giving rise to more frequent incidences of a-synchronous authorizations and rejection of consignments.
Italy	2007	Maize in pet food	-	US	Official control at import	consignment redispatched
	2009	Maize in Dried Pet Food	-	US	Official control at import	consignment rejected
	2010	Maize for pop corn	25	Argentina	Official control at import	consignment redispatched
	2013	Maize grains (pop corn)	2.5	Argentina	Market control	withdrawal from the market
Japan	2005	Maize (Bt10)	42000	US	(Detected in Japan) Notification by the exporting country	After the notification, consignments already imported into Japan were tested and those found positive were shipped back. After the above phase, import became acceptable only when consignments for Japan were tested and certified to be free of Bt10. Without such certification, consignments were tested in Japan, and if Bt10 was detected, those consignments were rejected
	2008	Maize (DAS59132)	N/A	US	Notification by the exporting country	After the notification, consignments already imported into Japan were tested and found to be free of DAS59132. After the above phase, import became acceptable only when consignments for Japan were tested and certified to be free of DAS59132. Without such certification, consignments were tested in Japan, and if DAS59132 was detected, those consignments were rejected
	2009	Flax (FP967)	N/A	Canada	Notification by the industry iinvolved	After the notification, consignments already imported into Japan were tested and found to be free of or < 1 percent FP967. If FP967 was detected at < 1 percent, the consignment could be used as feed but only for processing under appropriate measures to limit the contact with the environment. After the above phase, import became acceptable only when consignments for Japan were tested and certified as under the threshold. Without such certification, consignments are tested in Japan, and if FP967 is detected: at < 1 percent, the consignment can be imported but only for processing under appropriate measures to limit the contact with the environment; at > 1 percent, the consignment will be rejected.

Table 11. LLP/AP incidents *(cont.d)*

Reporting Country	Year	Commodity	Amount (Tonne)	Imported from	How was the situation discovered?	How was the situation managed?*
	2011	Papaya	N/A	Taiwan	By testing conducted in response to information from a researcher	Recalled unplanted seeds from their distributors.. Destroyed all plants germinated from the seeds of concern.
	2006	Rice (powder, noodle)	138	China	Testing at the time of importation	Consignment rejected
	2007	Rice (powder, noodle)	362	China	Testing at the time of importation	Consignment rejected
	2008	Rice powder, noodle)	69	China	Testing at the time of importation	Consignment rejected
	2008	Corn	610	US	Testing at the time of importation	Consignment rejected
	2009	Rice (powder, noodle)	26	China	Testing at the time of importation	Consignment rejected
	2009	Flax seed (fresh, roasted)	31	Canada	Testing at the time of importation	Consignment rejected
	2010	Flax seed (roasted)	5.6	Canada	Testing at the time of importation	Consignment rejected
	2011	Flax seed (granola)	0.04	Canada	Testing at the time of importation	Consignment rejected
	2011	Rice (powder, noodle)	1.1	China	Testing at the time of importation	Consignment rejected
	2011	Rice noodle	14	Vietnam	Testing at the time of importation	Consignment rejected
	2012	Rice noodle	3.6	Vietnam	Testing at the time of importation	Consignment rejected
Latvia	2011	Soybean meal	5451.5	Argentina	Manufacturing enterprise attested GMO certificate Monsanto Roundup 40-3-2	Consignment was released for free circulation in EU
	2012	Hipro soybean meal and Soybean expeller (feed materials)	5700	US	Manufacturing enterprise attested GMO certificate Monsanto Roundup 40-3-2(1 from all consignment was selected for sampling and tested quality and quantity of Monsanto 40-3-2)	Consignment was released for free circulation
	2012	Soybean meal	7615	Argentina	Manufacturing enterprise attested GMO certificate Monsanto Roundup 40-3-2	Consignment was released for free circulation in EU

Table 11. LLP/AP incidents *(cont.d)*

Reporting Country	Year	Commodity	Amount (Tonne)	Imported from	How was the situation discovered?	How was the situation managed?*
Luxembourg	2009	Linseed	55	Germany/ Canada	EU RAFF	After confirming the AP by testing, the linseed was withdrawn from the market
Madagascar	2007	Maize		France	Environmental Impact Study	Demolition
Namibia	2013	Maize	Not disclosed	South Africa	The enterprising trust sent samples of maize for testing in South Africa and found that these products contained genetically modified maize.	The Namibian Agronomic Board (NAB) has reprimanded those responsible for producing and marketing maize products that a consumer lobby charged contains so-called Genetically Modified maize
Netherlands	2005	Bt10 maize in feed		US	Announcement by company	Consignments held for testing and later released on basis of neg results; EU emergency measure put in place (19 April 2005)
	2006	Chinese rice (Bt63)in food		China	Greenpeace/Friends of the Earth	EU emergency measure (9 April 2008)
	2006	LLRICE601 in food		US	Announcement by company	Blocking of US rice consignments by Dutch companies till negative test results were obtained, risk assessment done by Dutch Food safety authority (NVWA-front office), EU Emergency measure (23rd august 2006)
	2007	Maize in maize gluten, brewers grain Herculex RW 59122		US	Greenpeace	Consignments traced and held for testing by Dutch Food safety authority, tests negative, no need for further measures. Action plan put in place by US company for voluntary testing of consignments to EU and certification.
	2009	FP967 linseed (CDC Triffid) in food		Canada	Detection by third country authorities	Consignments traced and held for testing by Dutch Food safety authority, recalls performed risk assessment done by Dutch Food safety authority (NVWA-front office), Action plan by Canadian government.
New Zealand	2001	Maize seed		US	In-house testing of growing crop by company.	Crops 'held' while information was sought and then released.
	2002	Maize seed	1400 seeds	US	In-house testing of finished crop by company.	Seed testing; field management.
	2003	Sweet corn product		US	Testing of sweet corn product in Japan.	Residual seed tested.
	2004	Maize		US	Re-testing seed consignments from earlier season.	Stored grain used for feed rather than food.
	2006	Sweet corn seed	1.8	US	MPI quality system.	Retesting arranged by seed supplier. Unplanted seed and young plants destroyed.

Table 11. LLP/AP incidents *(cont.d)*

Reporting Country	Year	Commodity	Amount (Tonne)	Imported from	How was the situation discovered?	How was the situation managed?*
Norway	2008	JiangXi Rice Vermicelli		China	Compulsory testing by authorities according to national legislation	Consignment held for testing and rejected after testing.
	2010	Rice Mix		US (origin Thailand)	Testing according to national surveillance programme	The product was not allowed to sell and the finding was notified in the European RASFF-system
	2012	Dongguan Rice Vermicelli	7.9	China	Compulsory testing by authorities according to national legislation	Consignment held for testing and rejected after testing, notified in the European RASFF-system
	2012	Oriental Rice Cracker Mix	6.2	China	Compulsory testing by authorities according to national legislation	Consignment held for testing and rejected after testing, notified in the European RASFF-system
Philippines	2006	Liberty Link Rice LL601(for food use)			Report of alleged presence in the local market by Greenpeace	All commercial rice alleged to contain LL601 was recalled by the National Food Authority; Further shipments from the source were required for testing (negative) by Philippine authorities (Department of Agriculture-Bureau of Plant Industry)
	2008	TC 1508 (for propagation)			Declaration by Technology Developer	Whole shipment was quarantined and destroyed
Poland	2011	RR Oilseed, rapeseed				Market Withdrawal
Spain	2009	Maize, Soy cake,		US		Border Rejection

Note: These data are compiled from the responses of the survey and do not necessarily reflect the complete official figures..

2.8 Importance of factors contributing to the trade risks posed by LLP/AP

What is the importance of the factors below in contributing to the trade risks posed by LLP/ AP in your country? ***Please indicate the importance of each on a scale of 1-5 where 1 indicates "not at all important" and 5 indicates "very important".*** **(Q.21)**

Among the responses, the most important factor that contributes to the trade risk is indicated as different policies on GMOs exist between trading partners, (56 percent of countries stated that this issue is very important, score 5), unintentional movement of GM crops (49 percent of countries stated that it is very important), and different timing for approvals, (48 percent of countries stated that it is very important).

Figure 23. Importance of factors-different policies

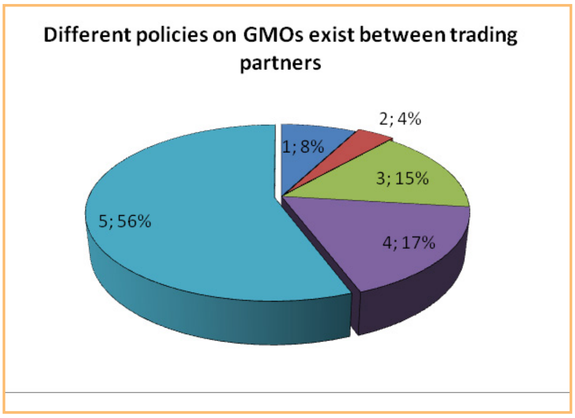


Figure 24. Importance of Factors-different timing

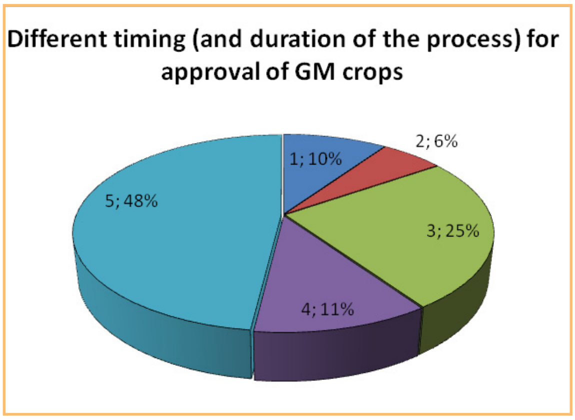


Figure 25. Importance of factors-approvals request consistency

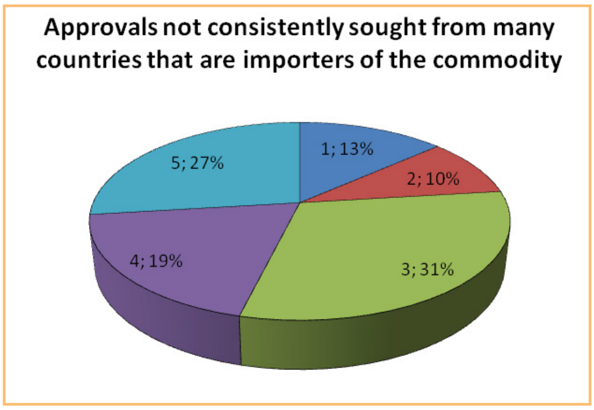


Figure 26. Importance of factors-lack of trust

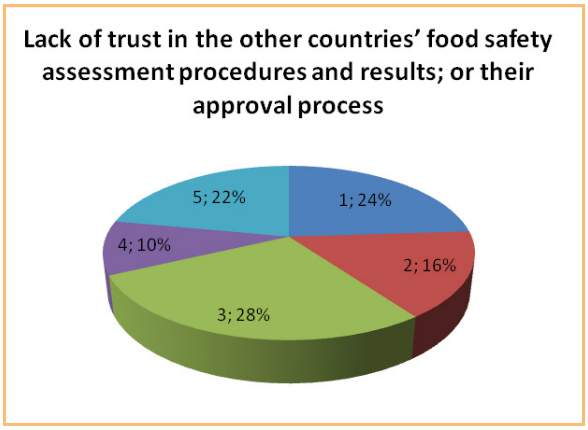


Figure 27. Importance of factors-unintentional movement

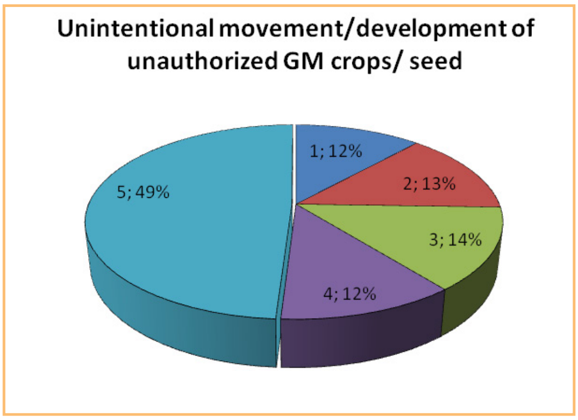


Figure 28. Importance of factors-inadequate separation between the commercialized and field trial area

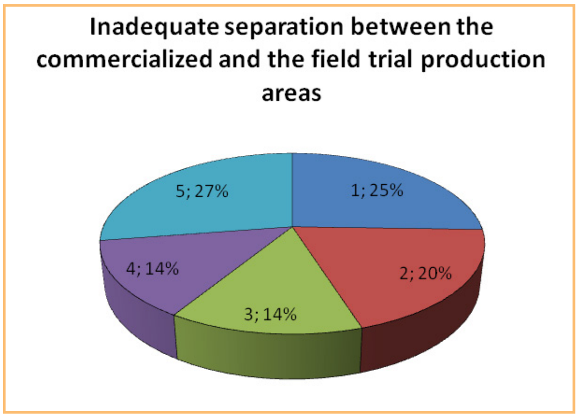


Figure 29. Importance of factors-inadequate separation between GM/NON-GM crops

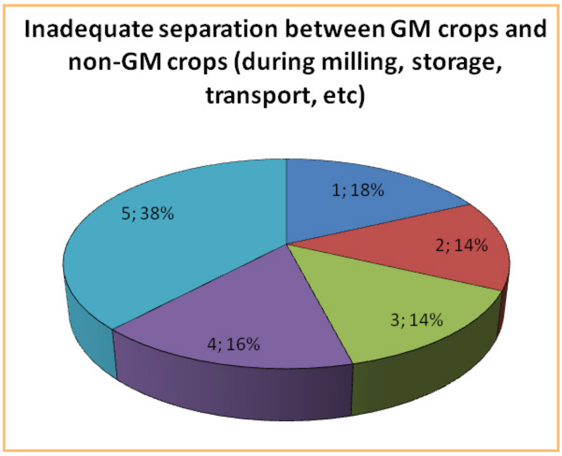


Figure 30. Importance of factors-difficulty in accessing information on food safety assessment

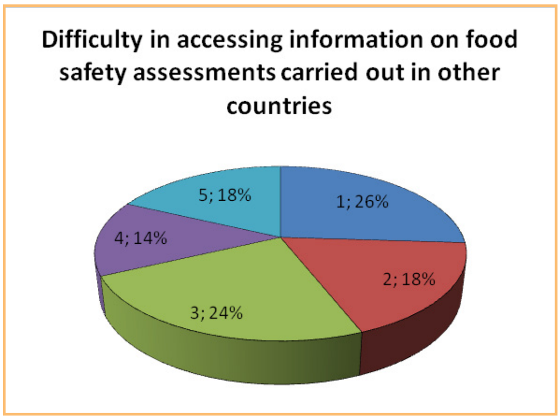


Figure 31. Importance of factors-difficulty in accessing information on feed safety assessment

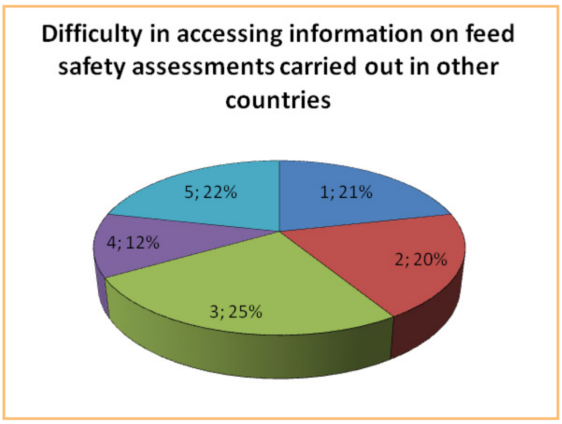


Figure 32. Importance of factors-difficulty in accessing information on environmental safety assessment

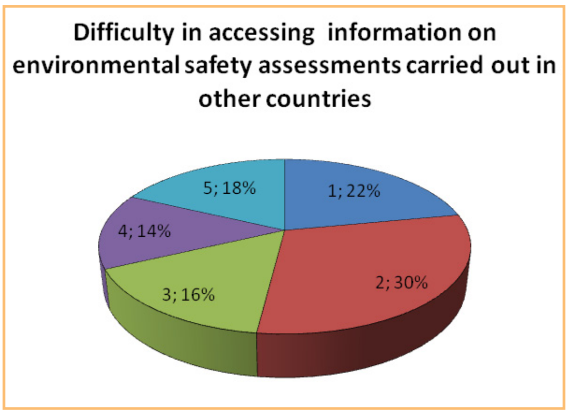


Table 12. Please specify any other factors that you consider relevant:

Country	Opinion
Argentina	Asynchronous approvals, authorization for a limited period (as 10 years).
Australia	Quality assurance processes in seed production and handling, harvesting and transport practices.
Bahamas	Unscrupulous importers of GM crops. Lack of technical capability in the country in areas related to biotechnology. Lack of legislative framework to deal with GM crops.
Germany	Zero Tolerance for Traces of Unauthorized GM Food.
Iran	Internal disagreement and lack of harmony and cooperation among different authorities in developing countries could also be considered as a major problem in dealing with LMOs.
Jamaica	Test for GM product are currently not conducted, therefore the incidence of LLP/AP would not be an issue.
Japan	Lack of functioning mechanisms for information sharing among countries on unauthorized GM crops/ seeds. Lack of measures by industries in exporting countries to prevent LLP situations, such as appropriate control of seed quality.
Mongolia	Difficulty in accessing information on medical and beauty products, raw material assessment made in another country.
Togo	Awareness of policy makers and the public is an important factor in Togo for the collection of GMO issues and questions concerning the PFQ and PA.
France	Operators who export do not ensure sufficient compliance of the products with the applicable regulations in the country of destination (item recalled in Annex 3 of the Codex document CAC / GL 45-2003). Regarding seeds: face with growing GMO authorizations for cultivation in the world, traces of GMOs in conventional seeds are likely to be detected although precautions are taken by the operators to separate the GMO and non-GMO and reduce the rate of unintended presence. The main sources of adventitious presence of GMOs in conventional seeds are (according to a report by the Joint Research Center, 2006). - The presence of GM seeds in seed base, - Cross-pollination with GMO neighbouring fields, - Shared use of tools planting and harvesting fields of GMOs and non-GM fields, - Use the same facilities or containers for storage, drying and transport of GMO seeds and non-GMO seeds.
Netherlands	The US and Canada do not require separate authorization of stacks, contrary to the EU. Requests for authorization of stacks will rapidly increase the coming years. Consequence is a further increase in the asynchronous authorization between EU and 3rd countries. LLP for not yet authorized GMO's in food is lacking. This is also an important factor.
Sweden	The above mentioned factors may contribute to the trade issues. However, the importance of the different factors is difficult to estimate.

Some General Comments on Analysis of Survey Data

- Almost half of the respondents (47 percent) indicated that they produce GM crops either for commercial or research purpose.

- 5 percent of the respondents indicated that GM events under pipeline are between 21 and 50, while 3 percent of the respondents indicated that GM events under pipeline are 51-80. This may have a triggering effect on LLP incidence in the future.

- 78 percent of respondents indicate that they have a GMO regulation; however, still 22 percent either don't have or planning to have in the future. This situation may give a rise to uncontrolled import of GM crops including LLP especially for developing countries.

- High level of regional guidelines (33 percent) (i.e. the EU) is a critical issue in food safety regulations worldwide.

- 37 percent of the respondents (mostly EU members) indicate that they have a LLP threshold (feed, technical solution). Thus remaining 63 percent do not have any threshold limit for LLP related feed import, and there is almost no threshold for LLP related food import.

- Only 33 percent of the respondents indicated that they have a technical capacity to detect GMOs in import. Therefore, capacity development is particularly an important issue for developing countries.

- 37 percent of the respondents indicated that they faced LLP/AP in their imports in the last 10 years.

- The main crops that are subject to LLP/AP incidents are linseed, rice, maize, papaya, and soybean. The US (73 incidents), China (62), and Canada (44) were main exporters whose consignments were involved in LLP/AP incidents in the survey.

- The most important factors that contribute to the trade risk are indicated as different policies on GMOs exist between trading partners, and unintentional movement of GM crops, and different timing for approvals.

3. ECONOMETRIC ANALYSIS OF LLP ON TRADE FLOW: THE CASE OF MAIZE

3.1 Introduction

Maize is a widely traded agricultural commodity. According to the FAOSTAT (2013), the amount of maize traded was 107 million MT in 2010, valuing around US$ 26 billion with import prices. Major maize producing countries are listed in Table 13. As can be seen the US is a major producing country accounting for 35 percent of world maize production.

In terms of trade value, major maize exporters are the US, Argentina, Brazil, and France, while major importers are Japan, Republic of Korea, Mexico, China, Iran, and Egypt (Tables 14, 15).

In this study maize is chosen to test the impact of LLP/AP partly because it is a major commodity subject to trade, and because in the FAO survey, it is reported as a one of the major commodities which is subject to LLP incidences by the respondents (around 30 incidences in the last 10 years).

Table 13. Major maize producing countries, 2011:

Rank	Country	Production, MT
1	US	313918000
2	China	192904232
3	Brazil	55660400
4	Argentina	23799800
5	Ukraine	22837900
6	India	21570000
7	Mexico	17635400
8	Indonesia	17629000
9	France	15703000
10	Romania	11717600
11	Canada	10688700
12	S. Africa	10360000
13	Italy	9752590
14	Nigeria	9180270
15	Hungary	7992000
	World total	**883460240**

Source: FAOSTAT, 2013

Table 14. Major maize exporters, 2010:

Rank	Country	Quantity (MT)	Value (1000 $)
1	United States of America	50906268	10110465
2	Argentina	17546457	3145255
3	Brazil	10815275	2214956
4	France	6609262	1835496
5	Hungary	3910699	882522
6	India	2293396	533674
7	Romania	2054489	514527
8	Ukraine	2888339	506545
9	Serbia	1662151	334923
10	South Africa	1239178	304853
11	Canada	856726	249217
12	Germany	646600	193360
13	Paraguay	1066864	190621
14	Bulgaria	650566	167223
15	Chile	57081	166069
16	Mexico	558617	155742
17	Thailand	478518	142370
18	Austria	320416	111258
19	Slovakia	259230	88302
20	Spain	187070	77645

Source: FAOSTAT, 2013

Table 15. Major maize importers, 2010:

Rank	Country	Quantity (MT)	Value (1000 $)
1	Japan	16192571	3955650
2	Republic of Korea	8540967	1989860
3	Mexico	7848998	1583297
4	China	6213149	1417915
5	Iran	5790014	1353793
6	Egypt	6170460	1271480
7	Spain	3955005	968045
8	Colombia	3613900	805756
9	Malaysia	3076957	766550
10	Netherlands	2911583	688473
11	Germany	1880907	588707
12	Algeria	2588335	524354
13	Italy	2219022	501042
14	Saudi Arabia	1926269	471487
15	Peru	1917973	449634
16	Morocco	1897367	445391
17	Syria	1918514	420719
18	Viet Nam	1659176	396623
19	Indonesia	1527516	369076
20	United States of America	380583	343944

Source: FAOSTAT, 2013

3.2 Empirical model and data

In this study a bilateral export flow model is employed utilizing cross sectional data. Although the theoretical foundations and estimation issues are constantly updated (Evenett and Keller, 1998; Anderson and van Wincoop, 2003; Baier and Bergstrand, 2007) these models are widely used because of their usefulness in trade policy analyses, and agriculture related applications can be found in some recent studies (Anders and Caswell, 2009; Jongwanich, 2009; Vollrath et al., 2009). Gravity type trade flow models assume that bilateral trade between partner countries increases with the size (income, population etc.) and closeness (distance). The model utilized in the study can be described as:

$$E_{ij} = \alpha Y_i^{\beta 1} Y_j^{\beta 2} D_{ij}^{\beta 3} Z_j^{\beta 4} \varepsilon_{ij} \qquad (1)$$

and in log-linear form as;

$$lnE_{ij} = ln\alpha + \beta_1 lnY_i + \beta_2 lnY_j + \beta_3 lnD_{ij} + \beta_4 lnReg - Index_j + \beta_5 lnLLP_j + ln\varepsilon_{ij} \qquad (2)$$

where:

E: Bilateral export flow between country i and j, in volume,

Y_i: GDP of exporting country,

Y_j: GDP of importing country,

D_{ij}: Distance between exporting and importing country,

$Reg\text{-}Index_j$: GMO Regulation Index of importing country,

LLP_j: LLP Threshold of the importing country,

ε_{ij}: Residual term.

The regulation index is similar to the Vigani et al, (2009); however their index includes six factors (approval process, risk assessment, labelling policies, traceability system, coexistence guidelines, membership in international GMO related agreements) while our index covers twelve factors. Specifically, regulation index takes the form:

$$Regulation - Index : \left\{ \begin{array}{l} RI = \sum_{i=1}^{12} Regulation\ Items \\ Min{:}0 \\ Max{:}10 \\ Adjusted\ Index{:}100 \end{array} \right\} \qquad (3)$$

The GMO regulation index is composed based on the questions answered in the survey in 2013 and EU Food Safety Regulation, EC-178/2002 (OJEU, 2002). The components of the index are presented in Table 16. Highest score is assigned to the existence of restrictive regulations, and then indexed to the value 100. As can be seen (Figure 33), Norway ranks top with the score of 100, followed by the EU members. For the LLP thresholds three different methods were used based on the various assumptions because of the some inconsistencies in the responses to the survey. The first one assumes that the LLP variable takes the value 0.1, a technical solution for the EU members for feed import, EU-619/2011 (OJEU, 2011) and 10 for countries that do not have the threshold. The second method assumes that LLP threshold includes some other factors, taking into account not only reported threshold levels but also combination of other factors such as zero tolerance and existence of GMO regulation. Finally, the third method assumes that LLP variable takes the value 0.1 as before for the non-EU members, 1 for EU-member countries, controlling for the EU internal trade.

Since our study focuses on the impact of bilateral variable (LLP), in addition to estimation of the econometric model explained above, another theoretically robust model is estimated. Anderson and Van Wincoop (2003) explain trade flow with the following formula:

$$\ln(X_{ij}/Y_iY_j) = \beta_0 + \beta_1 \ln T_{ij} + (1-\sigma)\ln P_i + (1-\sigma)\ln P_j + \varepsilon_{ij} \qquad (4)$$

Here, X is bilateral exports; Y is gross domestic product (GDP) of countries; T_{ij} represents observable multilateral resistance terms including distance; P_i and P_j represent the unobservable resistance terms; and σ is the elasticity of substitution between the goods of countries. A major advantage of this generalized model is the inclusion of these unobservable multilateral resistances, which eliminates omitted variable bias. Thus, for the cross section bilateral trade flow estimation of the model, the equation can be represented as

$$lnE_{ij} = \beta_0 + \beta_1 lnT_{ij} + \beta_2 lnLLP_i + \alpha_i + \alpha_j + \varepsilon_{ij} \qquad (5)$$

where α_i and α_j are home and partner country (importer, exporter) fixed effects, respectively.

Table 16. Composition of GMO regulation index

Number	Item
1	Existence of Food, Feed and Environmental Regulation
2	Safety Risk Assessment
3	Labelling Requirement
4	LLP Test Requirement
5	Traceability Requirement
6	Socio-Economic Assessment
7	Existence of Zero-Tolerance for Unauthorized GM Crops
8	Conducting Food, Feed, and Environmental Safety Assessments According to International Guidelines
9	Restrictiveness of Authorization Policy
10	Testing Requirement from Exporting Country
11	Technical Capacity to Detect GMOs
12	Detection Methods Utilized

3.3 Descriptive statistics of data

This econometric part of the study utilizes bilateral maize exports among the countries that responded to the FAO survey. Therefore, bilateral maize exports data among 64 countries for the year 2011 is utilized. There were 582 number of observations covering 4656 data points. Data on export flow come from Comtrade (2013). Data on GDPs and population come from World Bank's World Development Indicators (2013). Bilateral distance data come from CEPII (2013). The descriptive statistics of the data is presented in Table 17.

3.4 Results and discussion

The GMO regulation index values are presented in Figure 33. As can be seen, Norway ranks first followed by the EU members. In general developed countries have higher index values, with the exception of some such as the US, while developing countries have lower index values with the exception of some such as Samoa and Mongolia. The estimation results are presented in Table 18. Based on variable selection procedures, eight different models were estimated, such that the first three models estimate the conventional trade flow model covering, income, population, and distance. The fourth and fifth model estimates the impacts of GMO regulation on maize trade flow. The remaining models estimate the LLP threshold in a more detailed way utilizing various assumptions as explained above.

The robust estimation results indicate that GDPs of exporting and importing countries are positively related to the trade flow and have same impact on the bilateral export flow of the maize. For instance, 1 percent increase in the income level of importing country leads to 0.51 percent higher trade flow. Distance variable, a proxy for transportation cost is found to be negative and significant, meaning that trade flow is less between distant partners. Model 4 accounts for the GMO regulation index together with a detailed specification that accounts for GDP per capita and population. The per capita incomes have a negative sign indicating that maize trade flow is mainly affected by size of the population; however, GDP per capita of importing country becomes positive and significant with the inclusion of the regulation variable. The regulation variable is found to be negative and significant. This implies that more restrictive GMO regulation has a deterrent effect on maize trade flow. Model 3 estimates the impact of LLP threshold on trade flow. First two models associated with the LLP (column 6 and 7) indicate that LLP is not significant on trade flow. The last column indicates the impact of LLP on trade flow is significant but negative. Keeping in mind that restrictive thresholds have lower limits, it mainly shows that even when EU internal trade is taken into account, the LLP threshold has no deterring effect on bilateral export.

Table 17. Descriptive statistics of the data:

	Mean	St. Deviation	Min.	Max.
Export (MT)	128,196.24	800,308.46	0,42	12,972,100
GDPC$_i$ (US$)	31,951.41	18,964.67	465	114,232
GDPC$_j$ (US$)	33,476.00	23,325.41	533	114,232
Population$_i$	77,341,400	99,283,200	500,000	311,600,000
Population$_j$	35,202,100	51,839,300	100,000	311,600,000
Distance (km.)	4,391.94	4,955.26	60	19,264
Regulation Index	76,09	17,37	1	100
LLP Threshold	2,63	4,28	0,10	10

In trade flow analyses endogeneity can be a main issue. Although, model specification assumes that trade flow is mainly determined by exogenous variables such as size of the income, in econometric specification, the endogeneity of policy variables becomes an estimation issue especially caused by simultaneity. In order to test and eliminate this problem first an endogeneity test is carried out, validity of instruments was checked, and model is re-estimated through 2SLS for the LLP threshold (Table 19). The results confirmed that LLP threshold is not endogenous highlighting insignificance of that variable. Table 20 presents the results of theoretically robust trade flow regression based on importer and exporter fixed effects and focusing on LLP threshold of importing countries. As can be seen, inclusion of fixed effects yielded similar results for regulation index, parameter value of distance increased to unity and LLP variable becomes significant but at 10 percent only.

Figure 33. GMO regulation index, 2013

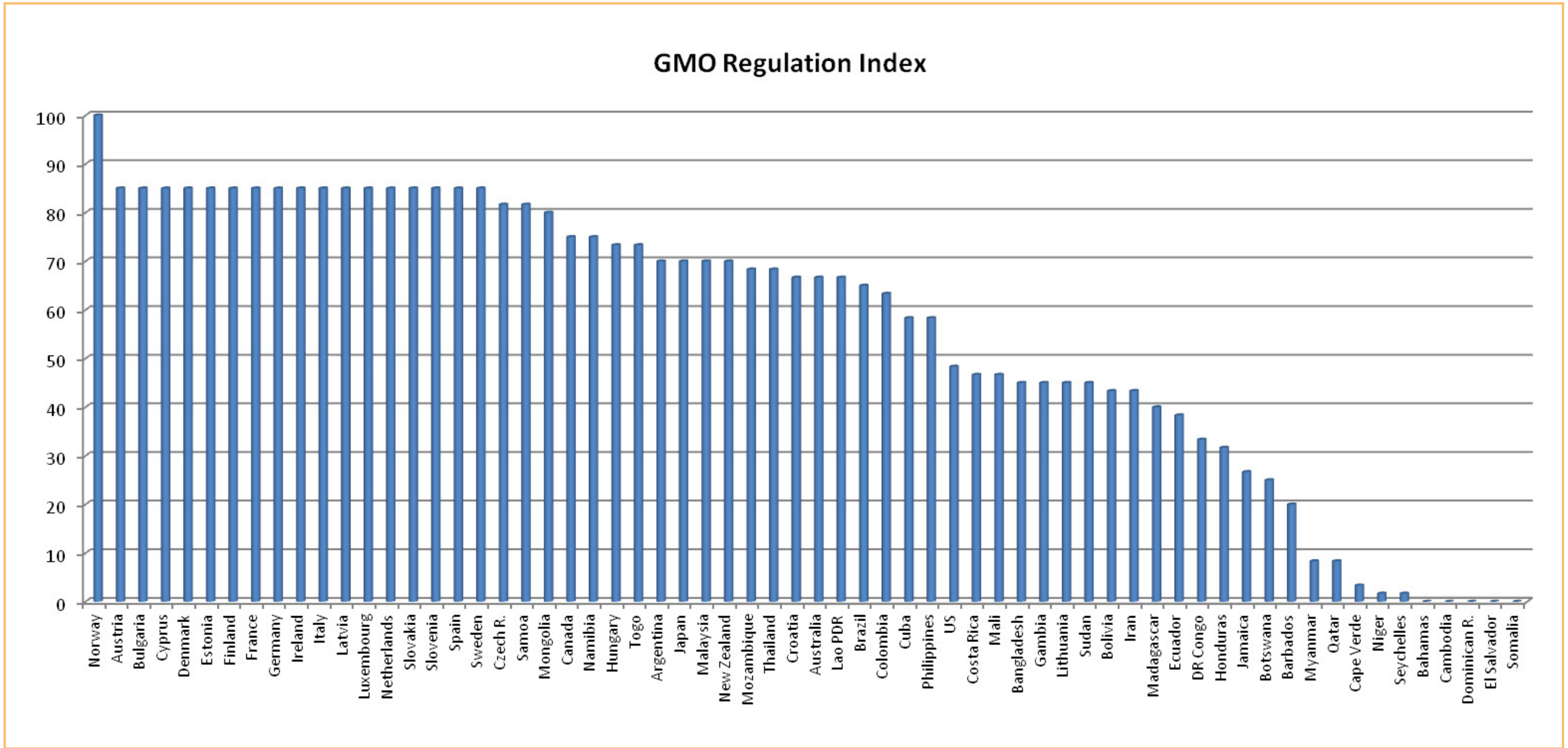


Table 18. Regression result of bilateral maize export flow

Variable	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
c	-14.59 (-4.98***)	-11.59 (-4.06***)	-11.59 (-4.06***)	-10.28 (-3.43***)	-10.28 (-3.43***)	-10.68 (-3.99***)	-10.73 (-3.98***)	-5.22 (-1.89*)
$Ln\text{-}Y_i$	0.40 (4.83***)	1.02 (10.34***)	-	1.00 (10.20***)	-	-	-	-
$Ln\text{-}Y_j$	0.51 (6.63***)	0.83 (9.19***)	-	0.84 (9.23***)	-	-	-	-
$Ln\text{-}GDPC_i$	-	-1.73*** (-8.00)	-0.70 (-3.88***)	-1.70 (-7.72***)	-0.69 (-3.76***)	-0.69 (-4.08***)	-0.68 (-3.94***)	-0.64 (-3.68***)
$Ln\text{-}GDPC_j$	-	-0.64 (-4.16***)	0.18 (1.45)	-0.56 (-3.43***)	0.28 (2.10**)	-	-	-
$Ln\text{-}P_i$	-	-	1.02 (10.34***)	-	1.00 (10.21***)	1.03 (10.47***)	1.01 (10.23***)	0.72 (6.62***)
$Ln\text{-}P_j$	-	-	0.83 (9.20***)	-	0.84 (9.23***)	0.86 (9.39***)	0.86 (9.44***)	0.81 (8.80***)
$Ln\text{-}D_{ij}$	-0.35 (-3.40***)	-0.95 (-8.53***)	-0.95 (-8.53***)	-0.97 (-8.68***)	-0.97 (-8.68***)	-0.92 (-8.20***)	-0.93 (-8.35***)	-0.90 (-7.17***)
$Ln\text{- }Reg.\ Index_j$	-	-	-	-0.49 (-1.70*)	-0.49 (-1.70*)	-	-	-
$Ln\text{-}LLP_j$	-	-	-		-	-0.10 (-1.48)	-0.17 (-1.48)	-0.24 (-2.10**)
R^2	0.10	0.22	0.22	0.23	0.23	0.22	0.22	0.18
F	21.49***	32.60***	32.60***	28.21***	28.21***	32.63***	33.10***	26.03***
Schwarz B.I.C.	1503	1467	1467	1468	1468	1467	1467	1481
N	582	582	582	582	582	582	582	582

Note: t values are in parentheses. *, **, and *** denote 10 percent, 5 percent, and 1 percent significance, respectively. T values reflect heteroscedasticity consistent standard errors.

Table 19. Results of 2SLS estimation

Variable	[1]	[2]	[3]
c	-11.33 (-4.06***)	-11.70 (-4.13***)	-5.19 (-2.03**)
$Ln\text{-}GDPC_i$	-0.75 (-4.00***)	-0.78 (-3.91***)	-0.65 (-3.54***)
$Ln\text{-}P_i$	1.06 (8.95***)	1.05 (9.04***)	0.73 (7.30***)
$Ln\text{-}P_j$	0.88 (9.44***)	0.89 (9.48***)	0.82 (8.48***)
$Ln\text{-}D_{ij}$	-0.89 (-7.24***)	-0.90 (-7.38***)	-0.91 (-6.07***)
$Ln\text{-}LLP_j$	-0.20 (-1.46)	-0.49 (-1.48)	-0.28 + (-0.88)
R^2	0.22	0.21	0.18
F	32.49***	32.46***	25.27***
N	582	582	582

Note: t values are in parentheses. *, **, and *** denote 10 percent, 5 percent, and 1 percent significance, respectively.

Table 20. Maize export flow regression with country fixed effects (dependent variable ratio of export flow to product of incomes)

Variable	[1]	[2]
$Ln\text{-}D_{ij}$	-1.35*** (-11.94)	-1.48*** (-13.00)
$Ln\text{-}RegIndex_j$	-0.63** (-2.25)	-
$Ln\text{-}LLP_j$	-	0.20* (1.79)
R^2	0.41	0.40
F	5.26***	5.12***
N	582	582

Note: t values are in parentheses. *, **, and *** denote 10 percent, 5 percent, and 1 percent significance, respectively.

4. Conclusions

This study aimed to examine the current production, trade, and regulation issues of GM crops in a global scale and impact of LLP/AP in GM crops on trade flow. Therefore, these issues are evaluated utilizing the available statistics, related literature review, the FAO survey, and an econometric analysis. The FAO survey covers the main points related to GM crops such as production, regulation, safety assessment, detection and quantification, LLP/AP incidents, and importance of factors contributing to the trade risks posed by LLP/AP. As the FAO survey highlighted, almost half of the countries (47 percent) produce GM crops for commercial or research purposes. However, 67 percent of the respondents indicated that they have no or have limited technical capacity to detect GMOs according to Codex guidelines. Therefore, capacity development and technical assistance are essential for developing countries. Some of the respondents (37 percent) indicated that they faced LLP/AP incidents in their imports over the last decade. Given the fact that more countries are producing GM crops every year and there are some GM events in pipeline, it is probable that LLP/AP incidents can be observed in the future as well.

Employing a bilateral trade flow model and utilizing cross section data including the responses of the FAO survey, this study found that restrictiveness of regulation, including zero tolerance has a deterrent impact for the maize trade. However, the restrictive LLP threshold has a limited deterring effect on the bilateral export flow in general. The FAO survey reveals that there are some incidents reported by the importing countries related to the LLP/AP. Most of the time the situation is handled through rejection or market withdrawals by the importers of developed countries, and in some cases it was accepted by some developing countries. These incidents may have several welfare impacts on producers, consumers, and agribusiness firms. A certain level of incidents can lead to income loss for exporters and consequently for producers. Our econometric study has implications similar to the findings of Gruere (2009; 2011) which favour nonzero tolerance policies from the perspective of regulation restrictiveness, but suggests caution for the impact of LLP itself on trade flows since its impact is found to be insignificant in ad hoc model while and theoretically robust estimation yielded a negative impact at the margin. Consumers in importing countries can potentially face higher domestic prices when import is deterred from one country and directed to distant partner, as indicated by Kalaitzandonakes et al. (2011). On the other hand, although some developing net importing countries indicated that they have a zero tolerance policy, insufficient technical capacities to detect LLP incidences, and ability to manage the situation contradicts restrictive food safety polices. Certainly more research is needed in this area.

Another important issue is related to the LLP threshold. Although many countries reported that they have a GMO regulation, they do not have a declared LLP threshold. The EU applies a technical solution for feed and few other countries adopt the EU regulations. Lack of LLP threshold and possible solutions can be addressed in the further negotiations. Although this situation can have a trade restrictive effect for some countries based on zero tolerance policy, lack of such standards, accompanied by insufficient technical capacities for detecting such incidences especially for developing countries may lead to underreporting of LLP incidences as indicated in the FAO survey.

As reported by the respondents of the survey, the most important factors that contribute to the trade risk are indicated as different policies on GMOs existing between trading partners, and unintentional movement of GM crops, and different timing for approvals. Therefore, GM crop producing countries, either research or commercialized production, should take all the necessary measures in the stages of production, harvesting, transportation, storage, and marketing to eliminate low level of presence in conventional crops. More international collaboration is needed in this area. When evaluating the impacts of related regulations and standards a holistic approach that covers consumer safety and environmental effects should be considered together with the trade effects.

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Appendix 1

Country responses of some selected questions

7. Does your country have any food safety, feed safety or environmental regulations on GM crops?	a. Yes.	b. No, but we plan to have one in the future.	c. No, we don't have one.	
	Argentina	Barbados	Bahamas	
	Australia	Botswana	DR Congo	
	Austria	Cape Verde	Dominican R.	
	Bangladesh	Myanmar	El Salvador	
	Bolivia	Qatar		
	Brazil	Seychelles		
	Canada			
	China			
	Costa Rica			
	Croatia			
	Cuba			
	Cyprus			
	Czech Republic			
	Denmark			
	Ecuador			
	Estonia			
	Finland			
	France			
	Gambia			
	Germany			
	Honduras			
	Hungary			
	India			
	Indonesia			
	Iran			
	Ireland			
	Italy			
	Jamaica			
	Japan			
	Lao			
	Latvia			
10. Does your country have a "zero-tolerance policy for unauthorized GM crops?	a. Yes	b. No		
	Argentina	Bahamas		
	Australia	Dominican R.		
	Austria	Ecuador		

Appendix 1 (*cont.d*)

Country responses of some selected questions

10. Does your country have a "zero-tolerance policy for unauthorized GM crops?	a. Yes.	b. No, but we plan to have one in the future.	c. No, we don't have one.	
	Bangladesh	El Salvador		
	Barbados	Honduras		
	Bolivia	Jamaica		
	Botswana	Madagascar		
	Brazil	Mali		
	Bulgaria	Mozambique		
	DR Congo	Myanmar		
	Costa Rica	Niger		
	Denmark	Seychelles		
	Estonia	Somalia		
	Finland	USA		
	France			
	Gambia			
	Germany			
	Hungary			
	Iran			
	Ireland			
	Italy			
	Japan			
	Lao PDR			
	Latvia			
	Lithuania			
	Luxembourg			
	Malaysia			
	Mongolia			
	Namibia			
	Netherlands			
	New Zealand			
	Norway			
	Philippines			
	Samoa			
	Slovakia			
	Slovenia			
	Spain			
	Sudan			
	Sweden			
	Thailand			
	Togo			

Appendix 1. (*cont.d*)

Country Responses of Some Selected Questions

17. Does your country's domestic (reference) laboratory have technical capacity to detect or quantify GMOs according to the Codex guidelines (CAC/GL 74-2010)?	a. Yes	b. Partially	c. No, but capacity is being developed	d. No
	Australia	Argentina	Barbados	Bahamas
	Botswana	Mongolia	Gambia	Cape Verde
	Brazil	Mozambique	Lao PDR	DR Congo
	Canada	Myanmar	Madagascar	Costa Rica
	Colombia	Philippines	Namibia	Cyprus
	Croatia		Qatar	Dominican R.
	Czech Republic		Sudan	Ecuador
	Finland		Togo	El Salvador
	Germany			New Zealand
	Hungary			Nicaragua
	Ireland			Seychelles
	Jamaica			Somalia
	Japan			
	Lithuania			
	Malaysia			
	Mali			
	Norway			
	Sweden			
	Thailand			
	USA			

Appendix 2. Survey

FAO survey on accidental presence of low levels of genetically modified organisms (GMOs) in internationally traded food crops

Introduction

Low level presence (LLP) and adventitious presence (AP) of Genetically Modified Organisms (GMOs) in internationally traded crops is of growing concern to national authorities in a number of countries and to a number of private sector bodies. National policies and regulations that govern the acceptability of genetically modified (GM) crops vary. The land area under GM cultivation has grown steadily over the last two decades and many of the GM crops are important in international trade (including maize, canola, soybean). Furthermore, available information suggests that there are a number of new GM crops under development and that a growing number of countries are involved in developing these crops. Current systems of production, handling and transport lead to unintentional low level presence of GMOs in "non- GMO" consignments. A number of trade-related problems have been reported due to such unintentional mixing. FAO is carrying out a study to better understand the extent of trade-disruption due to LLP and AP. This questionnaire has been designed to collect information from countries and will serve as the basis of the FAO analysis. Relevant environmental, food and feed safety regulations that may affect the movement of commodities with LLP or AP of GMOs will be considered within the study.

Working definitions

For the purposes of this study, LLP refers to low level presence of those GMOs that have been approved in at least one country on the basis of a food safety assessment according to the relevant Codex Guidelines. AP refers to the unintentional presence of GMOs that have not been approved in any countries on the basis of the international guidelines for safety assessment.

Objectives

- To determine the extent of the impact of LLP in internationally traded commodities or trade flows, on food and feed availability, food security and to determine which commodities and which countries are most affected.

- To determine how the impact of LLP/ AP in internationally traded commodities is likely to evolve over the next 5-10 years and how this impact will affect food security and economic development.

- To investigate how selected regulatory scenarios could affect the movement of commodities with LLP or AP of GMO

QUESTIONNAIRE

GM Crop Production

1. Does your country produce GM crops?

    a. Yes - Research only (field trials)
    b. Yes – Both research and commercial production
    c. No

2. How many GM crops (the number of GM events) does your country produce (both research and commercial production)?

    a. Less than 20
    b. 21-50
    c. 51-80
    d. Over 80

3. In your country, how many GM crops (the number of GM events) are currently in pipeline?

    a. Less than 20
    b. 21-50
    c. 51-80
    d. Over 80

4. How many GM crops (the number of GM events) are authorized to be ***commercialized*** in your country?

    a. Less than 20
    b. 21-50
    c. 51-80
    d. Over 80

Export/import of agricultural commodities (both non-GM and GM)

5. Please fill out the table below for your country's export situation of some selected agricultural commodities.

Commodity	Does your country export any GM crops of this commodity?	What is the proportion of GM in total exports of this commodity?	Please list the major trade partner countries
Maize			
Soy			
Sorghum			
Wheat			
Rice			
Rapeseed			
Other (specify)			

6. Please fill out the table below for your country's import situation of some selected agricultural commodities.

Commodity	Does your country import any GM crops of this commodity?	What is the proportion of GM in total imports of this commodity?	Please list the major trade partner countries
Maize			
Soy			
Sorghum			
Wheat			
Rice			
Rapeseed			
Other (specify)			

Regulations on GM crops

7. Does your country have any food safety, feed safety or environmental regulations on GM crops?

   a. Yes.
   b. No, but we plan to have one in the future.
   c. No, we don't have one.

8. Please provide the following information for each regulation:
9. If your country has a specific labelling requirement for GM crops, please briefly describe key features of the requirement. Please select all that apply.

   a. Mandatory
   b. Voluntary
   c. Positive Labelling
   d. Negative Labelling
   e. Subject to Threshold Level (Specify...)

10. Does your country have a "zero-tolerance[3]" policy for unauthorized GM crops?

   a. Yes
   b. No

   Please Explain:

In what year did the regulation go into effect?	
What is the scope/ objective of the regulation?	
Is a safety/ risk assessment required?	
Is there a labelling requirement?	
Is there a LLP test requirement?	
Is there a traceability requirement?	
Is a socio-economic assessment required?	

[3] Zero tolerance policy: any imported food or feed material cannot contain even trace amounts of GMO substances that have not been authorized in the importing country.

11. How does your country conduct food safety assessment of GM crops?

   a. According to the international guidelines (Codex principles and guidelines)
   b. According to the domestic guidelines
   c. According to the other guidelines (regional, private, trade-partner countries' etc): please specify: ______________________
   d. We do not conduct food safety assessment of GM crops

12. How does your country conduct feed safety assessment of GM crops?

   a. According to the international guidelines (OECD)
   b. According to the domestic guidelines
   c. According to the other guidelines (regional, private, trade-partner countries' etc): please specify: ______________________
   d. We do not conduct feed safety assessment of GM crops

13. How does your country conduct environment safety assessment of GM crops?

   a. According to international guidelines (state which)
   b. According to the domestic guidelines
   c. According to the other guidelines (regional, private, trade-partner countries' etc): please specify: ______________________
   d. We do not conduct environment safety risk assessment of GM crops

14. What is the authorization policy for the imported GM crops in your country?

   a. Authorization (including various risk assessments according to the international guidelines) process is done domestically, then permit the crops to be sold in the country
   b. Authorization (including various risk assessment according to the international guidelines) process depends on the one done by the country of origin, then permit the crops to be sold in the country
   c. Do not permit any GM crops to enter the country
   d. Other: please specify: _________________________________

Detection and quantification

15. Does your country require testing for imported agricultural commodities for detection of low level or adventitious presence of GMOs? Please select all that apply.

   a. Yes, testing in the exporting country
   b. Yes, testing in the importing country (domestic laboratories)
   c. Other – please specify ______________________________________
   d. No

16. Does your country have a threshold level for LLP/AP?

   a. Yes (Please write the limit level for each crop....)
   b. No

17. Does your country's domestic (reference) laboratory have technical capacity to detect or quantify GMOs according to the Codex guidelines (CAC/GL 74-2010)?

a. Yes
b. Partially
c. No, but capacity is being developed
d. No

18. What kind of detection methods does your country use?

a. Quick methods (presence or absence)
b. Detection and quantification
c. Other – please specify: ___________________________________
d. We don't conduct detection/quantification testing

LLP and AP incidents

19. Has your country faced situations of LLP or AP in imports in the last 10 years?
a. Yes
b. No

20. If yes, please provide the details below:

Year	Commodity	Amount (Tonne)	Imported from	How was the situation discovered?	How was the situation managed?*

* Consignment held for testing; consignment reconditioned; consignment rejected; consignment held while information was sought and then released; other.

21. What is the importance of the factors below in contributing to the trade risks posed by LLP/ AP in your country? ***Please indicate the importance of each on a scale of 1-5 where 1 indicates "not at all important" and 5 indicates "very important".***

Factor	Score (from 1-5)
Different policies on GMOs exist between trading partners	
Different timing (and duration of the process) for approval of GM crops	
Approvals not consistently sought from many countries that are importers of the commodity	
Lack of trust in the other countries' food safety assessment procedures and results; or their approval process	
Unintentional movement/development of unauthorized GM crops/ seed	
Inadequate separation between the commercialized and the field trial production areas	
Inadequate separation between GM crops and non-GM crops (during milling, storage, transport, etc)	
Difficulty in accessing information on food safety assessments carried out in other countries	
Difficulty in accessing information on feed safety assessments carried out in other countries	
Difficulty in accessing information on environmental safety assessments carried out in other countries	

Please specify any other factors that you consider relevant:

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