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Security Analysis for Agroterrorism: Applying the Threat, Vulnerability, Consequence Framework to Developing Countries

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ABSTRACT

In some developing countries the potential exists for agroterrorism to cause widespread disruption through loss of sustenance, income and production. Defense of agriculture may also be problematic because of the lack stability and basic biosecurity infrastructure for the detection and prevention of diseases or invasive species. Currently new methodological approaches for terrorism risk assessments are being actively explored for resource prioritization. One such methodology for risk based allocation of resources is Threat, Vulnerability, and Consequence (TVC) Analysis. A qualitative application of the TVC framework is used to analyze the risk of agroterrorism in developing countries relative to industrialized countries. The analysis suggests that evidence exists to demonstrate general terrorist threats, vulnerability of agriculture and, depending on the country, potentially serious consequences arising from argoterrorism. Where specific threats emerge, action may be needed by the international community to strengthen biosecurity systems in developing countries through: increasing global cooperation, capacity building in monitoring, remediation and risk analysis technologies, and the dissemination of novel technologies for control of pests and diseases.

Key Words: Agroterrorism, terrorism risk analysis.

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SECURITY ANALYSIS FOR AGROTERRORISM: APPLYING THE THREAT, VULNERABILITY, CONSEQUENCE FRAMEWORK TO DEVELOPING COUNTRIES

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1. INTRODUCTION

Many developing countries are reliant on agricultural production for their well-being. The consequences of sharp declines in productivity may be famines, disruptions, and diversion of limited foreign aid to disaster management and away from developments and the loss of important sources of export earnings. The relationships between rural poverty, agricultural production and political instability are well studied by De Soysa and Gleditsch (1999). Significantly countries with GDPs in the range of 250-5000 USD are typically heavily dependent on agricultural production for their economic prosperity and in this context agroterrorism has the potential to cause continued instability and slow growth, further destabilizing governments and creating favorable environments for insurgent activity, exacerbating the problems of underdevelopment. If it can be shown that (certain) developing countries are at risk of terrorist attacks on their food chains, it will be justified to spend resources to deal with this risk. However, in view of competing interests in the allocation of scarce resources to meet development goals, and in view of modest current levels of development aid, such measures would have to be based on a careful analysis. Therefore in this paper we qualitatively explore the relative risk of

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agroterrorism between industrialized and developing countries by applying Threat, Vulnerability, and Consequence (TVC) Analysis (Willis *et al.* 2004).

Our application of the TVC analysis framework to the problem of agro-terrorism risk evaluation is motivated from an increasingly apparent need to provide national policy makers with risk assessment tools that can be used to help guide the allocation of security resources. Broadly developed and developing countries share many characteristics that make may make them attractive targets for agroterrorism including:

1. the proliferation of terrorist groups who have grievances against both developed and developing countries;
2. the dependence of a significant portion of the economy on agricultural exports and imports; and
3. the large scale of agriculture.

Additionally developing countries suffer from:

1. a lack of capacity to monitor for potential agricultural pests and diseases;
2. a lack of expertise is in risk assessment practice and decision-making;
3. poor existing security measures; and
4. often fragile economic circumstances.

By organizing and discussing these issues within the TVC framework we hope to demonstrate, at least qualitatively, the utility and applicability of the framework for the emerging issue of agroterrorism.[3]

In general some work now links the need for development to address security concerns. For example DFID (2005) cites evidence that countries with per capita GDP

[3] The United Nations Report from the Panel on Threats, Challenges and Change, "A more secure world: Our shared responsibility" discusses some of these issues within the broader security environment (UN 2004)

levels of $250 USD have a 15 percent risk of experiencing a civil war within the next five years. Where countries with per capita GDP levels of $5,000 USD the risk of civil war is less than one percent. However the empirical evidence is less clear on linkages between development and terrorism. Krueger and Malečková, (2003) argue that there is little evidence of direct linkages between poverty and terrorism but that there may be indirect linkages. In this paper we restrict our attention to agroterrorism and the immediate response that can be developed to deal with such threats. However, longer term policies associated with promoting development may well contribute towards reducing the threat level, vulnerability and consequences associated with agroterrorism.

The remainder of this paper is divided as follows. Section 2 elaborates the TVC framework. Section 3 applies the framework to qualitative assessment of relative risk of agroterrorism in industrialized and developing countries. Section 4 discusses a number of policy measures that can be used to deal with agroterrorism in developing countries. Section 5 concludes.

2. ANALYTICAL FRAMEWORK

DEFINING AGRO-TERRORISM

The United Nations defines terrorism as "any action that is intended to cause death or serious bodily harm to civilians or non-combatants, when the purpose of such act, by its nature or context, is to intimidate a population, or compel a Government or an international organization to do or abstain from doing any act (UN 2004). Agroterrorism is more narrowly defined as the deliberate disruption of the production and distribution of food using biological agents with the aim of creating terror (Parker 2002) by utilizing

threats against food or water to create anxiety and manipulate the main target audience, turning it into a target of terror, a target of demands, or a target of attention, depending on whether intimidation, coercion, or propaganda is primarily sought.[4] Agroterrorism can take many forms, including poisoning livestock, or introducing and/or deliberately spreading plant and animal pathogens.

THE THREAT-VULNERABILITY-CONSEQUENCES (TVC) ANALYSIS FRAMEWORK

Traditionally, risk has been defined as the triplet $\langle s_i, p_i, x_i \rangle$ where s_i is the risk scenario and each s_i has a probability p_i of occurring and a consequence x_i if it occurs (Kaplan and Garrick 1981, Kaplan 1997). Specific disciplines use modifications of this general definition that reflect the underlying structures of the risks they encounter. For example in engineering risk is generally defined as the probability of an event occurring multiplied by its associated consequence, reflecting the risk of failure rates or industrial accidents (Stewart and Melchers 1997). In actuarial science insurance companies are concerned about the risk of insolvency and calculate the probability of ruin, which is the risk that the insurer's surplus (assets – liabilities) falls below zero (Dickson and Waters 1992). Similarly we need a definition of terrorism risk that reflects the underlying structure of the risk.

Terrorism risk may be thought of as function of the threat level, vulnerability to the threat, and consequence from the terrorist action (Willis *et al*. 2004). For example, the risk estimate could refer to an attack by terrorists against food trade using a particular disease or toxin. The threat would then be an estimate of the terrorists' priority for such

[4] Definition from Jane's Information Group, an authoritative security think tank http://jtic.janes.com/public/jtic/terrorism_definition_noscript.shtml

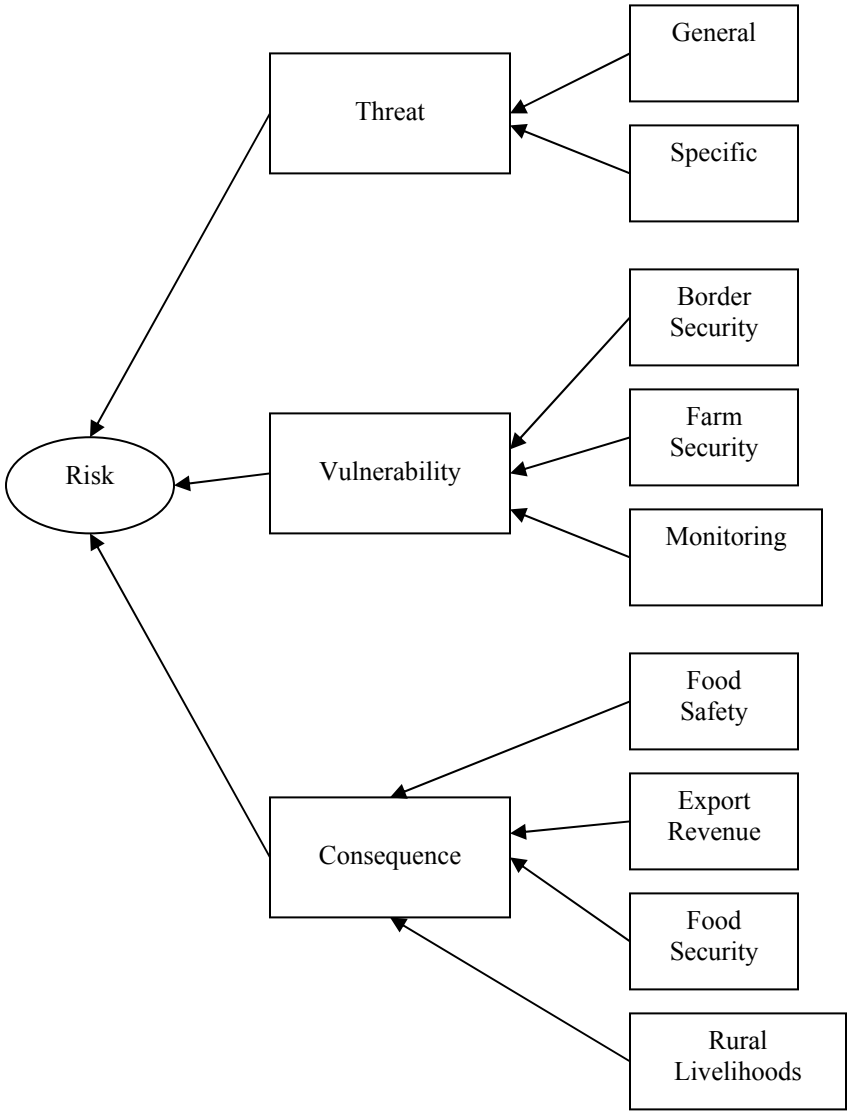
as attack against the available alternatives. Vulnerability could be estimated as likelihood of port interception and the consequences would be an assessment of the impact of the disease. Threat, Vulnerability, Consequence analysis is an interactive approach designed to elicit areas where high threat levels, extreme vulnerabilities, and high consequences overlap (Figure 1). It is the intersection of these events that cause security concerns. The following section discusses in more detail which factors have to be considered when applying this framework to agroterrorism.

Figure 1. Overlapping regions of high threat, vulnerability, and consequence great security risk.

APPLYING THE TVC ANALYSIS FRAMEWORK TO AGROTERRORISM

Figure 2 shows the factors that need to be considered in order to assess the levels of threat, vulnerability and consequences with regard to agroterror.

Figure 2. The anatomy of the threat, vulnerability, and consequence analysis.



Threat

The purpose of the threat assessment is to gain an understanding of where terrorists are targeting their activities; typically based on intelligence information gathered from a variety of sources. Threats may be general or specific and security responses are conditioned on the nature of the information received. Typically an analysis will first assess whether a country or region is under a general threat from terrorist attacks. If this is the case, the next step is to analyze whether terrorists are likely to attack the food chain, which will turn the general into a specific agroterrorist threat. Existing empirical evidence suggests that the frequency of agroterrorist attacks is very low, with the documented attack rate being less than once in every four years (Parker 2002). However, such estimates are backward looking and do not taken into account the evolving security environment.

We argue, based on rational-choice considerations (compare Krueger and Malečková, 2003), that terrorist (organization) will choose agroterrorist actions in addition to other actions, if agroterrorist means contribute to reaching their goals for relatively low cost and have high impact. Therefore it would be rational for terrorists to attack the food chain, if this allows them to realize their goals to a larger extent with lower costs than would be incurred by other means. However, one has to consider both the economic and the political dimension of costs and benefits. For example, if a terrorist group has an anti-poverty ideology, using a technique that hits mostly poor people implies a political cost, because it reduces the credibility of their cause. It may also be argued that the rational-choice model has limitations in explaining suicide attacks.

The rational-choice model proposed implies that the following factors are crucial for turning a general into a specific agroterrorist threat: (1) The availability and the costs

of obtaining and using technologies for agro-terrorism as compared to technologies needed for other types of terrorism. (2) The contribution of an agro-terrorist attack to the goals of the terrorist group under consideration, as compared to the contributions achieved by other types of attacks. This implies that one has to study the goals of the terrorist groups under consideration and assess how the consequences of different types of terrorist attacks would contribute to reaching their goals. The rational choice consideration links the different elements of the analytical framework, because the terrorists will consider perceived vulnerability and consequences in deciding on whether to launch an agro-terrorist attack.

Vulnerability

As shown in Figure 2, the vulnerability against an agro-terrorist attack depends on the structure of agricultural production, on the controls that are in place at the borders and on the monitoring systems in the food chain. If the public health system is underdeveloped, a country is also more vulnerable because it is less able to detect and deal with the consequences to human health.

Consequences

It is useful to distinguish between the consequences for the agricultural producers, for the consumers, and for the economy as a whole. Accordingly, we suggest considering farm incomes, food safety and food security, and export earnings as the major consequences. One can also distinguish between the short- and long-term consequences, which may have both an economic dimension (loss of productive capacity and food availability) and a political dimension (vicious cycle effects mentioned in the introduction).

3. EXPLORATORY ANALYSIS

In this section, we use the framework presented in Section 2 for an exploratory analysis of the question whether developing countries are comparatively more or less at risk from agro-terrorism than industrialized countries.

THREAT ASSESSMENT

The purpose of the threat assessment is to gain an understanding of where terrorist are targeting their activities. According to the analytical framework outlined in Section 2, the threat assessment proceeds in two steps: (1) assessing whether the country – and which regions in the country – are under threat of terrorist attacks, and (2) assessing whether terrorists are likely to attack the food chain, rather than launching terrorist attacks against other targets. In practice, this assessment is typically this based on intelligence information gathered from a variety of sources. The nature of the information received may allow the analysts to find out whether the threats are general or specific.

Contrary to popularly held perceptions, developed countries are not the only targets of terrorists. Local political conditions in many developing countries have led to extensive campaigns by local terrorist groups. Table 1 provides a summary of some terrorist organizations operating in developing countries, based on data from the US Department of State.

Table 1: A summary of some terrorist organizations operating in developing countries. The list is not exhaustive and more detailed information on the activities of the organizations listed below and other organizations can be obtained from: Patterns of Global Terrorism. 2003. United States Department of State http://www.state.gov/s/ct/rls/pgtrpt/2003.

.Country	Terrorist Groups	Aims	Operational sphere of influence	Recent activities
India	• Harakat ul-Mujahidin (HUM) • Jaish-e-Mohammed (JEM)	Creation of an independent state in Kashmir.	Indian administered Kashmir from bases in Pakistan.	Operations against Indian military targets in Jammu and Kashmir.
Philippines	• Abu Sayyaf Group (ASG), • New People's Army (NPA), • Alex Boncayao Brigade (ABB)	ASG: Creation of an independent Islamic state in the southern Philippines. NPA and ABB: The establishment of a Marxist state in the Philippines. NPA is the mainly rural armed wing of the Communist Party of the Philippines, and ABB is an urban-based split-off group from NPA.	Various groups operate in the Philippines with Islamic extremists operating in the southern Philippines.	Operations involve kidnappings for ransom, bombings, beheadings, assassinations, and extortion, within the Philippines.
Malaysia	• Kumpulan Mujahidin Malaysia (KMM)	KMM favors the overthrow of the Malaysian Government and the creation of an Islamic state comprising Malaysia, Indonesia, and the southern Philippines.	Operations throughout Malaysia, with links to groups operating in Indonesia and the southern Philippines.	Activities include bombings and robberies, and the murder of a former state assemblyman within Malaysia.

Indonesia	• Jemaah Islamiya (JI) •	Stated goal of creating an Islamic state comprising Brunei, Indonesia, Malaysia, Singapore, the southern Philippines, and southern Thailand.	Southeast Asian–based terrorist network with links to al-Qaida.	Australian embassy bombing in 2004. The J. W. Marriott Hotel in Jakarta August 2003, the Bali bombings October 2002, and an attack against the Philippine Ambassador to Indonesia in August 2000.
Sri Lanka	• Liberation Tigers of Tamil Eelam (LTTE)	LTTE aims to establish a Tamil homeland. The LTTE is currently observing a cease-fire agreement with the Sri Lankan Government.	The Tigers control most of the northern and eastern coastal areas of Sri Lanka but have conducted operations throughout the island.	The terrorist program targets key personnel in the countryside and senior Sri Lankan political and military leaders in Colombo and other urban centers. Political assassinations and bombings are commonplace.
Egypt	• Al-Gama'a al-Islamiyya (Islamic Group, IG)	Egypt's largest militant group, active since the late 1970s, appears to be loosely organized. Has an external wing with supporters in several countries worldwide. The group issued a cease-fire in March 1999	Operates mainly in the Al-Minya, Asyut, Qina, and Sohaj Governorates of southern Egypt. Also appears to have support in Cairo, Alexandria, and other urban locations,	Group conducted armed attacks against Egyptian security and other government officials, Coptic Christians, and Egyptian opponents of Islamic extremism before the cease-fire. From 1993 until the cease-fire.
Columbia	• Revolutionary Armed Forces of Colombia (FARC)	The establishment of a Marxist government in Columbia. FARC was established in 1964 by the Colombian Communist Party to defend what were then autonomous Communist-controlled rural areas.	Primarily in Colombia.	Bombings, murder, mortar attacks, narcotrafficking, kidnapping, extortion, hijacking, as well as guerrilla and conventional military actions .

Somalia	• Al-Ittihad al-Islami (AIAI)	Establishment of an Islamic government.	Primarily in Somalia, with limited presence in Ethiopia and Kenya.	The group is believed to be responsible for a series of bomb attacks in public places in Addis Ababa in 1996 and 1997 as well as the kidnapping of several relief workers in 1998.
Rwanda	• Army for the Liberation of Rwanda (ALIR)	ALIR seeks to topple Rwanda's Tutsi-dominated government, reinstitute Hutu domination, and, possibly, complete the genocide.	Mostly eastern Democratic Republic of the Congo.	The Armed Forces of Rwanda (FAR) was the army of the ethnic Hutu-dominated Rwandan regime that carried out the genocide of 500,000 or more Tutsis and regime opponents in 1994. Ongoing operations against the government of Rwanda.

While some terrorist incidents can be explained by attacks against US interests, the majority of attacks are directed against the national interests of the developing country in which the attacks occur (US Department of State 2003). The examples in table 1 are provided to demonstrate the presence of a general threat in some developing countries. However, in developing countries where no terrorist organizations with national targets are active, the general risk of terrorism may be lower than in industrialized countries. Nethertheless, many developing countries are at risk due to actions occurring in violent conflicts and wars which can also lead to attacks on the food chain. As discussed in Section 2, a general threat is a necessary, but not a sufficient condition for a specific threat against agriculture. There is some evidence that general threats are more likely to be turned into specific threats of agro-terrorism in the future, because there is a growing interest among terrorist groups in the use of biological agents. More than seventy percent (19 of 27) of confirmed bioterrorism cases occurred in the 1990s (Carus 2001).

With regard to industrialized countries, many observers and intelligence analysts in the West consider the occurrence of agro-terrorism to be a "low probability - high consequence" event, largely because terrorists act against their primary targets, such as transport hubs, directly creating anxiety, fear, and disruption. However, there is growing concern that industrialized countries may be more at risk than developing countries based on the assumption that terrorists may utilize agroterrorism as other types of terrorist attacks become more difficult due to increased controls[5] (Frazier and Richardson 1999). Some estimates are available from the experience in the United States, which suggests that that the frequency of agroterrorist attacks is very low, with the documented attack

[5] For example comments by United States Secretary of Health Tommy Thompson http://www.showmenews.com/2004/Dec/20041204News009.asp

rate being less than once in every four years (Parker 2002). Analysts also suggest that such attacks are unlikely to threaten food security in developed countries (Wheelis *et al.* 2002), despite substantial economic costs.

In developing countries, the contribution of agriculture to the gross domestic product (GDP) and to the employment of the labour force is much larger than in industrialized countries (see below). Therefore, the question arises whether in countries under general threat, terrorist groups are more likely to use agroterrorist means than they are in industrialized countries. There are few documented examples of actual acts of agroterrorism, using disease or toxins, in developing countries. One example was reported in 1952, when British colonial authorities charged that individuals associated with the Mau Mau rebellion in Kenya had used a plant toxin to poison livestock (Carus 2001). The picture becomes different, if one includes attacks against the food chain occurring in conflicts and wars. As historians of hunger have noted, "Hunger as a weapon is at least as old as the first siege of a city" (Kates and Millman, 1990). The destruction of crops and looting of cattle by militia aligned with the government in Darfur, Sudan (Human Rights Watch 2004) is perhaps the most recent example.

According to the rational choice considerations above, the availability and costs of techniques to be used for agroterrorism influences the likelihood that a general threat is turned into a specific threat. In this context, one has to note that terrorists have relatively easy access to pathogenic bacteria such as anthrax (and their complete gene sequences); potent and accessible chemical agents such as ricin, which can be made from by-products of castor oil production (ARS 2001); and other pathogens causing diseases in crops and animals. The list of potential agroterror agents includes crop diseases that affect most of

the world's key crops: potato beetle, fungal spores that cause cereal rust, wheat smut, and rice blast, and highly contagious animal diseases such as foot and mouth (WHO 2004a), rinderpest, and avian influenza (WHO 2004b).

A second issue to be considered according to the rational choice considerations above is the degree to which an agroterrorist attack contributes to the goals of a terrorist organization, in comparison to the contributions from other available techniques. Terrorist groups involved in an ethnic conflict, such as the Liberation Tigers of Tamil Eelam in Sri Lanka, may use agroterrorist techniques only if the damage can be confined to the ethnic group against which they are fighting. This is unlikely to be the case for plant diseases, except for situations where the ethnic groups in conflict grow and consume completely different crops. For the same reason, state actors engaged in attacks against parts of their own population may not use plant diseases. Terrorist groups with a Marxist ideology, such as the Revolutionary Armed Forces of Colombia, may not choose an agroterrorist action that negatively affects rural small-holders, because of the political costs involved in such an action that contradicts their own ideology, and the threat to the drug crops that fund the rebellion. An agro-terrorist attack using a livestock disease that would affect mainly the large-scale cattle-keeping landowners might, however, be more plausible for such a terrorist organization. Since the terrorist groups operating in developing countries differ widely with regard to their goals (see table 1), a case-by-case analysis would be required for assessing whether the emergence of a specific threat to agriculture is likely to occur. Moreover, in the absence of intelligence, it is difficult to provide any clear statements on specific threats. Nevertheless, given the general threat

environment in some developing countries, the above considerations show that a specific threat against agriculture could develop.

VULNERABILITIES

According to the framework developed in Section 2, an assessment of vulnerabilities should at least consider the issues of border and farm security and monitoring of human, animal and plant health.

Border security

Industrialized countries reduce their vulnerability against terrorist attacks by controlling people and material crossing their borders. Even though major reasons for operating comprehensive border control systems in industrialized countries include preventing illegal immigration and controlling and taxing import commodities, having border control systems in place facilitates controls regarding terrorist attacks. The resources needed for a comprehensive border control system are, however, considerable. One of the best documented examples which serves to illustrate the issues of border security and the difficulties inherent in ensuring the integrity of borders are the efforts of the USA to control the influx of drugs. Each year, 60 million people enter the United States on more than 675,000 commercial and private flights. Another 6 million come by sea and 370 million by land. In addition, 116 million vehicles cross the land borders with Canada and Mexico. More than 90,000 merchant and passenger ships dock at U.S. ports. These ships carry more than 9 million shipping containers and 400 million tons of cargo. Another 157,000 smaller vessels visit coastal towns (DEA 2004). The US has systematically addressed vulnerabilities in this area with increased costal and border

surveillance activities, additional airport security and tighter passport control and increased port inspections (DHS 2004).

In developing countries, the resources spent on border control are typically much lower than in industrialized countries, since the scarcity of available resources means that other goals have higher priorities. As a consequence, the vulnerability with regard to this factor is generally considerably higher. The difficulties faced by developing countries in securing borders can be illustrated by an example where considerable resources have been spent: India's efforts in securing the Kashmiri border with Pakistan. In 1947-8 and again in 1965 India and Pakistan fought wars over Jammu and Kashmir. Since 1989 there has been a growing and often violent separatist movement against Indian rule in Kashmir fueled by the movements of arms and fighters from Pakistan. In 1999 India fought Pakistani-backed forces that had infiltrated Indian-controlled territory in the Kargil area. The example demonstrates the difficulty developing countries face in securing borders against the determined efforts of terrorists.

Farm security

The vulnerability for agroterrorist attacks also depends on the structure of agricultural production and food consumption. The larger the proportion of crops for which agroterrorist techniques are available, the higher is the vulnerability. The same applies to livestock.

As a result of rising incomes and urbanization, developing-country consumers are demanding more meat and dairy products in their diets. As a direct result of this, demand is increasing for cereal crops, particularly to feed livestock. Net cereal imports by developing countries are expected to double between 1997 and 2020 and their net meat imports are expected to increase eightfold**,** with meat production in developing countries

also rising (Rosegrant *et al.* 2001). As developing countries produce more grain and more livestock, there are more potential terrorist targets.

The change in food consumption patterns has the effect that especially livestock production and imports in developing countries are becoming comparatively more vulnerable. The rising demand for meat is being satisfied through intensive types of livestock production such as battery hen farms and cattle feed lots. The highly crowded conditions that characterize intensive livestock production combined with poor security on farms such as the lack of fencing, patrols, and locks, and a high dependence on agriculture imply a high vulnerability, which may make it more likely that livestock production will provide a tempting target for terrorists. Under intensive farming conditions, outbreaks of contagious diseases are difficult to contain and can be highly disruptive of food production, resulting in extensive culling of animals. For example intensive feedlots in the US hold as many as 150,000-300,000 head of beef, and cattle are transported from one site to another as they mature or to be slaughtered. Other examples include the intensive battery hen farms prevalent in Asia and persistent out breaks of avian influenza. These conditions may facilitate the spread of disease from a single animal. A factor which contributes to the vulnerability of both crop and livestock production in developing countries is that the agricultural research and extension systems are less developed than in industrialized countries. As a consequence, the capacity to cope in a timely and effective manner with crop or livestock disease problems caused by agro-terrorist attacks is lower.

Monitoring

Food safety is receiving greater attention as the important links between food and health are increasingly recognized. Improving food safety is an essential element of

improving food security. All countries share similar concerns about food safety, but the relative importance of different risks varies with climate, diets, income levels, and public infrastructure. Some food safety risks are greater in developing countries, where poor sanitation and unsafe drinking water pose greater risks to human health than in developed countries (Unnevehr 2003).

Under the conditions described above a reliable monitoring system is critical for detecting and preventing the spread of disease before damage is inflicted (RAND 2003). This need was graphically demonstrated by recent outbreaks of avian influenza. The absence of prompt control measures backed by a good surveillance system might have contributed to the long and devastating effects from 1992 to 1995 in Mexico (CDC 2004). On the other hand, the prompt culling of Hong Kong's entire poultry population in 1997 was considered to have averted an influenza pandemic.

CONSEQUENCES

As shown in Figure 2, one can distinguish four types of consequences of an agroterrorist attack affecting the domestic supply of food, rural livelihoods, potential export revenues, and the safety of food in importing countries.

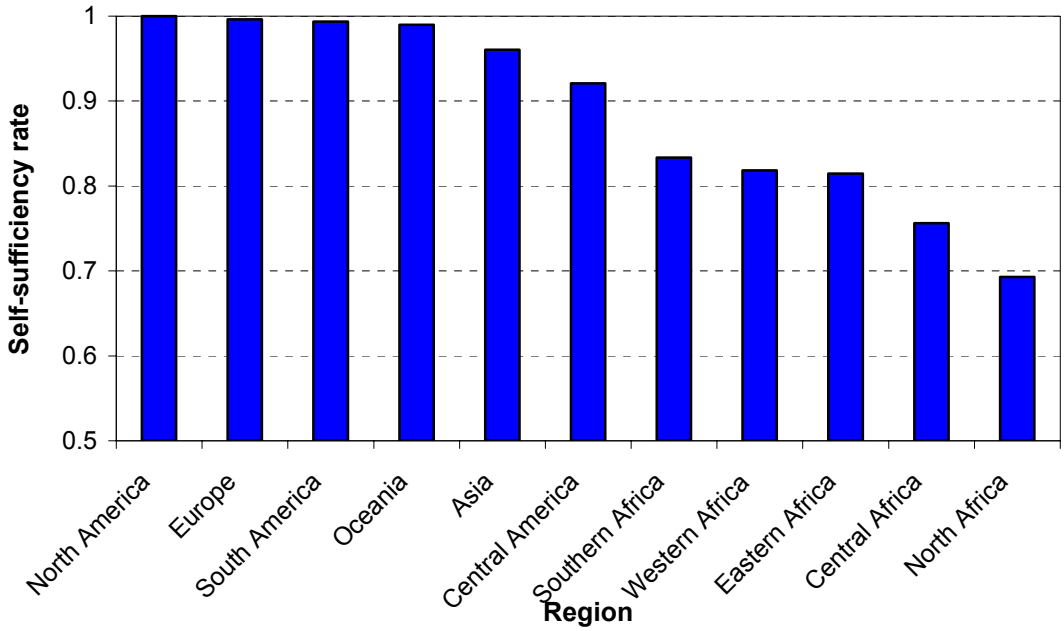
In many developing countries, decreases in food and cash crop production have far-reaching consequences, which is due to their agricultural and economic conditions. Many developing countries suffer from chronic food shortages due to the large share of agriculture that is rainfed and depends on often unpredictable and increasingly variable weather conditions. In these countries, typically, the majority of low-income people (75 percent) (IFAD 2001) depend directly or indirectly on agriculture for their livelihoods and commonly spend 50 percent or more of their household income on food (Pinstrup-

Andersen et al. 1999). The impacts of crop and livestock infestations can be devastating. There are impressive historical examples to illustrate this point. The Irish Potato blight killed one million people and forced another million people to leave Ireland (Rogers et. al 1999). More recently, avian influenza in Hong Kong cost hundreds of millions of dollars in lost poultry production, commerce, and tourism (US National Intelligence Council 2000).

Conceivably, agroterrorism could lead to disruption of food supplies sufficient to lead to food price hikes, leading potentially to food riots in urban areas. In addition, many developing-country governments depend heavily on earnings from cash crop exports such as coffee, cotton, sugar, or cocoa as a major source of public spending. Often, developing countries depend on a few or even a single such crop for the bulk of hard currency earnings; for example, in war-torn Burundi, coffee accounts for 62 percent of all export revenues (Messer and Cohen 2004).

On the domestic side, table 2 shows that the share of agriculture in the gross domestic product (GDP) in South Asia and Sub-Saharan Africa is 18-23 percent, compared to 2 percent in the United States and European Union member states. Figure 3 shows that in all African subregions, domestic cereal production accounts for less than 85 percent of total consumption.

Figure 3--Self sufficiency rate of cereals, 2003



Source: FAO Food Outlook (June 2004), FAO Foodcrops and Shortages (May 2004)

Food aid often fills in the gap. Production of adequate amounts of nutritious food is of highest concern in these countries (Islam 1995; Pinstrup-Andersen et al. 1999), and any disruption of food supply due to agroterrorism may create the potential for famine if food assistance or commercial food imports are not readily available.

On the export side, Table 2 also shows that the share of food in the exports of Latin America and the Caribbean, South Asia, and Sub-Saharan Africa is double or more the figure for the high-income countries.

Table 2--Structure of economy by region, 2002

Region	Share of agriculture in GDP	Share out of merchandise export	
		Food (percentage)	Manufactures
Low and middle income countries			
East Asia & Pacific	15	7	79
Europe & Central Asia	9	6	57
Latin America & Carib.	7	22	48
Middle East & N. Africa	11	4	19
South Asia	23	13	77
Sub-Saharan Africa	18	17	35
High income countries	2	7	82

Source: World Bank, World Development Indicators 2004.

Given the high volume of agricultural products that enter into international trade, the deliberate or accidental contamination of food in one country can have significant impacts in other parts of the world and lead to serious economic damage for the exporting country. An example of the deliberate contamination of food exports occurred in 1978, when the Arab Revolutionary Army poisoned Israeli citrus exports to Europe. An example of accidental contamination occurred in 1989 when exported cantaloupes from Mexico infected approximately 25,000 people in the U.S. with salmonella poisoning (Carus 2001). In 1985 the United States suspended Chilean grape imports after receiving threats that the grapes had been contaminated with cyanide (FAO 2003). It is estimated that this incident cost Chilean growers upwards of 333 million dollars (Ban 2000). These examples indicate that threats against agricultural exports can be used as effective terror weapons with considerable consequences.

NEED FOR FURTHER RESEARCH

The application of the TVC analysis framework shows that, not surprisingly, developing countries have a higher vulnerability for agroterrorist attacks than industrialized countries. The factors that increase the vulnerability of a country are related to general problems of the current level of development, agricultural production, food security, and food safety in developing countries. These factors have been subject to research for many years, and there is typically sufficient information available. The same applies to the assessment of the consequences of agroterrorist attacks: to the extent that data on the structure of the agricultural sector is available, an assessment of potential consequences is possible. A need for further research, however, exists with regard to assessing the threat, especially the specific threat of agroterrorist attacks. The rational choice considerations presented above can be helpful in identifying the issues to be studied. However, empirical research in this field is obviously difficult and dangerous. There are few examples of empirical studies dealing with terrorism that are based on primary rather than on secondary data (see the review by Krueger and Malečková, 2003). Obviously, intelligence activities rather than scientific research is necessary to obtain much of the empirical information that would be required to assess specific threats. Nevertheless, given the high vulnerability of developing countries and the potentially large consequences, efforts to learn more about specific threats appear justified. This would allow countries and aid agencies to make informed decisions on the question whether and to which extent scarce resources should be spent on the prevention of agroterrorism.

4. POTENTIAL RESPONSES

This section discusses potential responses to the risk of agroterrorism. The analytical framework presented in Section 2 is used to categorize the possible responses. As discussed above, the extent to which a country or aid agency should invest resources in potential measures against agroterrorism should depend on the outcome of a risk assessment. However, as further detailed below, a number of activities that are justified on other grounds will also have the side-effect to reduce the risk of agroterrorist attacks.

ADDRESSING THREATS

According to the above analysis, activities that reduce the general threat of terrorism and conflicts will also reduce the specific threat of agroterrorist attacks. There is evidence that international efforts to increase security in developing countries should receive more attention. A recent case study of Uganda by IFPRI (Zhang 2004) found that security is a pre-condition for successful economic development and that there is in fact a threshold level of security below which public investments in infrastructure and education have little impact on growth.

One has to acknowledge, however, that international efforts to promote increased security in developing countries are inherently difficult, because conflicts typically occur in countries where national governments have limited legitimacy and where far-reaching governance problems persist. Limiting interventions to humanitarian purposes and working with non-governmental organizations are considered to be ways to deal with these problems (Wolfensohn and Bourguignon, 2004).[6] Contributing to the prevention of

[6] The discussion on "state failure" is related to this problem. The World Bank uses a less judgmental term and refers to countries with low governance indicators and conflict situations to "low income countries under stress."

conflicts is an important strategy to deal with this problem, as well. Food security, agricultural, and rural development programs in developing countries need to focus more explicitly on conflict prevention and mitigation, so that development assistance resources do not fuel conflict, as has happened in the past in Somalia, Rwanda, Ethiopia, Indonesia, and Colombia. This will usually require efforts to distribute assistance in an equitable and broad-based manner, so as not to encourage or exacerbate inter-group rivalries. The benefits of conflict avoidance might be calculated as returns to aid investment. At the same time, if emergency relief and post-conflict reconstruction programs are to move countries beyond periodic cycles of conflict, they need to focus on fostering sustainable food security and agricultural and rural development (Messer, Cohen, and D'Costa 1998; Messer, Cohen, and Marchione 2001).

ADDRESSING VULNERABILITIES

A reliable biosecurity system is critical for detecting and preventing the spread of disease before damage is inflicted (RAND 2003). The development of biosecurity measures could therefore contribute to reducing developing country vulnerabilities. As in the case of promoting general security, establishing biosecurity systems is justified on other grounds besides reducing the risk from agroterrorist attacks: naturally occurring disease problems in crops and livestock already cause considerable problems for agricultural productivity, food security, and food safety in developing countries.

The Food and Agriculture Organization of the United Nations (FAO) coined the term "biosecurity" in relation to sanitary, phytosanitary and zoosanitary measures applied in food and agricultural regulatory systems. It is a holistic concept, encompassing the policy and regulatory frameworks that analyze and manage risks in the sectors of food

safety, animal life and health, and plant life and health, including environmental risk. Biosecurity covers the introduction of plant pests and diseases, animal pests and diseases, and zoonoses, the introduction and release of genetically modified organisms (GMOs) and their products, and the introduction and management of invasive alien species and genotypes (FAO 2003). It addresses both deliberate and accidental introduction. Globalization and linkages through trade increase the likelihood of the movement of pests and disease from one location to another, either deliberately or inadvertently. Strengthening capacity in biosecurity is critical for promoting food security and access to agricultural markets thus promoting trade and development. Greater global cooperation in the form of financial aid and technical assistance to help build capacity in biosecurity would also assist developing countries to cope with any emerging specific threats of agroterrorism as well as the more general spread of pests and disease.

However, to date, international funding for integrated approaches to biosecurity appears limited, with international priorities focusing on developing more narrowly focused biosafety systems for GMOs and GM products. Currently, major donor organizations such as the United Nations Environment Program (UNEP), United States Agency for International Development (USAID), and the World Bank all manage biosafety capacity building programs, but have no comparable programs in biosecurity. For example, UNEP provides $38.4 M funding (UNEP 2004), and USAID provides $14.8M funding (USAID 2004) for biosafety in developing countries. FAO may soon spearhead the development, or coordination, of biosecurity capacity building programs (FAO 2003). Additionally, various amounts of financial support (at this time we are querying some of the reported amounts in the WTO database) are available to help build

capacity in developing countries to meet the sanitary and phytosanitary standards demanded in developed-country markets, consistent with the relevant agreement (SPS) adopted by the World Trade Organization (WTO)[7]. Synergies are possible biosecurity and trade related food safety. Given the importance of agricultural exports to many developing counties' economies the linkage to trade is especially important.

The development and application of new technologies could reduce vulnerabilities of some types of terrorist threats. For example ricin, a highly toxic chemical made from by-products of the production of castor oil and classified by the Centers for Disease Control as a Class B bioterrorism agent, could be used by agroterrorists to contaminate food supplies in developing countries. Components of the oil, known as hydroxy fatty acids, are essential for making high-quality lubricants for heavy equipment or jet engines, for example. Castor oil is also used in paints, coatings, plastics, antifungal compounds, shampoo, and cosmetics. The world demand for castor oil is about 1 billion pounds annually, valued at more than $400 million. The bulk of the annual castor crop is grown in developing countries, ensuring bioterrorists with access to this toxin. Current attempts to develop transgenic plants with reduced expression of ricin in the castor seeds could reduce the potential threat from this source (ARS 2001).

Transgenic crops with increased pest and disease resistance can have dual protection effects against both natural and terrorist-induced disasters. For example Eastern and Central Africa are currently witnessing the spread of a major coffee disease, coffee wilt. In Uganda, output has dropped by almost 20 percent, which translates into

[7] see www.wto.org on the SPS agreement. The agreement permits WTO members to take measures to ensure that the food that they import is safe to eat by the importing country's own standards, and, at the same time, aims to ensure that strict health and safety regulations are not used to erect trade barriers to protect domestic producers from competition.

approximately a 30 percent reduction in incomes[8]. If agroterrorists seek to spread this deadly scourge, there could be far-reaching effects. Besides causing severe hardship for poor rural households, collapse of cash crop incomes can be a factor that triggers violent conflict, especially when a country depends heavily on export earnings from that crop. Uganda derives 27 percent of export revenues from coffee (Messer and Cohen, 2004).

However, the export of technological capacity raises security concerns about the potential "dual-use" applications of these technologies to development of biological warfare agents, which may result in innovating countries embargoing the flow of biotechnologies to the developing world due to security concerns. These biotechnologies may include either R&D processes necessary to produce biotechnologies, or adaptable biotechnologies that have legitimate uses. For example the technology necessary to produce virus detection kits for animal or wildlife diseases may be used as an input to the development of biological weapons. Biotechnology innovations have the potential to help alleviate specific problems in the developing world (Huang et al. 2002) and more technologies are in the process of being developed to address country- and region-specific needs (Atanassov *et al.* 2004). Efforts to curtail the biotechnology innovation process in the developing world may limit opportunities for resolving many issues that have proven to be intractable under other technological approaches and will have a direct impact on the livelihoods of people in the developing world. Therefore, from a societal point of view, there is clearly a trade-off between potential gains from the use of biotechnology in the area of biosecurity, amongst many others, and the risks to security in developed nations. This trade-off is a matter of concern, because there is a broad range of technologies can be considered "dual use," and industrialized countries that consider

[8] CABI Biosciences. http://www.cabi-commodities.org/Coffee/Cfp/CfpcpICPA.htm

themselves to be under high risk of terrorist attacks may place restrictions on technology transfer which limit the growth potential of developing countries.

Such technology developments may themselves be controversial and may require biosafety assessments.

ADDRESSING CONSEQUENCES

With regard to managing consequences, building domestic capacity for emergency aid (both food security and public health) and providing international aid in case of agroterrorist attacks may be the most effective form of risk management. However, the recent Tsunami affecting much of Asia shows that monitoring systems, while not preventing disasters, can help minimize the extent of consequences and therefore monitoring may be a prudent allocation of society's resources.

5. CONCLUSIONS

In any risk strategy there are three management options: (1) accept the risk, (2) manage the risk, or (3) avoid the risk. The default position of many developing countries is the acceptance of the risk of agroterrorism with very limited attempts at risk management. The presumption is that the risk is low. However, the previous analysis suggests that, while it is difficult to be clear about specific threats posed to agriculture in developing countries, it is conceivable that some developing countries will find that the general threat environment, vulnerability, and consequences are such that the risk is high. As the analysis has shown, developing countries are in general more vulnerable to agroterrorist attacks than industrialized countries and they have a lower capacity to deal with the consequences.

This does not mean that specific threats will materialize; however, it does mean that the potential exists for specific threats to develop as the security environment changes. Therefore more analysis is needed of specific emerging threats of agroterrorism in developing countries. This will help to identify situations in which spending scarce resources for preventing such threats is justified. There is, however, a problem with waiting for the emergence of such specific threats. When specific intelligence emerges it may be too late to take action on the development of biosecurity infrastructure.

We hope to have shown in this paper that the potential threat of agroterrorism is an additional reason for the international community to invest more resources in activities that are already justified on more general grounds: contributing to the prevention of conflicts and to promoting security, including biosecurity, and assuring food safety and quality in developing countries.

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