UNISDR
The United Nations Office for Disaster Risk Reduction

GAR
Global Assessment Report on Disaster Risk Reduction
2013

Background Paper prepared for the Global Assessment Report on Disaster Risk Reduction 2013

Agriculture and Disaster Risk Reduction

Hill, H. and Pittman, J.

Agriculture and Agri-Food Canada

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

Geneva, Switzerland, 2013

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

Agriculture and Disaster Risk Reduction:

Draft Contributing Paper

Prepared in support of a contributing paper to the UNISDR GAR 13

Please cite this document as:

Hill, H. and Pittman, J. 2012. Agriculture and Disaster Risk Reduction. Draft contributing paper submitted to the UNISDR's GAR 13. Unpublished manuscript. Agriculture and Agri-Food Canada, Saskatoon, Canada.

Lead authors:

Dr. Harvey Hill, Agriculture and Agri-Food Canada
Jeremy Pittman, Pittman Sustainability Consulting

Contributing authors:

Frederick Lebarre
William van der Kamp

Pittman Sustainability Consulting

Jeremy Pittman **July 2012**

Table of Contents

1. Purpose of this Document

The purpose of this document is to serve as a ***Draft Contributing Paper*** to the United Nations Office for Disaster Risk Reduction's Global Assessment Review 2013 (GAR 13) developed to monitor progress towards the objectives in the Hyogo Framework for Action. Pittman Sustainability Consulting has been contracted by Agriculture and Agri-Food Canada (AAFC) to provide support in the development of the contributing paper focused on key and emerging issues related to disaster risk reduction in agricultural systems. This document serves as the second deliverable (the ***Draft Contributing Paper***) of three under the contract (#30004 82542).

2. Introduction

This section will introduce the purpose of the contributing paper and highlight the topics/themes to be covered. It will provide an overview of key concepts that are used throughout the paper and discuss the meta-synthesis approach used to identify key findings from the literature review.

Reducing the risks of agriculture to hazards at all points in food supply/value chain is essential to ensuring the resilience of the global food systems. Food is produced and consumed in an increasingly complex global system, where shocks and surprise in one part of the system can have significant implications in others. This system has the potential to provide food and nutritional security to the entire global population. Unfortunately, this does not typically occur. Agricultural disasters are one type of risk that limits the ability of the global food system to provide complete food and nutritional security; a risk that can lead to issues of national security and internal stability in some vulnerable nations.

Analyzing disaster risk in agricultural value chains is an emerging field of study that can help inform the development of effective disaster risk reduction strategies. Agricultural value chains provide linkages between global food system actors and mechanisms through which food travels from producers to consumers. Risk in these systems has been addressed by the application of a number of risk management strategies. As populations grow there are emerging pressures on agricultural systems that are increasing their vulnerability and exposure to disasters. These pressures will likely require adaptation of agricultural systems to effectively meet the challenges posed.

With this in mind, the objectives of this paper are to:

1. Provide an overview the global food system;
2. Discuss exposure, vulnerability and disaster reduction in the context of agricultural systems and value-chains;
3. Highlight some emerging challenges facing agriculture in the future; and
4. Provide insights into ways of transitioning to a more resilient future.

This paper has the following structure:

1. Section 3 of this paper provides an overview of the global food system,
2. Section 4 discusses disaster risk in agricultural value chains,
3. Section 5 describes some principles of effective disaster risk reduction in agriculture,
4. Section 6 presents some emerging pressures on agricultural systems over the next century,
5. Section 7 discusses some conclusions that can be drawn from this paper,
6. Section 8 contains an illustrative case study of disaster risk reduction, and
7. A thorough description of the linkages between food and national security can be found in Appendix 1.

2.1. Conceptual Framework

Within this paper, disaster risk is conceptualized as a function of hazard, exposure and vulnerability (Equation 1) (ADRC 2005). This commonly applied framework highlights the conceptualization of disasters as not solely dependent on the hazard, but also on broader physical, socioeconomic, political, environmental, etc. processes that contribute to risk by influencing vulnerability and exposure. Natural hazards are the actual biophysical phenomena that can potentially impact human and environmental (or socio-ecological) systems (e.g. earthquake, tsunami) (Birkmann 2006). Exposure refers to the components of a system that have the potential to be directly impacted by the hazard (Birkmann 2006). This typically includes people, critical infrastructure, crops, etc. that are at risk due in part to their location in areas where hazards are likely to occur. Vulnerability is a property of a system that describes its susceptibility to harm as it relates to a broad range of physical, social, economic and environmental processes (Birkmann 2006).

[1] (ADRC 2005)

Although Equation 1 seems relatively tidy, there are some considerations regarding the concepts of exposure and vulnerability. For instance, there are a number of diverging conceptualizations of vulnerability within the literature (Birkmann 2006). Vulnerability is often defined as a function of some or all of the following: sensitivity, adaptive capacity, coping capacity, resilience and, even, exposure. Sensitivity is commonly defined as the occupancy or livelihood characteristics of a system that make it susceptive to the impacts and consequences of hazard exposure (Smit and Wandel 2006). Those who conceptualize the vulnerability function as including exposure do so by linking exposure with sensitivity, due to the obvious interactions between the two (Smit and Wandel 2006). Adaptive and coping capacities are defined as the abilities of the system to deal with the consequences of disasters, with coping usually referring to capacity for managing through the disaster and adaptive to capacity for implementing long-term changes that reduce vulnerabilities or exposures (Smit and Wandel 2006).

Another consideration is how to conceptualize resilience and effectively integrate it within the concepts of disaster risk and disaster reduction. This can be done through linking resilience with the concept of vulnerability. Although there is still some debate over how to effectively make these linkages, there seems to be a number of emerging principles or guidance for how to do this properly. The first is that vulnerability and resilience are in some ways opposites, meaning that a reduction in vulnerability results in improved resilience and an increase in vulnerability results in less resilience. The second is that it appears as though the concept of resilience has gone beyond its original focus on the capacity to absorb or resist shocks and has been expanded to include the ability of the system to learn and adapt when dealing with shocks in order to maintain major functions and services. This definition of resilience provides, in addition to linkages with vulnerability, linkages with the concepts of both coping and adaptive capacity (Birkmann 2006).

Clearly many of these concepts are interrelated and they are typically not mutually exclusive. Within this paper, an integrative view of vulnerability is taken, where the linkages between and the importance of considering sensitivity, adaptive and coping capacities and resilience in determining or assessing vulnerability (and, as such, disaster risk) are acknowledged. This conceptualization of vulnerability treats exposure separately. Although the relationship between vulnerability and exposure is acknowledged, exposure is used here to refer to the components of the system physically located within the path of a hazard (Birkmann 2006).

2.2. Methods and Approach

This paper presents the findings of a limited meta-synthesis of key publications related to disaster risk reduction (DRR) and agriculture aimed at identifying the main considerations for this field moving forward. The meta-synthesis focuses on peer-reviewed publications since 2010, however older pieces of seminal literature were also included to illustrate particular topics or to help strengthen particular points. Grey literature (e.g. policy documents or strategic plans) has also been synthesized and referenced as relevant.

3. Overview of the Global Food System

This section will provide background on the global food system and the role of agricultural systems within it and across multiple scales. The linkages between agricultural system vulnerability and food security will be highlighted, including the role and relationship of national security and internal stability. The role of value and supply chains will be discussed, as well as the interconnections between diverse issues that contribute to food insecurity. Also, the influence of the numerous regulatory frameworks in which agricultural systems operate will be discussed (e.g. environmental, health, socio-political). Taking a systems approach, a key message of this section will be that local disasters can have global impacts, and the intricacies and mechanisms of multi-scale connectivity will be discussed. The negative consequences of multi-scale connectivity can conversely reduce at the local scale by increasing accessibility to food and revenue options. This section will help provide the context and foundation for arguments within subsequent sections.

The global food system is comprised of a number of interrelated and interdependent components and sub-systems, which includes the entire network of value and supply chains. It is the means by which agricultural commodity flows to the consumer, the processes that allow the value-signal to be transmitted from the consumer to the producer, the regulations that influence food production/consumption, the relationships that govern interactions within the food network, all critical built and social infrastructure, the biophysical (i.e. soils, water, climate) attributes of environments that food production relies upon, the socio-cultural conditions that are present throughout the system and many other emerging actors/components as the global food system changes and responds to new conditions. In addition, the global food system is embedded within global economic and environmental systems, meaning it is linked to other key sector systems through interdependencies or interrelated components (e.g. energy, biodiversity) and could potentially be affected by changes in these other systems as well as internal changes. As highlighted here, the global food system is extremely complex and dynamic. For the purposes of this paper, we will focus on the global food system as the agricultural producers, input suppliers, distributers, processors, retailers, consumers, natural resources, infrastructure and technology that function to (ideally) feed the global population or malfunction leading to famine or food insecurity. The agricultural value chain, as it operates within the global food system, will be used in our discussion of disaster risk (see Section 4).

Although the influence of the globalized food system is far reaching, the nature of connectivity within the system differs from place to place. Some regions are suppliers of food and others consumers; some rely heavily on imports to meet food demand and others have higher proportions supplied by local production; and some are more sensitive to changes in international food commodity pricing than others. The point here is that, when speaking of disaster risk, it is important to have an understanding of how a particular place of interest is connected within the global food system to better understand how this place is vulnerable to local and global risks.

3.1. Regulation of the Global Food System

The global food system is regulated by a number of formal and informal institutions operating at various scales. Formal regulation typically occurs through a number of state policies and legislation, which have, in some cases, been influenced by international food standards or pressures. In addition, the private or NGO sectors also have a role in food system regulation through setting internal standards or influencing the state through lobbying or acting as an interest group.

There are a number of reasons why regulations have been introduced. In a broad sense, many of these reasons are related to one or more of the following: health safety, environmental risk, consumer protection or agricultural industry protection. Health safety is probably one of the most dominant frameworks regulating the global food system. These regulations influence everything from the sanitary handling/storage of food to controlling pesticide and contaminant concentrations within foods. Environmental risks are also regulated in the global food system. Commonly, this is by regulating, for example, the types of pesticides and herbicides that can be applied during production. In addition to environmental risks, these regulations are also typically designed to address health safety concerns. Consumer protection regulations, such as food labelling requirements, are related to health safety as well (e.g. allergen alerts), but also help consumers make informed decisions about their food purchases. Another type of regulation, phytosanitary, is designed to prevent the transmission of potentially harmful pests, diseases and biomaterials to crops across national boundaries and to protect national agricultural industries and the environment, sometimes by restricting trade. As is apparent, although regulations may be introduced for a number of distinct reasons, typically they are designed to address multiple risks and issues in practice if well designed. Alternatively poorly designed regulations can increase risk by reducing options, increasing costs and reducing productivity.

In some cases, food regulations, particularly phytosanitary regulations, have contributed to trade barriers. These trade barriers are most often felt by developing countries, where limited resources, expertise and participation in developing and meeting stringent regulations constrains the ability of these economies to access foreign, highly regulated markets (Beghin and Bureau 2001; Gebrehiwet et al. 2007). This brings to question the role of such barriers in contributing to disaster risk by preventing the growth and development of resilient agriculture industries in some developing countries.

As mentioned earlier, although regulation is typically governed at the national level, there have been efforts in the past to harmonize food standards internationally. The Codex Alimentarius, established in 1965 by the Food and Agriculture Organization (FAO) of the United Nations and the World Health Organization (WHO), was developed to meet this end and contains standards, guidelines and codes of practice regarding the safe, healthy and equitable international trade of food. Although not a regulation in itself, the Codex Alimentarius has often influenced many national policies and legislation regarding food regulation and serves as a long-standing and important development in the pursuit of consistency in global food system regulation (FAO/WHO 2006).

In addition to formal rules and institutions governing the global food system, there are also informal rules in use that regulate agriculture at multiple levels. These informal institutions are typically related to local customs, conventions, practices and cultures. These informal institutions work with formal institutions to manage risk in the food system, in part by determining what levels of risk are acceptable in communities. For instance, local attitudes and practice towards food handling and preservation influence the quantity of food stocks available, which in turn influences food security and sensitivity to shocks in the agri-food system.

3.2. Food and Nutritional Security

In an ideal world, the global food system would function to provide food and nutritional security to everyone. Unfortunately, however, this is typically not the case. Food and nutritional security, meaning adequate access to healthy food supplies, varies over time and from place to place, as well as within populations. Food security is commonly related to food price, with access to sufficient income to purchase food a major determinant of food security.

Global food system dynamics can cause food security crises. One of the most recent occurred in 2008, when food prices soared resulting in significant impacts to vulnerable populations. This food crisis was the result of numerous pressures on the global food system working in tandem to cause the system to malfunction. Experts have identified a number of cumulating pressures – underinvestment in the agriculture sector, water scarcity, slowing rates of crop yield growth, lower levels of grain reserves and crop failures, population growth, changes in food consumption, oil prices and biofuel production – all of which play a role in food insecurity (Madramootoo and Feyles 2012).

3.3. Linkages to National Security and Internal Stability

Other important considerations are the linkages between food and national security. It is hypothesized by Lebarre (2012) – Appendix 1 in this document – that food security influences national security by affecting internal stability and fostering unrest among populations vulnerable to food insecurity. Labarre's study is provided in Appendix 1.

3.4. From Local Agricultural Disasters to Global Food System Impacts

The systems approach to global food highlights the linkages between impacts at a number of scales and it becomes apparent that local agricultural disasters can have global impacts to the food system, resulting in food security and other issues in distant parts of the globe. An obvious example is an increase in international commodity prices that can result from major production losses when a disaster strikes an agricultural system in some part of the globe. In addition to implications for local livelihoods and food security, this can impact the supply of food in distant regions or limit access to food by influencing food prices. These global impacts can also be felt for other disturbances along value chains, such as destruction of key shipping ports, food handling/ processing facilities and retail networks. These linkages across a number of scales highlight the importance of agricultural disaster risk reduction, whether at local or international scales, for the globe.

An example of the linkages between local disasters and global impacts may be looming. Drought conditions are currently impacting the United States agricultural industry in terms of maize and soybean production. These production losses could result in significant increases in commodity prices leading to food insecurity in vulnerable populations. Price increases are amplified by a number of factors, including competition for biomass between food and fuel production. Urgent measures are required to prevent a global crisis (Fan 2012).

4. Disaster Risk in Agricultural Value Chains

This section will discuss vulnerability in agricultural value chains. It will take a broad approach and comment on the characteristics of agricultural value chains that make them exposed, vulnerable and resilient to disaster risk. It will pay particular attention to differential or distributional aspects of vulnerability within agricultural systems and discuss how multiple exposures compound to influence the severity of impacts. In addition, externalities from agriculture will be discussed and their influence on disaster risk explored.

Agricultural value chains are integral components of the global food system. As such, the vulnerability and exposure of agricultural systems to hazards can have far reaching and cascading effects for global food security. As noted earlier, the discussion of disaster risk in this paper is framed around the agricultural value chain. That being said, however, the units of analysis are the components of the agricultural value chain, to better illustrate the propagation and distribution of disaster risk throughout the chain (Figure 4.1-1). For the purposes of this paper, agricultural value chains are conceptualized as having the following components: input suppliers (i.e. groups or businesses that supply producers with fertilizers, chemicals, seeds and other inputs), producers (i.e. the individuals or businesses that involved with primary agricultural production), intermediaries (i.e. commodity buyers or brokers who act as middle-people), processors (i.e. business that are involved with the secondary production of food goods from commodities), marketers (i.e. businesses that aim to sell the food goods) and consumers (i.e. those that eat the food). Implicit within the value chain are the relationships and social capital that exist between the components (GTZ 2008).

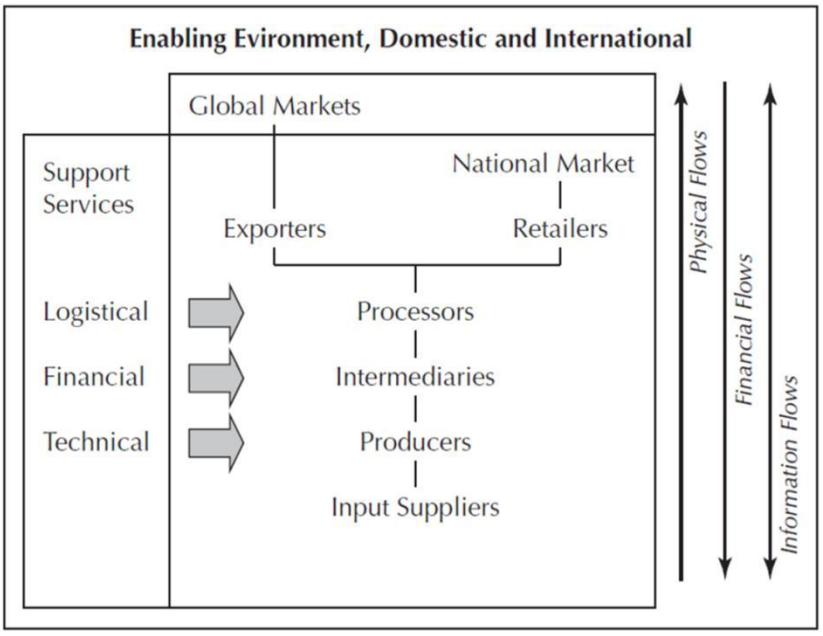


Figure 4.1-1 Agricultural value chain (from Jaffee et al. 2010).

Value chains are driven by economics and people participate in value chains in order to meet their economic needs. Within value chains, meeting these economic needs is facilitated by effective social capital and social networks, which improve connectivity within and between chains. Well-functioning value chains allow participants to satisfy their basic human needs, and it can be argued that value chains emerge for this purpose.

4.1. Exposure, Vulnerability and Resilience

To reiterate, vulnerability refers to the susceptibility to harm of a system as it relates to a broad range of physical, social, economic and environmental processes (Birkmann 2006). Exposure refers to the components of a system that have the potential to be impacted by the hazard (Birkmann 2006). Resilience refers to the ability of the system to absorb shocks, learn and adapt to changing or adverse conditions (Birkmann 2006). Agricultural value chains are vulnerable and exposed to hazards due to the disaster risk of each component of a value chain. Value chains operate as economic systems, and risks at certain nodes or of certain components have implications for other nodes and components. Resilience is a property of the value chain as a whole, and is related to the vulnerability of each value chain component. Table 4-1 provides an overview of disaster risk and examples of resilience in agricultural value chains.

The hazard-independent example of disaster risk presented in Table 4-1 highlights the propagation of risk throughout the system. This is based on a hypothetical situation and assumes all components are serving their function prior to a disaster. As is apparent, the vulnerabilities in the table for each component are really different ways of describing similar impacts, each viewed from the perspective of the component in question. Another notable similarity across the value chain is the dependence of exposure largely on the location of critical infrastructure. Critical infrastructure often provides the physical linkages between value chain components and is an explicit element of the chain, which is often exposed to hazards. Agricultural value chains are typically at risk of impacts to communications, drought/flood protection, electrical and transportation infrastructure (Oh et al. 2012). Resilience to disaster risk is provided by a number of elements. A subset of these elements is explored in greater detail in Section 5.

Disaster risk may also result in a disintegration or lack of agricultural value chains. If excessive disaster risk is perceived or apparent, some components of a value chain may choose to disconnect, leaving other components potentially more vulnerable. For example, in hazard-prone and highly vulnerable regions, input suppliers may be unwilling to take the risk of providing inputs to producers on credit. Consequently, these producers are less likely to increase their productivity and potentially decrease their vulnerability by using fertilizers or growing improved varieties. Similarly, brokers or buyers may neglect regions where crop failures are common, reducing the linkages between producers in these regions and markets and potentially limiting their earning potential.

It should be noted here, that although agricultural value chains are becoming better recognized as the appropriate system to investigate when studying disaster risk, most literature to date focuses

on disaster risk of only the producer and most studies are framed around risks to production. Understanding disaster risk for all components of an agricultural value chain can improve the design and development of disaster risk reduction strategies. For example, see the case study in Section 8.

Table 4-1. Overview of disaster risk in agricultural value chains.

Value Chain Component	**Disaster Risk**		
	Exposure	***Vulnerability***	***Resilience****
Input Suppliers	Critical transportation or storage infrastructure in exposed locations.	Reduced demand for inputs. Reduced capacity for producers to pay for inputs provided on credit.	Presence of early warning systems, including monitoring systems. Networks for information provision and dissemination. Presence of decision support systems. Policies enabling markets and market access. Well-designed risk sharing/transfer programs. Flexible and diversified livelihoods. Sound financial management and access to credit. Appropriate and efficient resource use. Good governance. Research, technology and innovation. Effective social capital and social networks.
Producers	Land, crops, infrastructure, equipment, households, etc. in exposed locations.	Decreased production. Reduced quality of production. Asset losses and liquidity. Limited technology. Reduced access to markets. Livelihood implications. Inability to pay debts.	
Intermediaries	Critical transportation infrastructure in exposed locations.	Increased transaction costs. Reduced quality of commodity. Reduced volumes of commodity.	
Processors	Critical transportation or storage/preservation infrastructure in exposed locations.	Reduced quality of commodity. Reduced volumes of commodity.	
Marketers	Critical transportation or storage/preservation infrastructure in exposed locations.	Loss of market access. Reduced quality of commodity.	
Consumers	Critical transportation or storage/preservation infrastructure or homes in exposed locations.	Increased food prices. Decreased food quality. Inability to access food supplies. Food and nutritional insecurity. Loss of livelihood/employment.	

*Note: this list is not exhaustive.

4.2. Distribution of Vulnerability

Vulnerabilities are not evenly distributed throughout regions or countries. Within any region or country, there are differential vulnerabilities in and between groups. The same is true for agricultural value chains. For example, not all producers in the same region growing similar crops have the same vulnerability, exposure or linkages with value chains. Often, vulnerability and exposure vary by socioeconomic status and a number of other conditions existing within producer communities.

Bannerjee (2010) presents an interesting case from Bangladesh that highlights differential vulnerability, most notably through differences in adaptive or coping capacity between producer groups with differential access to resources, such as agricultural inputs and improved crop varieties. This case focuses on rice producers in a region of Bangladesh prone to freshwater flooding. The floods can act as a creative destructive mechanism for rice production, having detrimental impacts when they occur but providing higher yields in subsequent crop seasons, as the floods act as a natural source of irrigation (Bannerjee 2010).

Yield benefits following floods (and in general) are greater when growing *boro* rice than when growing the local *aman* variety. Despite this, not all producers in the region have adopted *boro* varieties. *Boro* rice cultivation is intensive, requiring pesticides, fertilizers and irrigation. Poorer farmers are typically unable to afford these inputs or have difficulty assuming the additional financial risks associated with using agricultural inputs and, as such, are unable to take advantage of the benefits *boro* production can afford. This issue is amplified in the case of freshwater flooding, where the ability to plant a *boro* crop can allow producers to recover significantly better than when relying solely on *aman*. In this case, these poorer farmers are more vulnerable than their wealthier peers, even though they have similar exposures (Figure 4.2-1) (Bannerjee 2010).

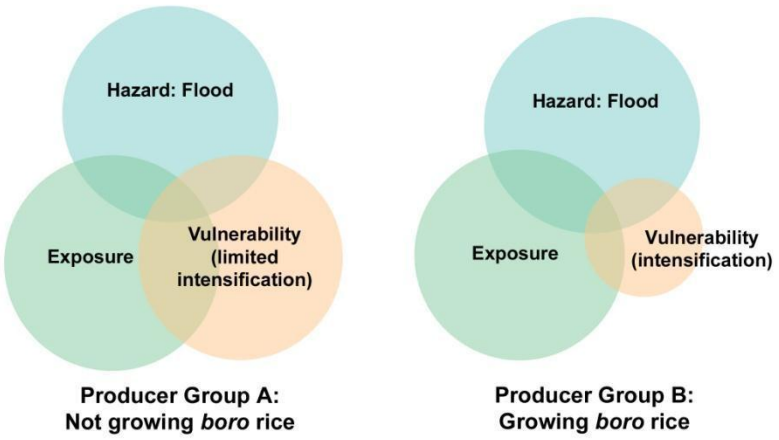


Figure 4.2-1. Differential vulnerability between producer groups (Bannerjee 2010).

4.3. Multiple Exposures

The concept of multiple exposures is useful when discussing agriculture and disaster risk reduction. Multiple exposures refer to the compounding effects of a number of types of risks to which a system may be exposed. In agriculture, other types of risks important to consider when discussing disaster risk are production, market, institutional, environmental, financial and health, to name a few (Belliveau et al. 2006; Jaffee et al. 2010; Mertz et al. 2012).

Multiple exposures can have an amplifying effect on certain types of risk. If a disaster occurs during a time when access to markets is limited, for example, the system is likely to be more vulnerable to the disaster than if market access was secure. This is related to the limited capacity inherent in a system to deal with multiple risks and exposure to different types of risk simultaneously (Belliveau et al. 2006; Habbiba et al. 2012; Chhotray and Few 2012).

Also, it is important to note that actors within a system typically manage trade-offs between when making decisions about risk management. For example, producers may actually choose to adapt in ways that increase their climate risk if they are able to reduce their market risks in doing so (Belliveau et al. 2006). Adaptation and risk management usually occur in ways that are influenced by multiple exposures, with most strategies undertaken to maintain the profitability of operations in light of multiple risks (Hadarits et al. 2010). With this in mind, it is also likely that strategic reduction of certain risks can lead to disproportionate increases in resilience to multiple risks by removing some of the key limitations on adaptive and coping capacity.

4.4. Externalities

There are a number of externalities associated with agricultural production, typically in the form of environment al or human health risks. Although agriculture can play a role in creating these risks, it also has the potential to be affected by them, contributing to the multiple exposures of agricultural systems. To help focus the argument, externalities discussed here include nutrient loss and pesticide contamination. There are other important externalities (e.g. biodiversity loss, greenhouse gas emissions) that are not discussed here.

Nutrient loss

Nutrient loss, typically of nitrogen (N) and phosphorous (P), is one of the major externalities from agriculture, resulting mainly from fertilizer application. Nutrients lost to ecosystems can cause imbalances in ecosystem dynamics, resulting in the domination of some species at the cost of others. Roughly half of the nutrients applied as fertilizers are not used in production, but rather escape into the environment (Goulding 2004). Major implications of this include eutrophication of water bodies, atmospheric pollution, greenhouse gas emission, acidification and human health risks. These externalities occur in the developed and developing world alike, and result from both artificial and organic fertilizers (Peoples 2004; Sue and Yee 2011).

Nitrogen can be lost from a field in the form of nitrate (NO_3), by dissolving into excess water in the soil and leaching away with the draining water. Phosphorous is unlikely to leach away, but

can under certain circumstances (e.g. soils contain high organic matter or are over-fertilized) (Sims et al. 1998; Smil 2000). If fertilizer is applied to the topsoil, both nutrients can simply run off the top along with any water flow. In each case the molecules dissolve into a body of water in the environment, greatly increasing nutrient input into water ecosystems. Usually, phosphorous is washed downstream, either until it reaches the ocean or until it is trapped in freshwater sediments. Nitrogen, being soluble, tends to be used up before it reaches the ocean. As a result, nitrogen is often the key limiting nutrient in coastal marine biomes, and phosphorous is often the limiting nutrient in freshwater biomes (Adiscott 2005). When the limiting nutrient becomes more abundant, organic matter, usually algae, builds up in response. The resulting algal blooms can lead to water toxicity, less aesthetic value, and losses of important species (such as fishery stocks). Massive 'dead zones' can result from the associated loss of oxygen and light. One study calculated the economic cost of eutrophication to be $2.2 billion per year in U.S. freshwater systems alone (Dodds et al. 2008). This cost is projected to increase into the future, though the right policies may mitigate this. In addition, nitrates may also be linked with some forms of cancer (Anjana and Muhamed 2006; Zeman et al. 2011).

Nitrogen can also be lost to the atmosphere from the surface as ammonia (NH_3) or from the process of denitrification by soil microbes (as N_2, N_2O, NO or NO_2). These atmospheric losses contribute to acidification and greenhouse gas emissions (Peoples 2004).

Pesticide contamination

Pesticides are lost from farms in much the same way as nutrients. They can leach through the ground, run off or escape into the atmosphere. Some of their effects are well-known; since a large proportion of pesticides make it into the environment (over 90% of wells and streams are frequently polluted in the USA according to Gilliom 2006). Pesticides can have large detrimental effects, particularly on aquatic and avian species (Newton 2004). Pesticide residues are passed along the food chain, and inevitably reach humans as well.

There are many impacts from pesticide use that are poorly understood. In 2012, it was discovered that some insecticides are likely an important cause of the widespread collapse of bee colonies throughout North America and Europe (Henry et al. 2012; Whitehorn et al. 2012). Neonicotinoid insecticides, rather than killing bees directly, seem to disorient foraging honey bees so that they cannot find their hives, causing them to die and thus weakening the colony (Henry et al. 2012). Another study found that queen bee production declined 85%, having negative consequences for colony growth rates, due to application of the same pesticide (Whitehorn et al. 2012). These unintended consequences of pesticide use present new challenges to agricultural sustainability.

In general, however, pesticide regulation and research in the past few decades has cut down use of some of the most problematic pesticides (such as DDT) , as well as significantly reduced the application rates necessary to protect fields from pests (Osteen and Padgitt 2002; Gilliom 2006).

Concentrations of pesticide have generally been kept within human-health benchmarks in the US (Osteen and Padgitt 2002). Developing countries often have less effective pesticide regulations (Ecobichon 2001; Shetty and Sabitha 2009; Wilson and Tisdell 2001). The ‘circle of poison’, however, referring to the trap of producers in loosely-regulated countries using dangerous pesticides on food which is then sold to consumers in strictly-regulated, no longer is of major concern (Galt 2008). This is a sign that policies are improving, and although pesticide use is still increasing, its growth is slowing (Rana 2010).

5. Principles of Enhancing Agricultural Resilience to Disasters

This section aims to identify the strategies that various actors with agricultural and global food systems use to address or reduce their disaster risk. A broad approach will be taken to characterize adaptive strategies throughout various types of agriculture systems throughout the globe.

Disaster risk reduction strategies can be implemented at a number of levels. The most common levels used for analyzing these strategies in agriculture include on-farm or household, community, regional, provincial, national and international. Typically, there are linkages between strategies implemented at different levels and they can either work towards or against each other in achieving goals. Also, actors at different levels, although all working towards resilience in agricultural systems, may have slightly different motivations or beliefs around what this means and how to most effectively reduce disaster risk.

The drivers or motivations for disaster risk reduction in agriculture are diverse and typically related to the broader context in which risk management takes place (Jewitt and Baker 2012). In a recent paper, Eiser et al. (2012) provide an overview of the current scientific understanding of how interpret and respond to risk. They find that there are a number of theories regarding the linkages between risk interpretation and action. The first is heuristics or basically the theory that actors will interpret risk and make decisions largely based on their prior experiences. For example, people who have been negatively impacted by a hazard in the past are more likely to undertake measures to reduce their risk to this hazard. Also, in reducing their risk, they are more likely to make decisions based, in part, on their past experience. This point relates to the next element to consider, which is learning and how people make decisions from experience. Learning is dynamic and can occur through a number of mechanisms (e.g. individually, collectively). Trust in others is another important point to consider. How individuals value or perceive risk information is partially dependent on the degree of trust they have for the source of the information (Eiser et al. 2012).

All of these factors influence how actors reduce their disaster risk. With this in mind, a number of disaster risk reduction strategies that have been developed in the agriculture sector are discussed below. These strategies have been the result of ongoing risk interpretation and action from actors within the agricultural sector. They are presented here to illustrate some fundamental principles of disaster risk reduction in agriculture, not to act as a recipe book for universal agricultural disaster risk reduction. Disaster risk reduction needs to be place-based, but could be guided by the principles highlighted below.

5.1. Diversification

Diversification is an important part of disaster risk reduction in agriculture. Diversification typically refers to introducing new crops and livestock to agricultural systems. This approach reduces vulnerability by increasing the commodity options for a producer. This in turn allows a

producer to improve their flexibility and manage uncertainties (Hallegatte 2009; Sun et al. 2012). Diversification is also a means to avoid being locked into negative consequences from wrong decisions.

Hallegatte (2009) has developed a number of principles for managing uncertainty that are useful when discuss agricultural diversification. Diversification is most beneficial in terms of reducing risk when it promotes the selection of 'no-regrets' strategies (Hallegatte 2009). This typically refers to strategies that produce some benefit regardless of the direction or state of external conditions (e.g. climate, weather, market) (Hallegatte 2009). Also, reversible and flexible options for diversification will allow producers to more easily modify practices and respond to risks more effectively (Hallegatte 2009). This includes things like the ability to change cropping or livestock decisions quickly with minimal consequences, or the ability to access different markets. Overall, diversification can provide general resilience to agricultural systems.

Typically, effective diversification is supported by broad institutional measures as well. This includes market development, education and awareness and decision support systems that can help producers adjust to diversified operations. Marchildon et al. (2008) provide a case study of institutional adaptation, more specifically the creation of the Prairie Farm Rehabilitation Administration (PFRA), following droughts on the Canadian Prairies in the 1920s and 1930s. This research shows how many PFRA programs, especially those related to irrigation development, helped producers adapt to drought by supporting their intensification and diversification (Marchildon et al. 2008).

5.2. Risk Transfer and Sharing

Risk transfer and sharing have been important parts of disaster risk reduction in agricultural systems in many parts of the globe. This form of disaster risk reduction involves, as its name suggests, shifting or distributing risk between or across different actors within an agricultural system. Although implemented in different ways, the mechanisms through which risk is transferred and shared in agriculture typically include insurance, subsidies and relief, among others. One common arrangement for risk transfer and sharing is when the state influences the distribution of risk by providing some form of programming to increase the public share of the risk while decreasing the risk held by some private actor, such as an agricultural producer. Other common arrangements can involve direct private-private or public-private partnerships involving state and non-state actors.

A common theme emerging from the literature is that risk transfer and sharing programs must take into account global pressures, signals and conditions in the food system but be implemented and relevant locally. Taking a place-based approach can help improve the efficacy of programs at the local level. The benefits of the place-based approach are particularly highlighted in the literature when discussing the differences in implementing risk transfer and sharing programs in developing and developed world contexts. Many of the risk transfer and sharing programs that have been successful in the developed world are not effective in the developing world. For

instance, government subsidized crop insurance programs (e.g. such as that in Canada) have been a useful tool in reducing disaster risk in developed country agricultural systems, and can be useful in some developing countries (Wang et al. 2011). In developing countries, however, this sort of program typically does not work for a number of reasons, most notably the inability of developing country governments to consistently commit the large budgets these programs require (Ibarra and Skees 2007; Hazell and Hess 2010; Mahul and Stutley 2010; Perumal 2011).

In developing countries, an emerging type of insurance program for disaster risk reduction is known as index-based insurance. Index-based insurance programs are typically designed to provide payouts to producers based on critical thresholds of weather-related indices. A recent review by Hazell and Hess (2010) found these types of insurance programs can provide equitable access to agricultural business risk management programming and can provide a safety net for a broad range of producer-types (e.g. large- and small-scale operators). In some cases for disaster risk reduction, index-based insurance programs can be favourable because it allows developing country governments to shift financial burdens associated with response and recovery to the international insurance market (Hazell and Hess 2010).

Although promising, index-based insurance programs are not without their challenges. Often, obtaining effective monitoring, quality assurance and control and interpretation into appropriate indices can be costly barriers to overcome. This is where government could have a role in developing and maintaining weather observation networks and supporting agro-meteorological research, while the private sector provides the insurance. Also, an ongoing challenge in highly variable environments/climates are extremely localized hazards that are typically quite difficult and costly to monitor, introducing the risk that program payouts may not be received by those in need due to limitations of monitoring networks (Hazell and Hess 2010).

Subsidies have been an alternative form of agricultural risk sharing. Dorward and Chirwa (2011) review the fertilizer subsidies in Malawi over the past decade and find promising results. Malawi has heavily subsidized fertilizer nationwide since 2005, aiming to increasing agricultural intensification. As a result of the program, national maize production and productivity per hectare have increased, positively effecting food availability and security. In addition, Malawi has experienced broad economic growth in relation to the program, resulting in higher real wages and poverty reduction. These successes were partially due to the management of the program, as government and stakeholder groups were consistently involved in formal and informal processes for program review. This led to learning and adjustment in light of dynamic economic and political pressures, which highlights the importance of good governance (Dorward and Chirwa 2011).

There were some negative implications of the program as well, however. National subsidies such as these typically contribute to higher international fertilizer prices, potentially affecting access for producers in unsubsidized nations. In addition, some of the poorest and most vulnerable

Malawian producers were still affected by food security issues, as they were unable to take full advantage of the program (Dorward and Chirwa 2011).

Dorward and Chirwa (2011) highlight a number of key considerations for applying this type of subsidy in other regions. Carefully considering the scale and focus of the program is important, as well as targeting and rationing to ensure resources are most effectively applied. Also, ensuring that the value chain can adequately handle the logistics associated with increased demand for inputs prior to implementing the program is essential. Other considerations include the need for complementary policies/programs and political commitment. And finally, the ability to manage the program flexibly in light of emerging concerns is important, highlighting the need for effective and ongoing monitoring, evaluation and review (Dorward and Chirwa 2011).

Also important to consider when designing subsidy programs are unintended consequences. When dealing with drought, Hazell and Hess (2010) conclude that feed subsidies for livestock producers can be somewhat beneficial, but potentially have a number of negative consequences. During drought, feed subsidies can help maintain livestock numbers, which is beneficial to a point, but can facilitate overuse of the land in light of looming drought conditions and reduce the ability of the land to recover (Hazell and Hess 2010). Feed subsidies also tend to encourage feed cultivation on marginal agricultural lands and range lands, increasing exposure to the drought hazard and reducing rangeland availability (Hazell and Hess 2010). Also, subsidies where payouts are based on farm size can be more beneficial to large producers than small, leading to reduced capacity of small producers to manage risks (Hazell and Hess 2010). Poorly designed subsidy programs can also lead to issues of food security (Jansen and Rukovo 1992).

5.3. Sustainable Intensification

Agricultural intensification has played a major part in increasing productivity over the last century. Intensification has occurred through a number of ways and has involved the following innovations: crop improvements, agroforestry, soil conservation, conservation agriculture, integrated pest management, horticulture, livestock and fodder crops and aquaculture (Keys and McConnell 2005; Pretty et al. 2011). Typically in the past, intensification has been most successful when accompanied by associated institutional capacity, in the way of policies for technology transfer and risk management (Keys and McConnell 2005; Pretty et al. 2011), and corresponding market signals that favor intensification (Richards et al. 2012; van Vliet et al. 2012).

Intensification helps reduce disaster risk in the global food system by increasing productivity and thus food supplies available in the case of a disaster. In some cases, there are also disaster risk reduction benefits for producers. The example from Bangladesh (see Section 4.2) shows how more intensified operations can reduce their flood risk (Bannerjee 2010). Often when intensifying operations, there is a trade-off in risk, meaning the actors assume more risk in some cases (e.g. financial risks associated with purchases inputs) to reduce risks in other cases (e.g. production risks). For example, the irrigation equipment of intensive cropping operations in

Saskatchewan, Canada is a major investment and can be highly exposed to extreme wind events (Pittman et al. 2011). This risk is commonly managed through a combination of insurance and management practice (e.g. filling the infrastructure with water to increase its weight when extreme wind is forecast), and is a trade-off for the management of drought risk, a far more serious disaster risk in the region (Pittman et al. 2011).

Sustainable intensification in the future will be required to meet future demands on agriculture. Pretty et al. (2011) recently analyzed a number of case studies to distill some key points to consider when advancing intensification in the future. They find that developing agronomic practices and agroecological management strategies based on input from scientists and producers is important, as well as engaging the private sector. Developing social capital and trust between individuals and agencies is also beneficial to help enable and mobilize collective action. In addition, there are a number of novel extension practices, such as farmer field schools and modern communication practices (e.g. ICTs), that will be important. Also, ensuring microfinance and technology transfer opportunities are broadly accessible will be beneficial. And the final requirement for sustainable intensification is ensuring public sector support for agriculture is adequate (Pretty et al. 2011).

5.4. Resource-use Efficiency

Efficient resource-use helps reduce vulnerability to multiple hazards in a number of contexts. In a general sense, increased efficiency typically leads to reduced vulnerability through decreased dependence on critical resources (e.g. fertilizer, water) and more sustainable resource management. Water use efficiency when dealing with drought for irrigation agriculture is an obvious example. Drought sensitivity and vulnerability can be reduced to a point through improving efficiencies in the way water is applied in agriculture. This can involve reducing water losses in delivery systems (e.g. lining canals or converting canals to pipes) or changing the way water is distributed over the crop (e.g. low-pressure systems, drip) to help target the water where it is used most effectively (Pittman et al. 2011). Sun et al. (2012) find that some producers in China autonomously adopt water efficient practices in response to drought that contribute to their resilience in the face of recurring drought.

Resource use efficiency also has many co-benefits in addition to disaster risk reduction. In the case of phosphorous use, efficiency can help manage externalities (see Section 4.4) and emerging pressures (see Section 6.2). By limiting phosphorous loss and ineffective use, producers can help control eutrophication and help ensure fertilizer supplies remain adequate to support growing global populations.

5.5. Market Governance

The governance of markets, especially at the local scale, is increasingly involving new actors. Access to value chains for small-scale agricultural producers, as related to market governance, can contribute significantly to their abilities to manage disaster risks by improving access to resources used in coping or adapting. These small producers are often competing with changing

food system dynamics, including the development of large-scale marketers (e.g. supermarket chains) and changing consumer demands. Many of these changes have occurred through public investment, market liberalization, urbanization and rising incomes in developing countries (Reardon et al. 2009).

There is evidence of both inclusion and exclusion of small producers in the emerging value chains. Exclusion is typically related to the inability of small producers to guarantee quality and quantity of production, which is often required when dealing with large-scale marketers who require a certain scale and consistency. Also, small producers with fewer non-land assets tend to have less ability to connect effectively with value chains (Reardon et al. 2009).

Inclusion is usually related to a number of innovative arrangements by producers and other value chain actors. Multi-stakeholder platforms for market governance have emerged as a way of addressing these problems in potato-based value chains in Bolivia, Peru and Ecuador. Two main types of these platforms seem to have emerged. The first functions to improve linkages between traders, processors, markets, producer associations and the research and development community, aiming to develop new market opportunities. The second functions to ensure quantity and quality of production in discrete geographic areas by improving collaboration between producers and services providers (Thiele et al. 2011).

Although successful in improving market governance and access to value chains, the long-term sustainability of these projects may be in question. Many of these emerging platforms have been initially funded through government subsidies. For continued function and scaling-up, alternative funding schemes may be required that remove the financial burden from the state. Thiele et al. (2011) suggest the possibility of developing a levy that could be used to fund these platforms, although adequate legislation in support of such as system would need to be ensured.

5.6. Research and Development

Another key principle of disaster risk reduction is the need for continued research and development. The Consultative Group on International Agricultural Research (CGIAR) has played a key role in facilitating effective agricultural research for poverty reduction over the last few decades, leading to reduced vulnerability to disasters. CGIAR has contributed significantly to the genetic improvement of agricultural crops, including varieties that are more stress resistant than their predecessors, reducing sensitivity to a number of hazards (e.g. drought). CGIAR research has also lead to reduced stresses on natural resources, protecting soils and water supplies while maintaining production in many regions of the developing world. Also, socioeconomic research undertaken by CGIAR (e.g. market liberalization, education and awareness programming) has significantly influenced policy in many countries and reduced the vulnerability of producers. Part of the success of CGIAR has been its collaborative approach to research projects and its ability to focus on fundamental concerns (e.g. gender), making progress towards more resilient agricultural systems throughout the developing world (CGIAR 2011).

6. Emerging Pressures

This section provides an overview of a number of emerging pressures that are expected on agricultural systems in the near future. There will be a number of pressures explored, including global population increase, fertilizer availability and access, urbanization and urban bias, land and water resource competition and global environmental change and climate change.

There are a number of emerging pressures on agricultural systems that will influence vulnerability and exposure to disasters. Any future measures undertaken to reduce the disaster risk of agricultural will need to adequately address emerging pressures in order to be effective. In addition, proactive management of emerging pressures can help reduce vulnerabilities *a priori* and mitigate the compounding effects of multiple exposures. Although there is never certainty in what the future may bring, this section provides an overview of some potentially emergent pressures on agricultural systems over the next century and briefly discusses potential implications for disaster vulnerability and exposure. This is not an exhaustive list of all possible pressures on agricultural systems over the next century, but an overview of some dominant emerging pressures as characterized by current literature on the subject.

6.1. Global Population Increase

The expected increase in global population over the next century will put pressure on existing agriculture and food systems. By 2050, it is estimated that global population will surpass nine billion people, an increase of approximately two billion people over current global population estimates. The majority of these new individuals are predicted to reside in developing countries with increases in the number of individuals in the main working age demographic (i.e. individuals aged 25-59) accounting for approximately half of this growth. Throughout the globe, populations over 60 years of age are the fastest growing demographic, at annual rates of 2.4% in the more developed world and over 3.0% in the less developed world expected until 2050. This demographic is anticipated to reach approximately two billion people by 2050 – 418 million in the more developed world and 1.6 billion in the less developed world (UN 2011).

These population projections present three main issues for agriculture: there will be significantly more people to feed; more and more of these new people will be in the oldest demographic (making them less likely to work) and the majority of increase in the working age population will be in less developed countries (UN 2011).

6.2. Urbanization and Urban Bias

It is not a new revelation, but the global population is increasingly urban. Since 1950, the percentage of the global population living in urban centres has been steadily increasing. By 2010, the majority of the global population was living in cities and by 2050 approximately two thirds of the global population is projected to be urban.

The increasing trend towards urbanization has a number of implications for agriculture. Competition for land and resources with urban populations is an obvious implication, and is dealt with below in Section 6.4. Here, the risks associated with urban bias in policy, legislation, etc. is explored. Although it is difficult to fully characterize the severity of this pressure, it is important to consider how increased urbanization may affect the political economy of agriculture in the context of disaster risk reduction.

Agricultural producers as an interest group, especially small holders, could find themselves increasing influenced by policies and regulations that do not necessarily promote the appropriate practices for agricultural resilience. Producers' ability to influence public policy as an interest group may be limited due to their relatively limited numbers compared to the urban interest group (Birner and Resnick 2010). Some would even argue that the 'urban bias' in development policy is already apparent through discriminant domestic commodity pricing and reduced financial support operating against agricultural growth in developing countries (Bezemer and Headey 2008). As urban populations typically become more disconnected and not attuned to the needs and modes of agricultural production, it becomes more likely that dominant political pressures may favour policies that do not adequately support the agriculture industry or provide sufficient capacity to cope, adapt or respond to disaster risk.

6.3. Competition for Land and Water Resources

In an urbanizing world with growing populations, the competition for land and water resources will most likely increase. The agricultural industry will need to compete with cities, other industries and changing societal demands for land and water. This competition will add increasing challenges to the sustainability of agricultural systems.

Agriculture competes for land with a number of sectors: municipalities, industry and conservation areas (Francis et al. 2012). In a recent study from Australia, the most significant competition for land occurred with conservation areas, followed by cities, forestry and mining (Millar and Roots 2012). Although the most significant in terms of acreage, conversion of agricultural lands into conservation areas typically has a minimal impact on production since conservation areas are often located on marginal farmland (Millar and Roots 2012). This type of land conversion may actually serve to reduce the exposure of agriculture to disasters by moving production systems off unsuitable lands (Millar and Roots 2012).

Urban expansion and sprawl are also significant contributors to reduced land availability for agriculture. This land conversion typically has significant implications for production, as cities often expand onto fertile lands. Also, urban expansion increases land values in areas surrounding cities, possibly making agriculture uneconomical if the land is purchased for these purposes. Finally, conflict between producers and urban residents in the peri-urban areas is another concern. This usually involves the displeasure of some urban residents, who find certain aspects of agricultural production unaesthetic or offensive, with certain agricultural practices occurring

too close to home. In some cases, this results in the forced relocation of agriculture to other areas (Millar and Roots 2012).

Agriculture could also be increasingly competing with other sectors and elements of the environment for water (Young et al. 2010). The maintenance of environmental flows (sometimes called in-stream flow needs) for aquatic life and systems is becoming more important in watersheds heavily influenced by human development. Also, increasing pressures on water resources from greater community and industry demands, especially in the context of rising global populations, will also influence the water security of the agriculture sector (Madramootoo and Feynes 2012).

An interesting case is competition for water with biofuel production. Biofuel production can be a significant source of energy in the future. One issue, though, is that current processes for creating biofuels are quite water intensive, with global water footprints from biofuel production projected to increase ten times from 2005 to 2030 (Gerbens-Leenes et al. 2012). Advances in technology and water efficiencies could help address some of these concerns, but agriculture will have to compete for water with energy production in a growing world. Biofuel production also leads to concerns over food security, as commodity prices increase due to resource competition between food and fuel production.

6.4. Fertilizer Availability and Access

A significant proportion of agricultural production is dependent on inputs, such as fertilizer. Fertilizers typically consist of nitrogen, phosphorous and potassium, and have become an integral component of sustaining and increasing current yields. Of these three elements, phosphorous, a non-renewable resource, has raised the most concern of late due to the potential that global phosphorous reserves and production will peak and then decline sometime over the next century (Cordell et al. 2009). If phosphorous availability decreases, there could be drastic implications for current modes of agricultural production and associated effects on food security, especially since there are no known alternatives. But are concerns over phosphorous availability for fertilizers warranted? It is very difficult to say. There are currently major gaps in the way phosphorous reserves are reported and tracked, raising questions regarding the accuracy of the data that is available (IFDC 2010).

Until recently, most claims on phosphorous availability were made based on United States Geological Survey (USGS) data on reserves in selected countries around the globe. These data were reported by the corresponding country governments, not the phosphorous mining/production industry, and were not triangulated by the USGS (Gilbert 2009; IFDC 2010). As such, these data were subject to a number of uncertainties and errors, providing the impetus for a more comprehensive and independent study recently completed by the International Fertilizer Development Centre (IFDC). This new study estimates that there is much more phosphorous than the USGS data suggest, expanding the window of phosphorous availability by two or three centuries (IFDC 2010). Only the countries originally included in the USGS

estimates were studied, however, meaning that not every country in the world was included and there are still many remaining countries that have not been fully explored for phosphorous reserves. In short, although these estimates are likely more accurate, and definitely more optimistic, there still remains considerable uncertainty around global phosphorous reserves and more inquiry is required to properly understand potential emerging pressures associated with this resource.

Even if reserves are greater than originally conceived, changes in access to fertilizer, as related to phosphorous production costs, could still potentially be an issue of concern. The recent study by the IFDC does note that not all the reserves that were included have the same production costs. The cost of phosphate rock will likely increase as the lower-cost reserves are depleted earlier, having a number of implications for the current production/consumption system. Higher phosphate rock costs will make more reserves economically viable, presenting the opportunity to expand supplies. It will also, however, mean that fertilizer costs to producers will likely rise, presenting issues around access, and more importantly differential access, for producers around the globe. In many parts of the world, one current barrier to agricultural intensification is the inability of producers to afford fertilizer inputs. With increased fertilizer costs, these barriers may be reinforced rather than removed during a time when, globally, more production is needed to feed an increasing population (IFDC 2010; van Vuuren 2010).

Regardless of the quantity of phosphorous that remains in the world, there is an increasing awareness that efficiency in the mining, production, processing, application and consumption of phosphorous is required to responsibly manage this resource into the future. As noted earlier, phosphorous is a non-renewable resource in finite supply that is essential to agriculture with no known alternatives. Effectively managing global phosphorous reserves will be of increasing importance to agriculture and food security over the next century (IFDC 2010; van Vuuren 2010).

6.5. Global Environmental Change

Global environmental change could place serious pressures on agricultural and food systems in the future (Liverman and Kapadia 2010). Rockström et al. (2009) highlight nine planetary boundaries that, if crossed, could drastically affect environmental and human systems as we know them. These nine planetary boundaries include: climate change, chemical pollution, ocean acidification, atmospheric aerosol loading, biodiversity loss, land-system change, water security, nutrient (phosphorous and nitrogen) cycles and stratospheric ozone depletion (Rockström et al. 2009). A number of these have been discussed separately as they relate directly to the agriculture industry in this paper, but these issues can also influence the agricultural sector as secondary impacts from global environmental change. Also, agriculture and food systems are contributors to global environmental change. Nonetheless, managing global environmental change in the future while feeding more people with fewer resources will place additional pressures on agriculture and food systems.

7. Conclusions: Towards Resilience

This section will provide an overview of potential future directions for disaster risk reduction that foster general resilience in agricultural systems. This will include a discussion of strategies aimed at reducing production risks, but also risks throughout the value chains. This section will provide an overview of how to deal with emerging pressures in light of current vulnerabilities and adaptive strategies in order to improve agricultural system resilience now and in the future.

Working towards general resilience of agricultural systems can be an effective way of reducing disaster risks. As illustrated in this paper, there are a numbers of options to pursue this goal. Those discussed here include: expanding diversification, managing externalities, bridging the rural-urban divide, improving resource use efficiency and innovation and governance. This list is definitely not exhaustive, but provides some general insights into the ways that general resilience could be pursued.

7.1. Expanding Diversification

As illustrated in Section 5.1, diversification has a significant role in the resilience of agricultural systems. Typically, diversification has meant growing new types of crops or raising new types of livestock, but is more recently being taken to mean much more. Diversification in terms of livelihood, income stream and other aspects of agricultural systems is gaining more attention of late and can play a critical role in the sustainability of agricultural systems. Increasing international trade opportunities has been shown to improve household livelihoods (Balat and Porto 2007). In theory, the more options available within agricultural value chains the more this will contribute to agricultural resilience; although in practice, there are likely optimal levels and combinations of agricultural and livelihood diversification that allow value chains to maintain their function throughout disasters. Determining these optimal levels and combinations requires place-based strategies that acknowledge broad linkages across multiple scales.

7.2. Managing Externalities

Managing externalities from agriculture will require ongoing developments in technology and practice. Some reduction in externalities will likely occur autonomously, based on market or other signals, while others may require incentive or other forms of programming. Similarly, research and development of new crop varieties or agricultural practices could play a role in managing the negative environmental and human health consequences from agriculture. For instance, the emergence of nanotechnologies for fertilizer application could contribute to the path forward in terms of improving fertilizer use efficiencies. This in turn would help manage risks associated with phosphorous depletion. In general, the solutions to agricultural externalities must be carefully considered by examining local circumstances and making sure to consider both the environmental and economic implications of decisions appropriately.

7.3. Bridging the Rural-Urban Divide

In an increasingly urbanized world, the need to bridge the rural-urban divide will become more apparent. This can be done by strengthening the agricultural value chain and bringing both producers and consumers of food together in dealing with complex challenges. Although seemingly simple, this is probably a major challenge. The need to construct this bridge has been apparent for quite some time, and is still apparent now. The sustainability of the global food system will increasingly require strong value chains in order to deal with many of the emerging pressures as well as the disaster risks discussed in this paper.

7.4. Improving Resource-use Efficiencies

In an increasingly resource-constrained world with greater demand for agricultural production, using the resources that are available most effectively will be crucial. As highlighted in this paper, phosphorous, water and land are all critical resources that need to be managed sustainably. Although not discussed here, there are many other resources that also require the same sort of stewardship (e.g. energy). In general, resource-use efficiencies are beneficial, reducing input costs and providing some stability in resource supplies. Technology and innovative practice, as supported by research and development, play key roles in improving efficiencies and could include a broad range of developments (e.g. new crop varieties, new fertilizer technologies).

7.5. Innovation and Governance

Innovation and governance will continue to play important roles in disaster resilient agricultural systems. As illustrated in Section 5, good governance can is related to multiple beneficial strategies, including strengthened value chains, effective risk transfer and sharing and sustainable intensification. Section 5.5 on market governance shows how innovative governance structures that empower local people can improve livelihood security. Governance that fosters innovation will be increasingly important in dealing with future disaster risks.

8. Case Study

8.1. Reducing Disaster Risk with Micro-insurance and Micro-finance: World Vision's Project in Tanzania

Overview of project: This project provides producers in the Same District of Tanzania with access to credit and flood insurance through a number of innovative arrangements with multiple actors. Small loans are provided to producers involved in farmer organizations for improving their operations. In order to receive the loan a flood insurance policy is integrated into the loan. Flood insurance policy pay-outs are based on critical thresholds of rain indices calculated from an observation network developed by the project.

Implications for disaster risk: This project reduces disaster risk in a number of ways. First, the access to credit allows producers to purchase inputs such as improved seeds and fertilisers that enhance productivity which contribute to improving the resilience of their operations. The credit also builds demand and facilitates input suppliers to be more willing to do business in this region, thereby strengthening the value chain. The flood insurance provides the producers with livelihood protection in the case of flood, which makes them less likely to default on their loans and transfers some of the costs of recovery to the international insurance market.

Main challenges: The main challenge for the project is finding a cost-effective way of obtaining adequate weather data. In the past, some of the observed thresholds in precipitation were not adequately reflecting agricultural impacts due to the complex topography and variable environment in the region.

Future direction: This was a pilot project and there are plans to scale up to other regions. Also, the possibilities of using alternate weather observation technologies (e.g. remote sensing) are being explored.

Bibliography

Adiscott, T., Benjamin, N. 2004. Nitrate and Human Health. Soil use and Management. Vol.20, pp. 98-104.

Addiscott, T.M. 2005. Nitrate, Agriculture and the Environment. Cabi Publishing. pp. 131-132.

ADRC. 2005. Total Disaster Risk Management: Good Practice. Asian Disaster Reduction Centre. Available online at: http://www.adrc.asia/publications/TDRM2005/TDRM_Good_Practices/GP2005_e.html (accessed July 2012).

Al-Kaisi, M. 2009. Soil Erosion & Water Quality. Iowa State University Department of Agronomy. pp. 1-3.

Anjana, S. and Muhammad, I. 2007. Nitrate accumulation in plants, factors affecting the process, and human health implications. A review. Agronomy for Sustainable Development. 27, pp. 45-57.

Balat, J. and Porto, G. 2007. Globalization and Complementary Policies: Poverty Impacts on Rural Zambia. NBER Chapters. In: Harrison, A. (Ed.) Globalization and Poverty. National Bureau of Economic Research, Inc., Chicago. pp. 373-416

Bannerjee, L. 2010. Creative destruction: Analysing flood and flood control in Bangladesh. Environmental Hazards, 9:1. pp. 102-117.

Beghin, J. and Bureau, J.-C. 2001. Quantification of Sanitary, Phytosanitary, and Technical Barriers to Trade for Trade Policy Analysis. Working Paper 01-WP 291. Available online at: http://econ2.econ.iastate.edu/research/webpapers/paper_2024.pdf (accessed August 2012).

Beilin, R., Sysak, T. and Hill, S. 2012. Farmers and perverse outcomes: The quest for food and energy security, emissions reduction and climate adaptation. Global Environmental Change. No. 22, pp. 463-471.

Belliveau, S., Smit, B. and Bradshaw, B. 2006. Multiple exposures and dynamic vulnerability: Evidence from the grape industry in the Okanagan Valley, Canada. Global Environmental Change. 16, pp. 364-378.

Bezemer, D. and Headey, D. 2008. Agriculture, Development, and Urban Bias. World Development. 36:8, pp. 1342-1364.

Birkmann, J. 2006. Measuring vulnerability to promote disaster-resilient societies: Conceptual frameworks and definitions. In: Birkmann, J. (Ed.) *Measuring Vulnerability to Natural Hazards – Towards Disaster Resilient Societies*. United Nations University Press, Tokyo, Japan. pp 9-54.

Birkmann, J. 2011. First- and second-order adaptation to natural hazards and extreme events in the context of climate change. Natural Hazards. No. 58, pp. 811-840.

Birner, R. and Resnick, D. 2010. The Political Economy of Policies for Smallholder Agriculture. World Development. 38:10, pp. 1442-1552.

Botzen, W., van den Bergh, J. and Bouwer, L. 2010. Climate change and increased risk for the insurance sector: a global perspective and an assessment for the Netherlands. Natural Hazards. No. 52, pp. 577-598.

Boyer, E., et al. 2004. Current Nitrogen Inputs into World Regions. In Mosier, A., Syers, J. and Freney, J. (Eds.) Agriculture and the Nitrogen Cycle. Island Press, Washington, DC. pp. 221-232.

Brown, M. et al. 2012. Country and regional staple food price indices for improved identification of food insecurity. Global Environmental Change. http://dx.doi.org/10.1016/j.gloenvcha.2012.03.005.

Brukner, M. et al. 2012. Materials embodied in international trade – Global material extraction and consumption between 1995 and 2005. Global Environmental Change. http://dx.doi.org/10.1016/j.gloenvcha.2012.03.011.

Burton, C. 2010. Social Vulnerability and Hurricane Impact Modeling. Natural Hazards Review. 11:2, pp. 58-68.

Cardinale, B. 2011. Biodiversity improves water quality through niche partitioning. Nature. Vol. 472, pp. 86-89.

CGIAR. 2011. The CGIAR at 40 and Beyond: Impacts that Matter for the Poor and the Planet. Consultative Group on International Agricultural Research. Available online at: http://library.cgiar.org/bitstream/handle/10947/2549/cgiar%4040_final_LOWRES.pdf?sequence_=1 (accessed July 2012).

Charudattan, R., et al. 2002. Biological Control. Wheeler, W. (Ed.) Pesticides in Agriculture and the Environment. Marcel Dekker, Inc., New York, USA, p. 25-58.

Chhotray, V. and Few, R. 2012. Post-disaster recovery and ongoing vulnerability: Ten years after the super-cyclone of 1999 in Orissa, India. Global Environmental Change. http://dx.doi.org/10.1016/j.gloenvcha.2012.05.001.

Chen, S., Bhagowalia, P. and Shively, G. 2011. Input Choices in Agriculture: Is There A Gender Bias? World Development. 39:4, pp. 561-568.

Chiang, Y., Cheng, W. and Chang, F. 2012. A hybrid artificial neural network-based agri-economic model for predicting typhoon-induced losses. Natural Hazards. DOI 10.1007/s11069-012-0188-3.

Collier, W. et al. 2009. Strengthening socio-ecological resilience through disaster risk reduction and climate change adaptation: Identifying gaps in an uncertain world. Environmental Hazards. 8:3, pp. 171-186.

Cordell, D., Drangert, J.-O. and White, S. 2009. The story of phosphorus: Global food security and food for thought. Global Environmental Change. No. 19, pp. 292-305.

Cox, T.P. 2012. Farming the battlefield: the meanings of war, cattle and soil in South Kivu, Democratic Republic of the Congo. Disasters. 36:2, pp. 233-248.

Diao, X., Hazell, P. and Thurlow, J. 2010. The Role of Agriculture in African Development. World Development. 38:10, pp. 1375-1383.

Dobbs, T. 2012. The enduring importance of understanding institutions and values, International Journal of Agricultural Sustainability, DOI:10.1080/14735903.2012.652379.

Dodds, W., et al. 2008. Eutrophication of U.S. Freshwaters: Analysis of Potential Economic Damages. Environmental Science & Technology. 43:1, pp. 12-19.

Doreen, G. 2010. Scale Matters: The Impact of Organic Farming on Biodiversity at Different Spatial Scales. Ecology Letters. 13:7, pp. 858-870.

Dorward, A. and Chirwa, E. 2011. The Malawi agricultural input subsidy programme: 2005/06 to 2008/09. International Journal of Agricultural Sustainability. 9:1, pp. 232-247.

Ecobichon, D. 2001. Pesticide use in developing countries. Toxicology. 160:1-3, pp. 27-33.

Eiser, J. et al. 2012. Risk Interpretation and Action: A Conceptual Framework for Responses to Natural Hazards. International Journal of Disaster Risk Reduction. http://dx.doi.org/10.1016/j.ijdrr.2012.05.002.

Fan, S. 2012. Effectively Responding to the Drought in the United States Can Prevent Another Global Food Crisis. Press Release, IFPRI. Available online at: http://www.ifpri.org/pressrelease/effectively-responding-drought-united-states-can-prevent-another-global-food-crisis (accessed August 2012).

FAO/WHO. 2006. Understanding the Codex Alimentaris. 3rd Edition. Secretariat of the Codex Alimentarius Commission, Joint FAO/WHO Food Standards Programme. Rome, Italy. 47 p.

Ferguson, M. et al. 2012. Post-flooding disaster crop diversity recovery: a case study of Cowpea in Mozambique. Disasters. 36:1, pp. 83-100.

Firbank, L. 2012. Commentary: Pathways to global sustainable agriculture. International Journal of Agricultural Sustainability. 10:1, pp. 1-4.

Francis, C. et al. 2012. Farmland conversion to non-agricultural uses in the US and Canada: current impacts and concerns for the future. International Journal of Agricultural Sustainability. 10:1, pp. 8-24.

Galt, R. 2008. Beyond the circle of poison: Significant shifts in the global pesticide complex, 1976–2008. Global Environmental Change. 18:4, pp. 786-799.

Gebrehiwet, Y., Ngqangweni, S. and Kirsten, J.F. 2007. Quantifying the Trade Effect of Sanitary and Phytosanitary Regulations of OECD Countries on South African Food Exports. Agrekon, 46:1.

Gerbens-Leenes, P.W. et al. 2012. Biofuel scenarios in a water perspective: The global blue and green water footprint of road transport in 2030. Global Environmental Change. http://dx.doi.org/10.1016/j.gloenvcha.2012.04.001.

Gilbert, N. 2009. The disappearing nutrient. *Nature.* 461, pp. 716-718.

Gilliom, R. 2006. Pesticides in the Nation's Streams and Ground Water, 1992–2001. United States Geological Survey.

Environment Canada. 2011. State of Lake Winnipeg, 1999 to 2007 highlights. Environment Canada. Ottawa, ON.

Godfrey, H. 2011. Food and Biodiversity. Science. 333:6047, pp. 1231-1232.

Goulding, K. 2004. Pathways and Losses of Fertilizer Nitrogen at Different Scales. In Mosier, A., Syers, J. and Freney, J. (Eds.) Agriculture and the Nitrogen Cycle. Island Press, Washington, DC. pp. 209-219.

Goulding, K. and Whitmore, A. 2012. Commentary: Developing sustainable farming systems by valuing ecosystem services. International Journal of Agricultural Sustainability. 10:1, pp. 5-7.

GTZ. 2008. ValueLinks Manual The Methodology of Value Chain Promotion. Deutsche Gessalshaft für Technische Zusammenarbeit, Eschborn, Germany.

Habiba, U. Shaw, R. and Takeuchi, Y. 2011. Drought risk reduction through a Socio-economic, Institutional and Physical approach in the northwestern region of Bangladesh, Environmental Hazards. 10:2, pp. 121-138.

Habiba, U., Shaw, R. and Takeuchi, Y. 2012. Farmers' perception and adaptation practices to cope with drought: Perspectives from Northwestern Bangladesh. International Journal of Disaster Risk Reduction. http://dx.doi.org/10.1016/j.ijdrr.2012.05.004.

Haddad, N. et al. 2011. The potential of small-scale rainfed agriculture to strengthen food security in Arab countries. Food Security. 3:Suppl 1, pp. S163–S173.

Hadarits, M., Smit, B. and Diaz, H. 2010. Adaptation in Viticulture: A Case Study of Producers in the Maule Region of Chile. Journal of Wine Research. 21:2-3, pp. 167-178.

Hallegatte, S. 2009. Strategies to adapt to an uncertain climate change. Global Environmental Change. 19:2, pp. 240-247.

Hao, L., Zhang, X. and Liu, S. 2012. Risk assessment to China's agricultural drought disaster in county unit. Natural Hazards. 61, pp. 785-801.

Harper, M. 2010. Inclusive Value Chains: A Pathway out of Poverty. World Scientific Publishing Co.

Havlin, J. 2004. Impact of Management Systems on Fertilizer Nitrogen Use Efficiency. In Mosier, A., Syers, J. and Freney, J. (Eds.) Agriculture and the Nitrogen Cycle. Island Press, Washington, DC. pp. 167-180.

Hazell, P. and Hess, U. 2010. Drought insurance for agricultural development and food security in dryland areas. Food Security. 2, pp. 395–405.

Hendrickson, M. and Heffernan, D. 2002. Opening Spaces through Relocalization: Locating Potential Resistance in the Weaknesses of the Global Food System. Sociologia Ruralis. 42:4, pp. 347-369.

Henry, M. et al. 2012. A Common Pesticide Decreases Foraging Success and Survival in Honey Bees. Science. 336:6079, pp. 348-350.

Hewitt, K. 2012. Environmental disasters in social context: toward a preventive and precautionary approach. Natural Hazards. DOI 10.1007/s11069-012-0205-6.

Hill,H, Wiener, J. and Werner, K. 2012. From fatalism to resilience: reducing disaster impacts through systematic investments. Disasters. 36:2, pp. 175-194.

Huijsmans, J., Hol, J. and Vermeulen, G.D. 2003. Effect of application method, manure characteristics, weather and field conditions on ammonia volatilization from manure applied to arable land. Atmospheric Environment. 37:26, pp. 3669-3680.

Ibarra, H. and Skees, J. 2007. Innovation in risk transfer for natural hazards impacting agriculture. Environmental Hazards. No. 7:1, pp. 62-69.

IFDC. 2010. World Phosphate Rock Reserves and Resources. International Fertilizer Development Centre. Available online: http://pdf.usaid.gov/pdf_docs/PNADW835.pdf (accessed July 2012).

Jackson, L.E. et al. 2012. Social-ecological and regional adaptation of agrobiodiversity management across a global set of research regions. Global Environmental Change . http://dx.doi.org/10.1016/j.gloenvcha.2012.05.002.

Jaffee, S., Siegel, P. and Andrews, C. 2010. Rapid Agricultural Supply Chain Risk Assessment: A Conceptual Framework. The World Bank, Agriculture and Rural Development Discussion Paper 47.

Jaleta, M. and Gebremedhin, B. 2012. Interdependence of smallholders' net market positions in mixed crop-livestock systems of Ethiopian highlands. Journal of Development and Agricultural Economics. 4:7, pp. 199-209.

Jansen, D. and Rukovo, A. 1992. Agriculture and the policy environment: Zambia and Zimbabwe: political dreams and policy nightmares. OECD Development Centre.

Jin, J. et al. 2012. Forewarning of sustainable utilization of regional water resources: a model based on BP neural network and set pair analysis. Natural Hazards. 62, pp. 115–127.

Jewitt, S. and Baker, K. 2012. Risk, wealth and agrarian change in India. Household-level hazards vs. late-modern global risks at different points along the risk transition. Global Environmental Change. No. 22, pp. 547-557.

Keen, D. and Lee, V. 2007. Conflict, trade and the medium-term future of food security in Sudan. Disasters. 31:S1, pp. 9-24.

Keesing, F., et al. 2010. Impacts of biodiversity on the emergence and transmission of infectious diseases. Nature. Vol. 468, pp. 647-652.

Keshkamat, S. et al. 2012. The Environmental Impact of not Having Paved Roads in Arid Regions: An Example from Mongolia. Ambio. 41, pp. 202-205.

Keys, E. and McConnell, W. 2005. Global change and the intensification of agriculture in the tropics. Global Environmental Change. No. 15, pp320-337.

Klepak, J. 2012. Selling Guatemala's next Green Revolution: agricultural modernization and the politics of GM maize regulation. International Journal of Agricultural Sustainability. 10:2, pp. 117-134.

Krzyzanowski, J. 2010. Review and Identification of Research Needs to Address Key Issues Related to Reactive Nitrogen (RN) Deposition and Eutrophication in a Canadian Context. Available online at: http://www.ccme.ca/assets/pdf/rn_eutrophication_1450.pdf (accessed July 2012).

Kugonza, D. et al. 2012. Pastoralists' indigenous selection criteria and other breeding practices of the long-horned Ankole cattle in Uganda. Tropical Animal Health and Production. 44, pp. 557-565.

Lampietti, J. et al. 2011. A strategic framework for improving food security in Arab countries. Food Security. 3:Suppl 1, pp. S7-S22.

Lewis, D., Barham, B. and Zimmerer, K. 2008. Spatial Externalities in Agriculture: Empirical Analysis, Statistical Identification, and Policy Implications. World Development. 36:10, pp. 1813-1829.

Lin, Y. et al. 2011. National policy of watershed management and flood mitigation after the 921 Chi-Chi earthquake in Taiwan. Natural Hazards. 56, pp. 709-731.

Lin, H. et al. 2012. Regional economic impact analysis of earthquakes in northern Taiwan and its implications for disaster reduction policies. Natural Hazards. 61, pp. 603-620.

Liverman, D. and Kapadia, L. 2010. Food Systems and the Global Environment: An Overview. In Ingram, J. et al. (Eds). *Food Security and Global Environmental Change*. Earthscan, Washington, DC. pp. 3-24.

Ma, W. et al. 2011. Phosphorus flows and use efficiencies in production and consumption of wheat, rice, and maize in China. Chemosphere. 84:6, pp. 814-821.

Madramootoo, C. and Feyles, H. 2012. Synthesis of findings from the four McGill conferences on global food security: 2008–2011. Food Security. 4, pp. 307-317.

Mahul, O. and Stutley, C.J. 2010. Government support to agricultural insurance: challenges and options for developing countries. World Bank, Washington DC.

Marchildon, G. et al. 2008. Drought and institutional adaptation in the Great Plains of Alberta and Saskatchewan, 1914–1939. Natural Hazards. No. 45, pp. 391-411.

Matyas, C. and Silva, J. 2012. Extreme weather and economic well-being in rural Mozambique. Natural Hazards. DOI 10.1007/s11069-011-0064-6.

McDowell, J. and Hess, J. 2012. Accessing adaptation: Multiple stressors on livelihoods in the Bolivian highlands under a changing climate. Global Environmental Change. No. 22, pp. 342-352.

Mercer, K., Perales, H. and Wainwright, J. 2012. Climate change and the transgenic adaptation strategy: Smallholder livelihoods, climate justice, and maize landraces in Mexico. Global Environmental Change. No. 22, pp. 495-504.

Merino, G. et al. 2012. Can marine fisheries and aquaculture meet fish demand from a growing human population in a changing climate? Global Environmental Change. doi:10.1016/j.gloenvcha.2012.03.003 .

Mertz, O. et al. 2012. Climate Variability and Environmental Stress in the Sudan-Sahel Zone of West Africa. Ambio. 41, pp. 380-392.

Mijatović, D et al. 2012. The role of agricultural biodiversity in strengthening resilience to climate change: towards an analytical framework. International Journal of Agriculture Sustainability. DOI:10.1080/14735903.2012.691221.

Millar, J. and Roots, J. 2012. Changes in Australian agriculture and land use: implications for future food security. International Journal of Agricultural Sustainability. 10:1, pp. 25-39.

Mills, B. et al. 2010. Assessment of lightning-related damage and disruption in Canada. Natural Hazards. 52, pp. 481-499.

Mycoo, M. 2011. Natural Hazard Risk Reduction: Making St. Lucia Safe in an Era of Increased Hurricanes and Associated Events. Natural Hazards Review. Pp. 37-45.

Nicholas, K. and Durham, W. 2012. Farm-scale adaptation and vulnerability to environmental stresses: Insights from winegrowing in Northern California. Global Environmental Change. No. 22, pp. 483-494.

Nielson, J.O. and Vigh, H. 2012. Adaptive lives. Navigating the global food crisis in a changing climate. Global Environmental Change. http://dx.doi.org/10.1016/j.gloenvcha.2012.03.010.

Neves, M. and Scare, R. 2010. Defining an Agribusiness Strategic Agenda for 2010-2020. International Food and Agribusiness Management Review. 13:1, pp. 83-90.

Neves, M. 2011. Food chains and the reasons behind rising food prices. Food Chains. 1:1, pp. 52-70.

Newton, I. 2004. The recent declines of farmland bird populations in Britain: an appraisal of causal factors and conservation actions. International Journal of Avian Science. 146:4, pp. 579-600.

Nguyen, H., Prabhakar, S. and Shaw, R. 2009. Adaptive drought risk reduction in Cambodia: Reality, perceptions and strategies. Environmental Hazards. 8:4, pp. 245-262.

Ogutu, J. et al. 2012. Dynamics of ungulates in relation to climatic and land use changes in an insularized African savanna ecosystem. Biodiversity Conservation. 21, pp. 1033-1053.

Oh, E., Deshmukh, A. and Hastak, M. 2010. Disaster impact analysis based on inter-relationship of critical infrastructure and associated industries A winter flood disaster event. International Journal of Disaster Resilience in the Built Environment. 1:1, pp. 25-49.

Olesen, J.E., et al. 2004. Integrated Nitrogen Input Systems in Denmark. In Mosier, A., Syers, J. and Freney, J. (Eds.) Agriculture and the Nitrogen Cycle. Island Press, Washington, DC. pp. 129-142.

Osteen, C., Padgitt, M. 2002. Economic Issues of Agricultural Pesticide Use and Policy in the United States. Ed. Wheeler, W. Pesticides in Agriculture and the Environment. pp. 59-77.

Palm, C., et al. 2004. Societal Responses for Addressing Nitrogen Fertilizer Needs: Balancing Food Production and Environmental Concerns. In Mosier, A., Syers, J. and Freney, J. (Eds.) Agriculture and the Nitrogen Cycle. Island Press, Washington, DC. pp. 71-92.

Peoples, M. 2004. Pathways of Nitrogen Loss and Their Impacts on Human Health and the Environment. In Mosier, A., Syers, J. and Freney, J. (Eds.) Agriculture and the Nitrogen Cycle. Island Press, Washington, DC. pp. 53-70.

Perumal, T. 2011. Weather Index Based Crop Insurance For Small And Marginal Farmers – Mexican Experience. In Gupta, M, Filing the governance gap in disaster risk reduction. Contributing paper to the GAR 11.

Phalan, B. 2011. Reconciling Food Production and Biodiversity Conservation: Land Sharing and Land Sparing Compared. Science. 333:6047, pp. 1289-1291.

Picazo-Tadeo, A., Gomez-Limon, J. and Reig Martinez, E. 2011. Assessing farming eco-efficiency: A Data Envelopment Analysis approach. Journal of Environmental Management. 92:4, pp. 1154-1164.

Pimentel, D. 1995. Environmental and Economic Costs of Soil Erosion and Conservation Benefits. Science. 267:5201, p. 1121.

Pimental, D., et al. 2004. Water Resources: Agricultural and Environmental Issues. Bioscience. 54:10, p. 909-918.

Pingali, P., Alinovi, L. and Sutton, J. 2005. Food security in complex emergencies: enhancing food system resilience. Disasters. 29:S1, pp. 5-24.

Pittman, J et al. 2011. Vulnerability to climate change in rural Saskatchewan: Case study of the Rural Municipality of Rudy No. 284. Journal of Rural Studies. 27, pp. 83-94.

Pretty, J. et al. 2010. The top 100 questions of importance to the future of global agriculture. International Journal of Agricultural Sustainability. 8:4, pp. 19-236.

Pretty, J., Toulmin, C. and Williams, S. 2011. Sustainable intensification in African agriculture, International Journal of Agricultural Sustainability, 9:1, pp. 5-24.

Raddatz, R. 2003. Agriculture and Tornadoes on the Canadian Prairies: potential impact of increasing atmospheric CO2 on Summer Severe Weather. Natural Hazards. 290, pp. 113-122.

Ran, L., Lu, X. and Yang, X. 2012. Mindset Change Needed for China's Water Crisis. Ambio. 41, pp. 216-218.

Rana, S. 2010. Global pesticide market to reach $52 billion in 2014. Pesticide & Toxic Chemical News. 38:45, p. 26.

Reardon, T. et al. 2009. Agrifood Industry Transformation and Small Farmers in Developing Countries. World Development. 37:11, pp. 1717-1727.

Reed, N. 2002. Risk Assessment. Wheeler, W. (Ed.) Pesticides in Agriculture and the Environment. Marcel Dekker, Inc., New York, USA, p. 97-126.

Richards, P., Myers, R., Swinton, S. and Walker, R. 2012. Exchange rates, soybean supply response, and deforestation in South America. Global Environmental Change. No. 22, pp. 454-462.

Rockström, J. et al. 2009. Planetary boundaries: exploring the safe operating space for humanity, Ecology and Society, 14:2, art 32.

Rupert, M. 2008. Decadal-Scale Changes of Nitrate in Ground Water of the United States, 1988–2004. Journal of Environmental Quality. 37:5, pp. 240-248.

Sandberg, A. 2010. Institutional challenges to robustness of delta and floodplain agricultural systems, Environmental Hazards, 9:3, pp. 284-300.

Seitzinger, S. 2010. Global river nutrient export: A scenario analysis of past and future trends. Global Biogeochemical Cycles. Vol. 24, GB0A08 16.

SERI. N.D. Establishing an environmental sustainability threshold on soil erosion. Fact Sheet, Available online at: http://seri.at/wp-content/uploads/2011/02/Factsheet_soil-erosion.pdf (accessed July 2012).

Shetty, P.K., Sabitha, M. 2009. Economic and Ecological Externalities of Pesticide Use in India. In Peshin, R. and Dhawan, A. (Eds.) Integrated Pest Management: Innovation-Deveopment Process Volume 1. Springer. pp. 126-127.

Sims, J.T., Simard, R.R. and Joern, B.C. 1998. Phosphorus Loss in Agricultural Drainage: Historical Perspective and Current Research. Journal of Environmental Quality, 27:2, pp. 277-293.

Smil, V. 2000. Phosphorous in the Environment: Natural Flows and Human Interferences. Annual Review of Energy and the Environment. Vol. 25, pp. 53-88.

Smit, B. and Wandel, J. 2006. Adaptation, adaptive capacity and vulnerability. Global Environmental Change, 16. pp. 282-292.

Spehn, E., et al. 2005. Ecosystem Effects of Biodiversity Manipulations in European Grasslands. Ecological Monographs. 75:1, pp. 37-63.

Stobl, E. 2012. Impact of Hurricane Strikes on Local Cropland Productivity: Evidence from the Caribbean. Natural Hazards Review. Pp. 132-138.

Sultana, P. and Thompson, P. 2010. Local institutions for floodplain management in Bangladesh and the influence of the Flood Action Plan. Environmental Hazards. 9:1, pp. 26-42.

Sun, B. et al. 2012. Agricultural Non-Point Source Pollution in China: Causes and Mitigation Measures. Ambio. 41, pp. 370-379.

Sun, Y. et al. 2012. Farmers' response to agricultural drought in paddy field of southern China: a case study of temporal dimensions of resilience. Natural Hazards. 60, pp. 865-877.

Suh, S. and Yee, S. 2011. Phosphorus use-efficiency of agriculture and food system in the US. Chemosphere. 84:6, pp. 806-813.

Thiele, G. et al. 2011. Multi-stakeholder platforms for linking small farmers to value chains: evidence from the Andes. International Journal of Agricultural Sustainability. 9:3, pp. 423-433.

Turner, M. et al. 2012. Conflict Management, Decentralization and Agropastoralism in Dryland West Africa. World Development. 40:4, pp. 745-757.

Tyler, J. and Singh, A. 2011. Enhancing post-earthquake disaster resilience. International Journal of Disaster Resilience in the Built Environment. 2:2, pp. 103-117.

UN. 2011. World Population Prospects The 2010 Revision. Volume I: Comprehensive Tables. ST/ESA/SER.A/313.

Uri, N., Lewis, J. 1998. The dynamics of soil erosion in US agriculture. Science of the Total Environment. 218:1, pp. 45-58.

Uy, N., Takeuchi, Y. and Shaw, R. 2011. Local adaptation for livelihood resilience in Albay, Philippines. Environmental Hazards. 10:2, pp. 139-153.

Valdes, A. and Foster, W. 2010. Reflections on the Role of Agriculture in Pro-Poor Growth. World Development. 38:10, pp. 1362-1374.

Value Chain Management Centre, George Morris Centre. 2012. Characterizing the Determinants of Successful Value Chains. Prepared for the Canadian Agri-Food Policy Institute. 36 p.

Van Vuuren, D.P., Bouwman, A.F. and Beusen, A.H.W. 2010. Phosphorus demand for the 1970–2100 period: A scenario analysis of resource depletion. Global Environmental Change. No. 20, pp. 428-439.

van Vliet, N. et al. 2012. Trends, drivers and impacts of changes in swidden cultivation in tropical forest-agriculture frontiers: A global assessment. Global Environmental Change. No. 22, pp. 418-429.

Verheijen, F. 2009. Tolerable versus actual soil erosion rates in Europe. Earth-Science Reviews. 94:1-4, pp. 23-38.

Wandel, J., Pittman, J. and Prado, S. 2010. Rural Vulnerability to Climate Change in the South Saskatchewan River Basin. In Sauchyn, D., Diaz, H. and Kulshreshtha, S. (Eds.) The New Normal: The Canadian Prairies in a Changing Climate. CPRC Press: Regina, SK. Pp. 245-257.

Wang, M. et al. 2011. Agriculture Insurance in China: History, Experience, and Lessons Learned. International Journal of Disaster Risk Science. No. 2:2, pp. 10-22.

Wassenaar, L., Hendry, M.and Harrington, N. 2006. Decadal Geochemical and Isotopic Trends for Nitrate in a Transboundary Aquifer and Implications for Agricultural Beneficial Management Practices. Environmental Science & Technology. Vol. 40, pp. 4626-4632.

Whitall, D. 2007. Assessment of Eutrophication in Estuaries: Pressure-State-Response and Nitrogen Source Apportionment. Environmental Management, 40:4, pp. 678-690.

Whitehorn, P., et al. 2012. Neonicotinoid Pesticide Reduces Bumble Bee Colony Growth and Queen Production. Science. 336:6079, pp. 351-352.

Wilhelmi, O. and Wilhite, D. 2002. Assessing Vulnerability to Agricultural Drought: A Nebraska Case Study. Natural Hazards. 25, pp. 37-58.

Willroth, P., Diez, J. and Arunotai, N. 2011. Modelling the economic vulnerability of households in the Phang-Nga Province (Thailand) to natural disasters. Natural Hazards. 58, pp. 753–769.

Wilson, T. et al. 2011. Impacts on agriculture following the 1991 eruption of Vulcan Hudson, Patagonia: lessons for recovery. Natural Hazards. 57, pp. 185-212.

Wilson, C.and Tisdell, C. 2001. Why farmers continue to use pesticides despite environmental, health and sustainability costs. Ecological Economics. Vol. 39. p. 454.

Wisner, B. 2011. Disasters: what the United Nations and its world can do. Environmental Hazards. 3:3, pp. 125-127.

Young, G. et al. 2010. Vulnerability and adaptation in a dryland community of the Elqui Valley, Chile. Climatic Change. 98, pp. 245-276.

Zeman, C. et al. 2011. New Questions and Insights Into Nitrate/Nitrite and Human Health Effects: A Retrospective Cohort Study of Private Well Users' Immunological and Wellness Status. Journal of Environmental Health. 74:4, pp. 8-18.

Appendix 1. Food Security and National Security

STUDY FOR GLOBAL ASSESSMENT REPORT 2013

By: Frederic Labarre, MA

Presented to Harvey Hill, PhD

Agriculture and Agri-Food Canada

Ottawa, Ontario
August 2012

Contents

List of Tables and Figures

Introduction

This study examines the relationship between food security, national security, and disaster vulnerability. It supports the UN International Strategy for Disaster Reduction's (UN ISDR) biennial Global Assessment Report (GAR) 2013, the theme of which will be food and military security's links to disaster.

This study cannot be exhaustive. It can offer general conclusions, but the scope would have to be widened significantly to permit the elicitation of precise correlations and theories. The obstacles to comprehensiveness have to do with how nation-States understand, apply and prepare for national security, the role of agriculture in the national economy, and how the economy supports the development of national defence. Currently, there are more than 190 nation-States in the world, each vulnerable to disasters, but each differently vulnerable, differently integrated in the world system of trade and economy, and differently leveraging agricultural production for national development.

Yet, regardless of their structure (or levels of development), economies of various types have become acutely interdependent. Interdependence means that nearly every economy is impacted by the slowdown in commercial exchanges and tepid growth. In the current context of global and economic distress, the necessity of growth has assumed proportions of vital importance. With fiscal instability, the terms of commercial exchange can become less advantageous, increasing the danger of interstate and intra-state conflict. How this affects the prospects of developing economies is plain to see, but interdependence also means that advanced economies that depend on overseas production could see their growth stymied by far-away conflict. Natural disasters are also events that aggravate the symptoms of conflict. Although structural and non-structural disaster risk reduction (DRR) measures have been put in place in many countries since the unveiling of the Hyogo Framework for Action, national and international security has become vulnerable to the economic consequences of large scale disasters because the aftermath affects the prospect for continued growth nationally and globally. In this perspective, the protection of human life and livelihoods is instrumental to the overall objective of national security understood as continued economic growth. In short, economic growth is the objective of resilience efforts.

Vulnerability has become function of the economic structure, of which the use of food and water is a critical determinant. With the disparities between the types of national economies, the relationship between food and national security – and in consequence the military manipulation of food and water for military objectives, or the impact of floods and droughts on coping mechanisms – also becomes different from one country to the next.

While these observations provide an overall context, they do not provide a starting point for analysis. Whereas famine sometimes occurs without conflict, conflict has always been associated with famine, or at least with the unequal distribution of resources.[1] Since the United Nations has

[1] Marie L. Besançon, "Relative Resources: Inequality in Ethnic Wars, Revolutions, Genocides", *Journal of Peace Research*, 2:4, July 2005, 409.

been set up to spare successive generations from the scourge of war, it seems appropriate to formulate a research hypothesis from the point of departure of war and military preparations.

Defining a research hypothesis

The celebrated mathematician Jacob Bronowski (1973) simply defined war as "an organised form of theft."[2] In the early 16th century the father of modern political science, Niccolo Machiavelli had defined conflict by the aims it pursued; "whoever makes war… has the intention of making gains and keeping them, and of acting in such a way as to enrich his city and his country and not to make them poor."[3] Indeed, the security of a city is determined by its relative wealth; "non fia difficile a uno principe prudente tenere prima e poi fermi gli animi de' sua cittadini… quando non li manchi da vivere né da difendersi."[4] With the onset of modernity and of the industrial revolution, national economic and agricultural development offered a way out of chronic poverty. Strategic thinkers, foremost of which are Carl von Clausewitz (1832) and Baron Antoine de Jomini (1852) have defined war as an act of violence in the pursuit of a political aim.

After five centuries national economies became more diversified so that military campaigns came to be fought for political objectives instead of direct material rewards. Finally, "political objectives" do not always relate directly to basic human commodities such as food and water. In his ground-breaking study Guns, Germs and Steel, Jared Diamond demonstrates that objective factors linked to a society's natural environment, not its inherent abilities (or disabilities) dictated economic and social development. This predicament was obviously aggravated by natural disasters such as droughts and floods. In Antiquity, disparities between societies were insignificant, so that a city like Carthage (in modern day Tunisia, which many dubbed the "Third World" not so long ago) was for a long period of time a source of constant worry for the nascent Roman Empire. In fact, the writings of Herodotus of Halicarnassus suggest that material and agricultural disparities were a frequent cause of war.

Consider this passage in Herodotus:

> Inheriting from his father [Alyattes] a war with the Milesians, he [Sadyattes] pressed the siege against the city by attacking it in the following manner. When the harvest was ripe on the ground he marched his army into Milesia… The buildings that were scattered over the country he neither pulled down nor burnt… but left them standing as they were. He cut down, however, and utterly destroyed all the trees and all the corn throughout the land, and then returned to his own dominions… The reason that he did not demolish their buildings was, that the inhabitants might be tempted to use

[2] "The Ascent of Man: A Personal View by Jacob Bronowski", British Broadcasting Corporation, 1973.

[3] Niccolo Machiavelli, *Discourses on Livy*, (Chicago: Chicago University Press, 1996), 341.

[4] Niccolo Machiavelli, *Il Principe*, (Milano: Oscar Mondadori Edizioni, 1994), cap. X, 49. "Therefore it will not be difficult to maintain the people's goodwill… so long as there is no want of provisions for one to live or defend oneself." (Author's translation).

> them as homesteads from which to go forth to sow and till their lands; and so each time that he [Sadyattes] invaded the country he might find something to plunder.[5]

Or consider this warning from the Oracle to Croesus;

> Thou art about, oh! King, to make war against men… who feed not on what they like, but on what they can get from a soil that is sterile and unkindly; who do not indulge in wine, but drink water; who possess no fig nor anything that else that is good to eat. If then, you conquerest them, what can thou get from them, seeing they have nothing at all? But if they conquer thee, consider how much that is precious thou will lose…[6]

Donald Kagan writes that one of the reasons why Athens held out so long against so many enemies during the Peloponnesian Wars is that Attica (the peninsula home to Athens) was then unusable for agriculture. This made the area impossible and unattractive to conquer, because it didn't deny the Athenians anything, and didn't provide anything of substance to an invader. The lands to the South, more fertile, were occupied by natives friendly to the Athenians, and became subjugated to the Spartan invaders. This caused more grief to the Spartans who were forever suspicious of their new subjects, than to the Athenians, who could always rely on access to the sea for sustenance.[7] Athenian mastery of the sea is a crucial element of security, for, as Kagan writes, Athenians could access the wheat fields of present-day Ukraine and rely on their navy-protected trade to supplement or replace their inadequate food supply if they were forced to abandon their own fields.[8] This also meant that Athens' critical survival depended on sea lanes of communication.

Even 2000 years ago, human society and agriculture had evolved to the point that the production of food in times of peace had ceased to be a matter of direct survival, and was in fact means to generate wealth through trade. Still, ancient texts reveal that a city's dependence on agriculture made survival precarious in case of war. More often than not, agricultural production was the objective of a campaign.

Up to the 19th century, campaigning was governed by where a marching army could find food for the fight, or deny it to the enemy; "indeed the very aim of warfare in this period was to live at the enemy's expense" writes historian Martin van Creveld.[9] This meant that an invading army went where there was food, because food was also the "centre of gravity", the point of maximum vulnerability for the host society. An invasion therefore had the same effect as a flood, an uncontrolled brush-fire, a drought, or a plague of locusts.[10] From the Renaissance until the

---

[5] Herodotus, *The Histories*, trans. By George Rawlinson (1858), (London: J. M. Dent's Everyman Library, 1996), The First Book, entitled Clio, para. 17, 10-11.
[6] Ibid., para. 71, 38.
[7] Donald Kagan, "Athenian Strategy in the Peloponnesian War", in Williamson Murray. Alvin Bernstein and McGregor Knox, eds., *The Making of Strategy*, (Cambridge: Cambridge University Press, 1994), 25.
[8] Ibid., 30.
[9] Martin van Creveld, *Supplying War*, (Cambridge: Cambridge University Press, 1976), 23-24.
[10] Aryeh Nusbacher, "Civil Supply in the Civil War: Supply of Victuals to the New Model Army on the Naseby Campaign, 1-14 June 1645", *English Historical Review*, 115:460, February 2000, 150, 153.

Treaty of Westphalia (1648) which terminated the 30 Years' War, army sizes oscillated between 20-30000 men and 55-65000 men. At two pounds of bread per day per capita, this meant that the countryside would be fairly quickly devastated by a marching army, since the peasantry had no means to make reserves for itself, or to sell to an invading army. As a consequence, the countryside was emptied of its production wherever the army would march, leaving the inhabitants with nothing. Add to this a baggage and artillery train numbering up to 40000 horses and the fodder needed to keep those beasts moving, and even the bovine population (which could also be requisitioned) of the host country would start to starve very soon. Evidently, a city wishing to steer an invader away from it would resolve to scorched earth tactics as a means of defence, which gravely impacted the inhabitants' well-being.

Garrisons were responsible for requisitioning foodstuffs from the inhabitants and then ensuring that the supplies would reach the army in the field wherever it may be, in addition to the army supplying itself from the land when it could. But a corollary problem was that belligerents had to move through farmland of uncertain quality. During the English Civil War, much of the farmland "had been subject for years to forced contributions in cash and in kind imposed by parliamentary and royalist garrisons. These areas had suffered the additional burden of losing farm labourers and draft animals to the armies of both sides..."[11] The resulting agricultural scarcity could rapidly propel households back to subsistence farming. Feeding an army has always been a logistical nightmare; little formal provision was made to ensure that armies of increasing size (and of ever-deepening agricultural footprints wherever they marched) got the required 3000 calories per capita per day until the Napoleonic era.[12]

The tyranny of supplies would be alleviated by the introduction of a calorie-rich biscuit in Napoleonic armies which would be easy to carry for the soldier, provide the required daily caloric intake, and would make unnecessary the plunder of territory (thereby avoiding the host constituents' resentment) that the invader sought to rule eventually. This also meant that an army could now move towards its actual political objective (the opposing army or capital) rather than to a source of sustenance. During the American Civil War, the introduction of tinned rations would complete this logistical revolution and divorce food for human consumption from a military campaign's objectives (although fodder for the horses remained an important matter). Ever since that time, military performance has become dependent upon technological innovation, and correspondingly, national security has also become hostage to innovation.

This drive to innovate has accentuated economic and strategic disparities between and within countries. These disparities have not ceased to increase since the agrarian and industrial revolutions of the 18th-19th century, yielding a world fragmented along lines of relative yet unequal economic and resource abundance. That this inequity is also the fruit of conflict cannot

[11] Ibid., 146.

[12] Martin van Creveld, *Supplying War*, 25-26. Nusbacher believes that during the English Civil War, supply was assured by tradesmen and merchants from big city centers like York and London, who sold local and imported victuals to both armies. See Aryeh Nusbacher, "Civil Supply in the Civil War…" 160.

be obviated, but this is not the subject of this study. This observation serves to underscore the present predicament of a world divided by wealth on the one hand, and by scarcity on the other, leading the latter regions' constituents to compete at the level of the family, tribe, community, and sometimes of the nation for basic subsistence.

One can therefore hypothesize that coercive food deprivation makes sense only if the economic and social structure of that society makes it vulnerable to scarcity. Food becomes the "centre of gravity" if that society's survival (and internal stability) is directly dependent on consuming what it produces. Food insecurity threatens national or group security in a context of absolute deprivation. This deprivation can be the consequence of natural or man-made disasters as much as invasion. When conflict impacts the nutrition of a people, we can speak of the political objectives that deprivation meets. This deprivation has biological consequences, and the coping mechanisms can be of two kinds: flight or fight.

During the Vietnam War, the United States Marine Corps applied the doctrine it had developed in its Small Wars Manual (1940). The doctrine's aim was the "social, economic and political development of the people subsequent to the military defeat of the enemy insurgent."13 The "combined action platoons" program (CAP program) deployed in South Vietnam aimed at supporting the evolution of rice farming from subsistence to market, and to deprive the Viet Cong from supplying itself from the farmers' production. The CAP program "measured success by looking at indicators of village stability… If the villagers felt secure enough to buy rice seed, harvest it, and not turn it over to the V.C. [Viet Cong]… [this] meant that another catty [of rice] had to be grown in North Vietnam and brought over…"[14] Agricultural production can still be used as a positive military incentive in countries, like Afghanistan and Sudan, where the peasant economy is exposed to extreme natural events or human depredation.

Advanced economies, on the contrary, have developed means to generate wealth that allow them to procure food for consumption. It is well understood that it is surplus household wealth that drives consumption and sustains a country's economic growth. Clearly, food deprivation is impossible as a tactic to compel an advanced society as global interconnections offer many avenues to supplement or replace consumables. Advanced societies, integrated in the global trade network depend on commercial lanes of communication for continued economic growth.

Because agricultural production has become another traded commodity, food security is only indirectly related to national security if an economy is diversified enough in what it produces and how it can access foodstuffs. But as Ted Robert Gurr has demonstrated in his seminal Why Men Rebel (1970), individuals' and groups' frustrated expectations, if intense and prolonged enough, will lead to aggressive behaviour.[15] In advanced economies, it is expectation of material reward

[13] Andrew Krepinevich, *The Army and Vietnam*, (Baltimore, MD: Johns Hopkins University Press, 1986), 172.

[14] Scott Sigmund Gartner, *Strategic Assessment in War*, (New Haven, CT: Yale University Press, 1997), 149-150, quoting Walt in Krepinevich.

[15] Ted Robert Gurr, *Why Men Rebel*, (Princeton, NJ: PUP, 1970), 47-53.

that needs to be met, not merely subsistence nourishment. This entails that continued internal social stability depends on sustained economic growth. In this case, one should not discount the possibility of economic warfare, of trade and financial tactics aimed at gaining a unilateral advantage over other countries, or aimed at unsettling a particular country's ability to allocate resources according to its own priorities. Economic or trade warfare can take place for example through the manipulation of interest rates, currency values, of commodity prices, by throttling production or exports, thereby depriving a rival country (or group) of supplies.[16]

It could therefore be hypothesized that a group or country could induce, through the use of force, conditions of absolute or relative deprivation in a bid to compel or destabilise an opponent.17 Regardless of the level of economic and social sophistication of a political system a "malfunctioning distribution regime will still descend into crisis."[18]

Governance, global interconnectedness and food-related conflict

Instability is the upsetting of a normal status of relations between the political leadership and the governed within a nation, or the "normal" relationship between nations (even if this relationship is asymmetrical). The premise that every system of government seeks to perpetuate itself has been demonstrated in the past by Bruce Bueno de Mesquita et al in The Logic of Political Survival (2003), while the solidity of the bonds between governed and leadership has been defined as a function of the ability of a government to provide for its people, as opposed to the people providing for the government (or regime).[19] Whether as a matter of regime survival or out of a sense of humanitarian responsibility towards its constituents, a government's duty is to ensure that no upheaval will threaten national institutions.

Weak governance is the inability to address underlying risk drivers. As the Global Action Report (GAR) 2011 argued:

> All governments are responsible for assets, some of which are risk-prone. Governments have explicit responsibility for the safety of publicly owned assets, including schools, hospitals and clinics, communication networks, roads, bridges and other parts of the national infrastructure. At the same time, they have a responsibility for protecting the lives, livelihoods and uninsured private assets of households and communities after a disaster.[20]

Because polities are interconnected through the world system of trade, an event in one country will have repercussions in another. Furthermore, the international legal and normative constraints

[16] Robert Loring Allen, "State Trading and Economic Warfare", *Law and Contemporary Problems*, 24:2, State Trading Part 2, Spring 1959, 261-263. See also Richard Stuart Olson, "Economic Coercion in World Politics, with a Focus on North-South Relations", *World Politics*, 31, July 1979.

[17] Jean-Paul Azzam and Anke Hoeffler, "Violence against Civilians: Looting or Terror?", *Journal of Peace Research*, 39:4, July 2002, 462.

[18] John Rapley, *Globalization and Inequality: Neoliberalism's Downward Spiral*, (Boulder, CO: Lynne Rienner, 2004), 8.

[19] Barry Buzan, *Peoples, States and Fear*, (Boulder, CO: Lynne-Rienner, 1991).

[20] GAR 2011, Introduction, 3.

inherent in the global commercial system will tend to limit governments' margin of action.[21] Conflict or drought in a low-income country that depends on agricultural exports for revenue will increase exposure to that country's absolute deprivation, but it may expose the client country to relative deprivation (i.e. inflationary pressures put staple commodities out of reach of average purses).

Global trade interconnectedness is not a new idea, nor is economic interdependence a new phenomenon. The episode of the Cold War may have given the illusion that the world was naturally divided in autarchic spheres of influence, but that has never been the norm. In fact, trade makes nations co-dependent, even in a neo-colonial or neo-imperialist setting; advanced economies need low-income economies for growth, whereas low-income economies rely on trade to move from a subsistence model of agricultural production to diversification. In being co-dependent, governments have mutual responsibilities when it comes to effective governance. This is what Kenneth Boulding has called the "world economic interest"; an objective "good" that makes consensus from one country to the next, regardless of the economic model being employed to keep constituents satisfied.[22] Governments are expected to behave in a way that will not adversely affect the security of other nations.

The United Nations declared the 1960s the "Decade of Development", urging more effective governance – through national planning – to remove hindrances to the entry of Third World production in the mainstream market. It is important to note that the objective of the Development Decade was to produce self-sustaining growth. But there were several structural impediments to meeting the UN's development goals. The first was the persistence of the peasant economy, which, not having changed much since Antiquity, remains vulnerable to conflict and disaster. "The way peasant units internalize risk and uncertainty [explains] the cropping methods which, though they generate lower income, lessen the variability of the expected values of output."[23] This explains why rural households seem less vulnerable to malnutrition than urban ones; farms produce in a way to ensure their own survival first, and variances in production affect the cities to which they sell.

The national policies of client States also mitigated economic diversification in the developing world. Economies whose constituents are peasant units are often confronted to the policies of client nations who engage in protectionism. A peasant economy that attempts to escape the Paretian logic of specialisation, and develop through diversification, will find itself at a disadvantage when developed economies subsidize their own agricultural sector.[24]

---

[21] For example, World Trade Organization rules and the belief that a free-market economy self-regulates.

[22] Kenneth Boulding, "The Concept of World Interest", in Richard A. Falk and Saul H. Mendlovitz, eds., *Disarmament and Economic Development, The Strategy of World Order, Vol. 4*, (NY: World Law Fund, 1967), 502.

[23] Alexander Schejtman, "The Peasant Economy: Internal Logic, Articulation, and Persistence", in Charles K. Wilber and Kenneth P. Jameson, eds., *The Political Economy of Development and Underdevelopment*, 5th ed., (NY: McGraw-Hill, 1992), 290. See also GAR 2009, Ch. 4, 90.

[24] Ibid., 320.

Finally, another disincentive for economic diversification has been the developing world's Cold War relationship with the two Superpowers. When the Cold War ended, the ideological quality of the aid relationship evaporated (and with it a significant amount of financial support to low-income countries). The "protection" that the low-income countries enjoyed from their superpower overlord vanished, exposing them to the depredation of other countries or ethnic groups, or even in recovery against major disasters. The national interest of the superpowers was not aligned with that of developing nations anymore. Governments were relieved of the conditions set by the superpowers, and became subject to the conditions of an expanding free market system instead.

National security has become dependent on human welfare enhancement, what Michael T. Klare has called the "economization of international security affairs".[25] Governments will define their national interests and identify risks to growth depending on their levels of economic sophistication. It is no surprise then that Klare anticipates conflict over water in regions that are still under development (in the Middle East) whereas industrialised nations will seek to shield their economies from disruption of vital natural resources (oil and gas).

Leaving the strategic and economic environment of an autarchic bi-polar system, polities took time to integrate the fact that faraway events had local consequences. In time, humanitarian intervention, the evolution of post-Cold War peacekeeping, and the Responsibility to Protect (R2P) have been developed as answers to the global consequences of local and disparate natural and man-made hazards. They are political mechanisms to force delinquent governments to take their responsibilities for the welfare of their constituencies, and also to compel them to continue honouring their commitment to norms of good behaviour regarding international trade and legal regimes.

Klare argues that a new geography of conflict is emerging, where tensions are driven by

> ...the priority accorded to economic considerations by national leaders, the ever-growing demand for a wide range of basic commodities, looming shortages..., social and political instability in areas harboring major reserves of vital commodities, and the proliferation of disputes over the ownership of important sources of supply.[26]

A government's central responsibility is then to mitigate natural or man-made events – including conflict – that can affect constituencies' agricultural production ability and output, and the prospect of sustainable development.[27] Because this is primarily a national responsibility, structural or non-structural mitigation measures could (intentionally or not) transfer risk extra-territorially.

[25] Michael T. Klare, *Resource Wars*, (NY: Henry Holt and Co., 2001), 10. Italics in the text.
[26] Ibid., 213-214.
[27] See GAR 2009, the disaster risk-poverty nexus, a function of trans-border risk transference, and Ch.6.

Case Study: Fishing and piracy off Somalia

In 2007-2008, food riots erupted in 14 African countries[28] because governance was unable to mitigate inflationary pressures by intervening in price controls, and because households were unable to enact usual coping mechanisms.[29]

This was only the latest in a long string of catastrophes to hit that continent. Somalia epitomizes poverty and state failure. The country exists in a context of "complex emergency"; an environment characterised by conflict, chronic poverty, as well as vulnerability to natural disasters and extreme events. Abdinasir Abdulle, Minister of Finance for Somalia's Transition Federal Government (TFG) stated that "…the Somali economy is surprisingly robust. […] The private sector has survived, and to some extent, flourished in the near anarchical environment of the last decade and a half. It has been a major source of livelihood for the population and the reason why the economy has not imploded."[30] While many might perceive such a statement as euphemistic, it reminds us that whereas human needs are universal, the governance models to meet these needs are not.

Somalia was abandoned by its Cold War sponsors, and fell into "anarchy" after the removal of Siad Barre in 1991. That Somalis suffered from the ensuing conflict is well-known.[31] But conflict was a function of power relations internal to the country. To the external viewer, governance was seen to collapse because there was no central authority. It could nevertheless be argued that the prominence of warlords and self-appointed militias are a reflection of Somalia's traditional clan-based social structure, and that this structure auto-regulates.[32] Admittedly, the reconciliation process between warring factions has permitted the emergence of a semblance of national authority in Puntland and Somaliland[33], but this outcome remains elusive for Central Somalia.

Lack of governance, which many analysts blame for the emergence of piracy off the coast of Somalia, should therefore be qualified. Fishing industry performance in Somalia offers an indicator of relative control over resources by a national authority, and offers a glimpse in the relationship between food insecurity, conflict and national security.

---

[28] Julia Berazneva and David Lee, "Explaining the African Food Riots 2007-2008: An Empirical Analysis", (Ithaca, NY: Cornell University – Charles S. Dyson School of Applied Economics and Management, March 2011), 30.

[29] Some examples of household survival strategies in contexts of extreme pauperization are provided by Tony Beck, "Survival Strategies and Power among the Poorest in a West Bengal Village" in Charles K. Wilber and Kenneth P. Jameson, eds., *The Political Economy of Development and Underdevelopment*, 5th ed., (NY: McGraw-Hill, 1992), 482-483.

[30] African Development Bank (ADB), *African Development Bank Group in East Africa: Consolidating the Present and Shaping the Future*, (Tunis: ADBG, 2012), 102.

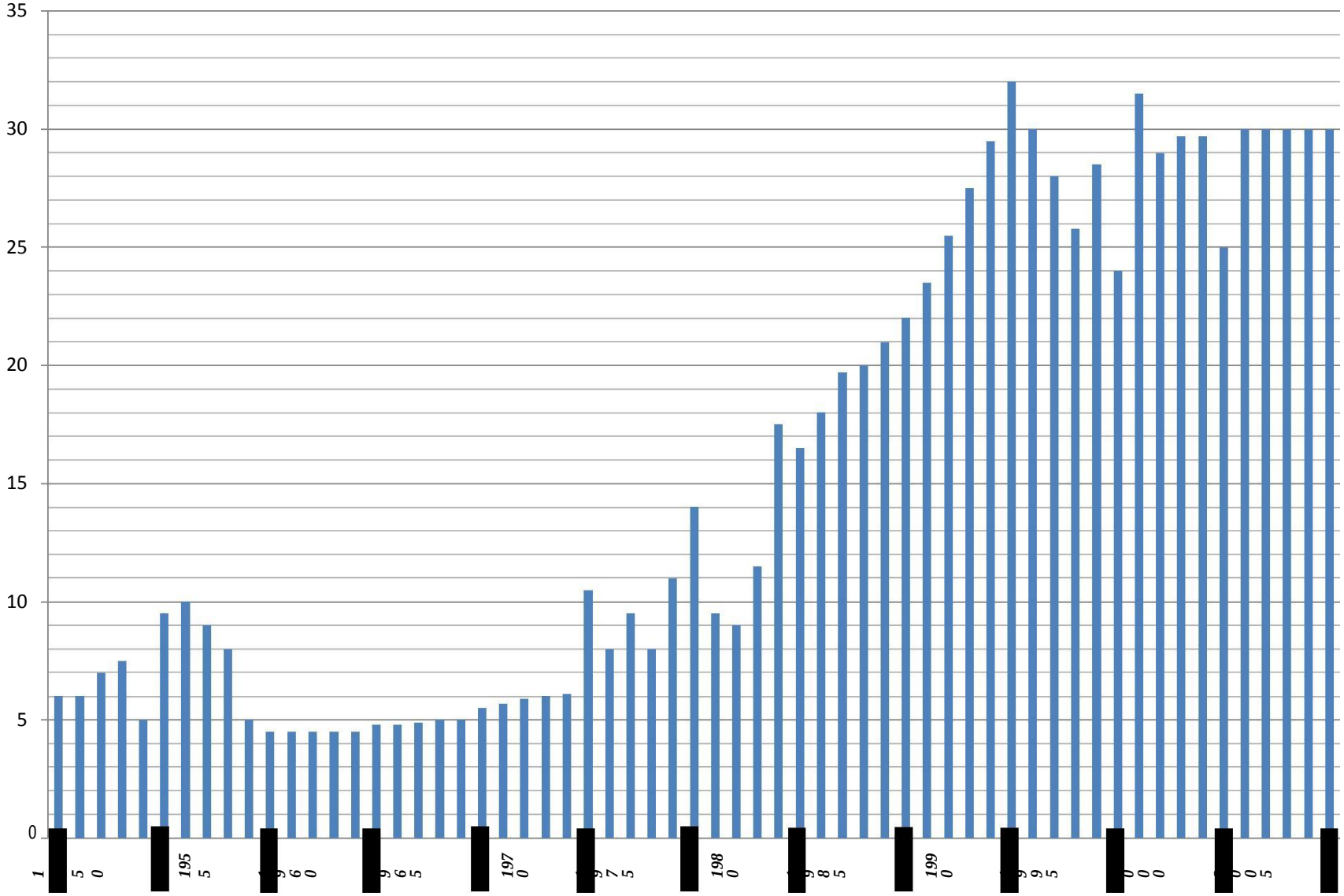
[31] Freedom C. Onuoha, "Sea Piracy and Maritime Security in the Horn of Africa: The Somali Coast and the Gulf of Aden in Perspective", *African Security Review*, 18:3, 2009, 37.

[32] Jeffrey Gettleman, "The Pirates are Winning!", *New York Review of Books*, October 14, 2010.

[33] ADB, 103.

Figure 1. Somalia

Figure 2: Yearly catch in Somalia, 1950-2010, in thousands of tons.[34]

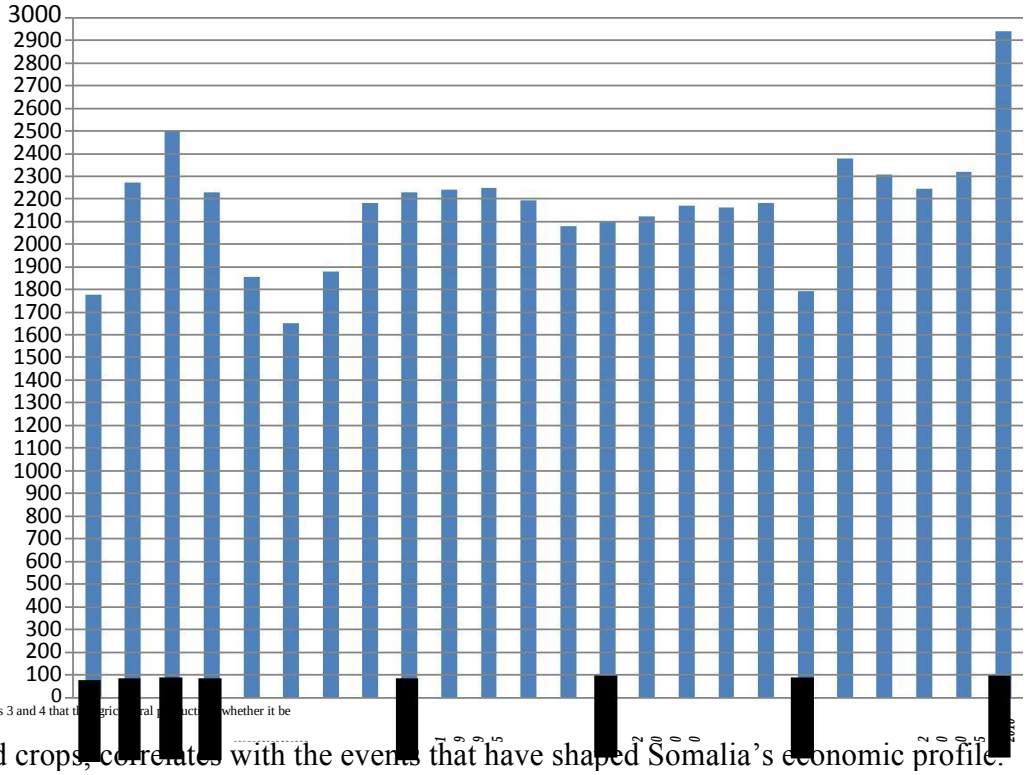


[34] Source: Food and Agriculture Organization (FAO), http://www.fao.org/figis/servlet/SQServlet?ds=Production&k1=COUNTRY&k1v=1&k1s=201&outtype=gif&gr_props=webapps/figis/species/format/gform_large.txt accessed 26 July 2012

Since decolonization, the Somali fishing industry has been mostly artisanal. Figure 2 above gives estimates of the tonnage captured off the coast of Somalia in the last 60 years. A number of observations of historical significance help us understand the trends. First, the graph shows the last decade of colonialism, 1950-1960, to be more profitable compared to the period of time between 1960 and 1974. This is due to the fact that statistics necessarily reflect the greater yield of the colonial fishing fleets until 1960. One notes that the proportion falls by half after 1960. We can therefore submit that the artisanal (domestic to Somalia) share of the yield is reflected after 1960 (Somalia being independent, the statistics are not mixed with that of colonial entities).

The spike observed in 1975 is due to the resettlement of pastoral farmers to the coast areas in the wake of the severe 1973-1975 droughts.[35] This was an economic mitigation measure that would reoccur whenever mainland agriculture would be under stress, as it was during the 1984-1985 droughts. We note, however, that in general, the performance of artisanal fishing continues to increase substantially. This reveals that a proportion of farmers have chosen to stay on the coast rather than to return to an ingrate field. The catastrophic drought of 1984-1985 is especially telling in this respect, as we see a steady increase in the yearly tonnage.

Figure 3. Milks produced, in thousands of metric tons, Somalia.[36]



We can note immediately from Figures 3 and 4 that the agricultural production, whether it be milks, meats and crops, correlates with the events that have shaped Somalia's economic profile. The drops in production associated with the drought in 1975, 1984-1985, the war years of 1991-

[35] Emanuel N. Sone, *Piracy in the Horn of Africa: The Role of Somalia's Fishermen*, MA Thesis, Monterey, CA: Naval Postgraduate School, December 2010, 13.

[36] Food and Agriculture Organization data compiled from FAOStats combining annual production of cow, goat, sheep and camel milk. faostat.fao.org/site/339/default.html, consulted 3 August 2012.

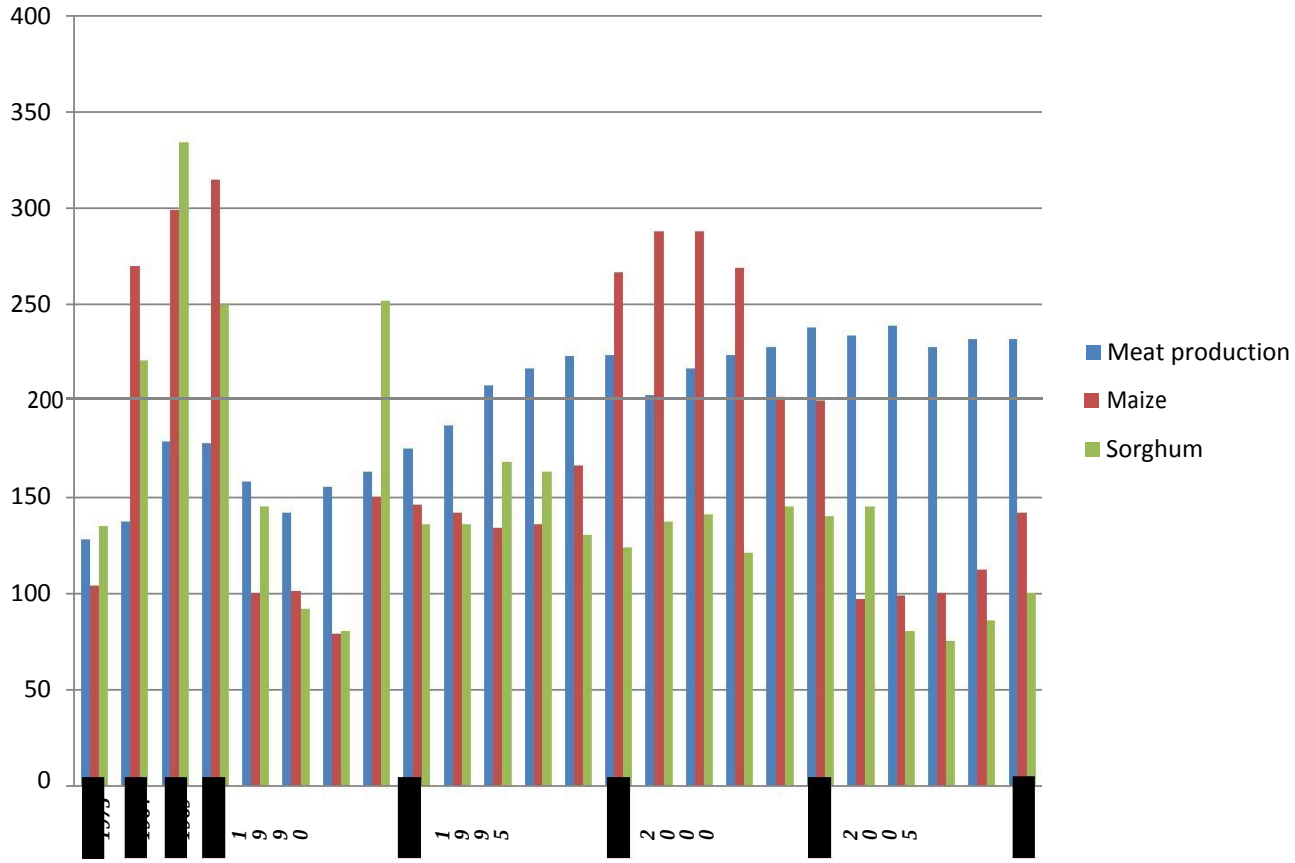
1994, and the Tsunami in 2005 correlate with an increase in fishing yields. This is all the more impressive since the Somali population, which had been stable at 6.6 million until 1990, began to grow in 2000.

Table 1. Population of Somalia[37]

1990	1995	2000	2005	2010
6.6 million	6.5 million	7.2 million	8.3 million	9.3 million

It is interesting to note that the demand created by demographic growth has been met by fishing. Proof of this is in the production rate of other top Somali products for mass consumption, such as meats, maize and sorghum. This proves that the Somalis have turned to the sea for sustenance since around 2000, and are leaving the fields.

Figure 4. Meats, maize and sorghum, in thousands of metric tons, Somalia.[38]



[37] United Nations Development Program (UNDP) Human Development Reports, hdrstats.un.org/en/indicators/306.html consulted 3 August 2012.

[38] Food and Agriculture Organization data compiled from FAOStats combining annual production of cow, goat, sheep and camel meats, maize and sorghum. faostat.fao.org/site/339/default.html, consulted 3 August 2012.

Again, the data for the 1975 shows a catastrophic return due to the drought, but also due to the fact that farm labourers had been redirected to the fishing industry. We see that the war years have had a no less catastrophic effect from 1991-1994. However, this drop also corresponds to the fishing industry's growth years in Somalia. Inversely, the years 1995-2002 indicate that farmers did return to their fields, as the performance of fishing momentarily dropped in favour of increased meat production. The production of maize in 2000 can also be seen as an indicator of field-to-coast movement, but the tendency there is less robust, unless one accounts for the dramatic demographic increase of those years. The meat and milk production has not increased since 2005, with the exception of 2010, which has been a banner year for milks.

In comparison the years 1974-1989 show the fisheries industry's performance increase significantly the Somali government of the time having granted fishing licenses to the USSR's industrial trawler fleet. It could be argued therefore, that between 1974 and 1989, control of Somali fishing waters was "governed" by the bilateral relationship between Somalia and the USSR. This idea finds support in the fact that Somalia ratified the UN Convention of the Law of the Seas (UNCLOS) in July 1989, as Soviet power waned.[39] Somalia may have sought the protection of its national waters and resources, but this is doubtful since Somalia did not declare an Exclusive Economic Zone (EEZ) of 200 miles, and also since the Convention came into effect only in November 1994.[40] Coincidentally, this is after General Mohammed Farah Aideed convened a national reconciliation conference to put a stop to the civil war that had been raging since 1992.[41]

According to Roland Marchal, Aideed's success in achieving a semblance of national control during the unrest earned him the support of neighbouring Ethiopia and Eritrea, as well as UNOSOM II, the UN mission to stabilize Somalia.[42] This relative control, as well as the fact that the UN had to use maritime points of disembarkation to offload supplies of humanitarian aid may have created a secure atmosphere for the fishing industry, explaining its performance during the period of conflict.

According to Carrie Booth Walling, the US-led Unified Task Force (UNITAF), which supplanted the UN Mission in Somalia (UNOSOM I) as the first peace enforcement mission, was designed to relieve the humanitarian crisis brought on by internal warfare.[43] The war years, compounded by drought and other catastrophes (such as the 2004 tsunami), eroded this function by triggering internal migration, leaving land untilled, and disconnecting families from their farms. In addition, local militias resorted to looting for their own survival, suggesting that the

---

[39] United Nations, *Report of the Secretary General on the Protection of Somali Natural Resources and Waters*, S/2011/661, 25 Oct. 2011, para. 26.

[40] Ibid., paras. 28-29.

[41] Ibid. para. 26. Coincidentally, this would also be the moment that the UN would choose to withdraw from Somalia and wrap up UNOSOM II.

[42] Roland Marchal, "Somalie" in Hélène Arnaud, Bertrand Badie *et al*, *L'État du Monde 1996*, (Montréal : Boréal, 1996), 413.

[43] Carrie Booth Walling, *The United Nations Security Council and Humanitarian Intervention: Causal Stories about Human Rights and War*, dissertation submitted in partial fulfillment of a Doctor of Philosophy degree, University of Minnesota, June 2008, 113.

degree of economic and commercial maturity of the country forced households back into subsistence agriculture.[44] In such a context, war created absolute deprivation, since no cultivation or harvesting took place, farmers having been displaced.

After the wrap-up of UNITAF, the UN Security Council expanded the UNOSOM mandate to include a disarmament component. The objective of disarming Somali militias was to protect NGO and UN workers and the delivery of humanitarian aid. Seen from the point of view of General Aideed and the SNA, however, this meant that whatever supplies that were unloaded by the UN could no longer be commandeered, as they would go more directly to the populations in need. Organizational survival, not to mention victory over competing militias, meant that the SNA had to resist this mandate. UN peacekeepers and workers became targets of the SNA militias, which lost Aideed whatever goodwill the UN was willing to extend.

This situation did not obtain on the coast because many displaced farmers took to coastal fishing because of the duress they faced inland. This explains why the statistics reflect an increasingly prosperous artisanal fishing industry throughout the war years, up to 1995.[45] That year was Somalia's most successful fishing year, and this could be attributed to the entry into force of UNCLOS. Foreign fishing fleets may have assumed that Somalia had declared an EEZ, freeing the seas for Somali fishing for that year. Figure 2 shows a loss of output in the years after the UN withdrawal, and corresponds to an increase in illegal, unreported and unauthorized (IUU) fishing by foreign fleets.[46]

Incidences of piracy started occurring around the time the UN departed (late 1994), lending credence to the notion that the UN mission and peace enforcement forces acted as deterrent to both piracy and illegal fishing. As Sone would contend, the UN presence (as the Soviet presence did years before) provided for a modicum of respect for Somali territorial waters. But while Sone does not believe there is a correlation between IUU and piracy, using fisheries output as an indicator is troublesome. An increase in output may indeed suggest that piracy is taking place despite good fishing results. However, one can also credit the deterrence effect of piracy on *any* kind of shipping for the increase in fishing output. Indeed, it seems that the pirates have taken back Somali waters on behalf of themselves and the artisanal fishermen. In this sense, the pirates have reclaimed seas from IUU fishing boats that leveraged Somali anarchy to fish with impunity. Establishing a positive effect between piracy activities and fishing output is straightforward.

The International Maritime Organization (IMO) has been keeping track of and publishing worldwide piracy incidents since May 1991. While the level of accuracy of the IMO's reporting has diminished by 1995, it is nevertheless easy to see that in 1991, virtually all reported instances of piracy occurred in Asia, except for one off Cameroon, and three in Rio de Janeiro, Brazil.[47]

---

[44] Roger Middleton, *Piracy in Somalia: Threatening Global Trade, Feeding Local Wars*, Chatham House Briefing Paper AFP BP 02/08, October 2008, 5.
[45] Sone, *Piracy in the Horn of Africa…,* 35.
[46] Ibid., 38, see also S/2011/661, Section III A-B.
[47] IMO, MSC Circ. 577 of 23 October 1991, and MSC Circ. 577 add. 2 of 8 January 1992.

The first reports of piracy on the East Coast of Africa came in late 1992, with two instances off Tanzania.[48] The first incidence of piracy off the Somali coast took place 12 January 1991, with the taking of the M. V. Naviluck, a dry bulk cargo ship registered in Malta.[49]

The following reporting period, January-March 1993, saw 50% of incidences of piracy coming from regions outside of Asia for the first time.[50] By December 1993, only a minority of reporting incidents came from Asia.[51] Piracy off the Horn of Africa took off in mid-1994, with one instance off Djibouti, one in the Gulf of Aden (the defection of Yemeni soldiers)[52] and two attacks in Somalia in 1994.[53] In 1995, one of the best years for Somali artisanal fishing, Somali piracy also took off; the first two attacks of the year took place in April 1995.[54] Incidences tripled for the final two reporting periods for that year, meaning that Somali piracy reports made up 15% of all reported piracy activities worldwide.[55] Between 1996 and 2002, the number of attacks on shipping off the coast of Somalia never exceeded 6, although this period also shows a steep drop in catch tonnage.[56] There is a correlation between the emergence of piracy and the performance of the fishing industry for the first 7 years. It is only in 2001, the year that Somalia regained some sort of central governability that the fishing output reached 1995 levels again. In 2004, the number of piracy incidents doubled to ten, with attacks far out to sea for the first time.

Figure 5. Incidences of piracy off the East Coast of Africa and Somalia, 1991-2011[57]

[48] IMO, MSC Circ. 577 add. 5, of 31 December 1992.

[49] IMO, MSC Circ. 577 add. 12, of 30 September 1994. The IMO records incidents as it receives reports. In this case, the report arrived more than three years later.

[50] IMO, MSC Circ. 577 add. 6, of 31 March 1993.

[51] IMO, MSC Circ. 577 add. 9, of 31 December 1993.

[52] IMO, MSC Circ. 577 add. 13, of December 1994.

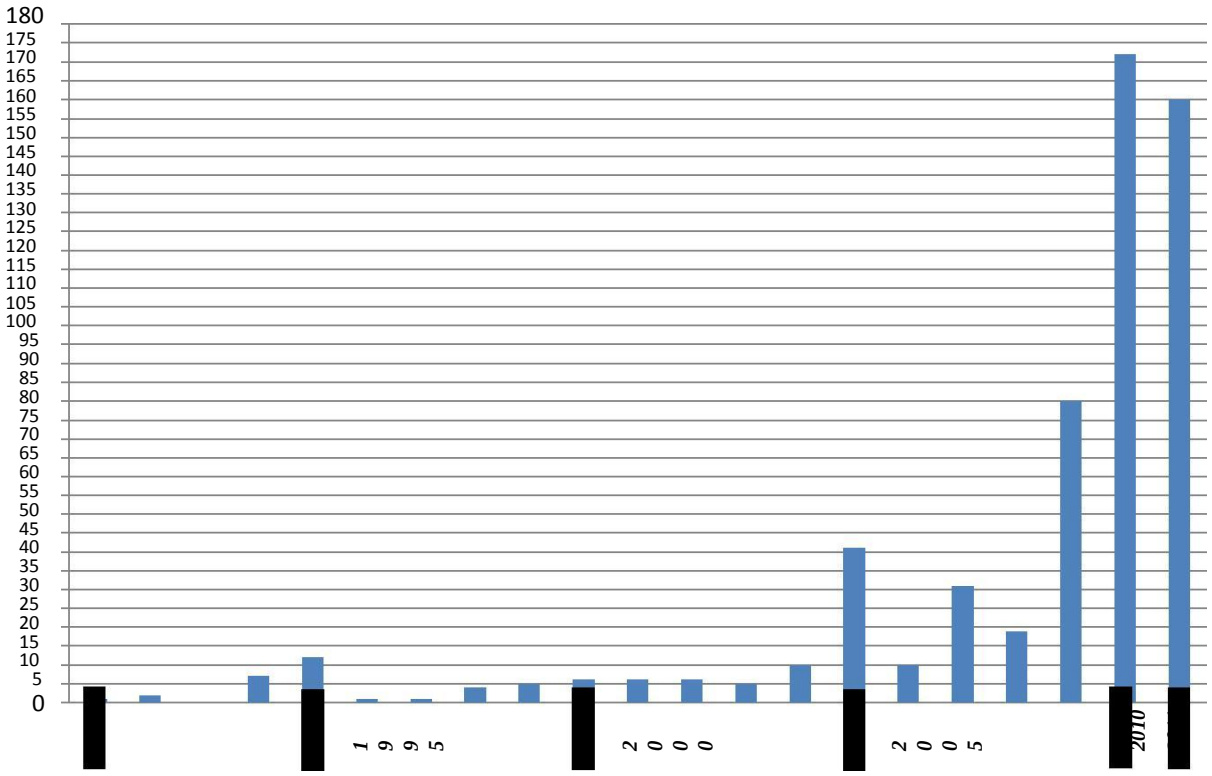
[53] IMO, MSC Circ. 679 of 31 March 1995.

[54] IMO, MSC Circ. 698 of 30 June 1995.

[55] IMO, MSC Circ. 709 of 30 September 1995, and MSC Circ. 714 of 31 December 1995.

[56] IMO, MSC various Circulars and Annual Reports.

[57] IMO, MSC various Circulars and Annual Reports for 2009, 2010 and 2011.



It is in 2005 that piracy off the coast of Somalia gained worldwide attention with 41 attacks, a number that steadied only for two years (43 in 2007). The impact of the 2004 tsunami cannot be put in doubt; the wave devastated the already impoverished coast, leading the fishermen with no means to earn a living or provide for their families. Whereas pre-tsunami piracy could have been "excused" as a form of Somali waters vigilantism, the sudden increase in events post-tsunami seems to indicate that piracy was being pursued for its own sake.

Farmers who had become fishermen could no longer ply their trade (as figure 2 shows) after their meagre infrastructure was destroyed by the giant wave. Even with receding IUU, piracy flourished to the point of denying labourers to both fisheries and agriculture, meaning that the resulting undernourishment had to be mitigated with humanitarian aid deliveries. Piracy became a coping mechanism for fishermen disaffected by the tsunami.

In 2006, there were virtually no occurrences of piracy in Somalia, thanks to the interlude provided by the Islamic Court in Mogadishu. It is interesting to note that the performance in fishing did not improve significantly, and neither did agricultural production. Analysts are quick to show that with a central authority, the problem of piracy can be solved.[58]

In 2000, Somalia had adopted the Transitional National Charter, a first step in regaining central control over the country. This was followed in 2004 by a Transitional Federal Charter, which

[58] Middleton, *Piracy in Somalia*, 3.

gave the current FTG its legitimacy. The transitional period will expire at the end of August 2012, following the signing of a new national Constitution.[59] On the other hand, the duty of any central government remains to better the lot of its constituents, and after only one year, it became evident that the Islamic courts were not delivering.

Pirates and other authority figures saw that the continued "patrolling" of the Somali coast was beneficial not only to sovereignty and the fishing industry, but to the general welfare as well. Since 2007 the attacks have more than tripled, making Somali waters and the Gulf of Aden the most dangerous waters to sail, and it is since that year that we can say that the degree of piracy has become less "legitimate" internationally, because neither the tonnage in fishing or agricultural production has not been improved by this activity, especially in a context where, according to table 1, the population will soon reach 10 million. In 2008, the World Food Program needed convoy protection by North Atlantic Treaty Organization (NATO) and European navies to avoid humanitarian aid deliveries from falling into pirates' hands.[60]

Above : The Canadian frigate *HMCS Ville de Québec's* bow gun with WFP commemorative logo sailing past a cargo ship on the St-Lawrence River, 30 July 2012 (Photo: F. Labarre).

The correlation between the increased legitimacy of "state" institutions and the dramatic increase in piracy cannot be avoided. Here, mainstream conceptions of governance clash with the evidence of relative success. With piracy comes respect for Somalia's international waters, and the improvement of the lives of artisanal fishermen. There is no doubt that the proceeds of piracy

[59] George Okore, "Somalia Moves to Get New Constitution", *AfricaNews.com*, 25 July 2012, http://www.africanews.com/site/Somalia_moves_to_get_new_constitution/list_messages/42039 accessed 26 July 2012.

[60] Middleton, op. cit., 9.

are recycled into the Somali system of government. Indeed, these activities cannot continue without the tacit or explicit avail of the current authorities in Puntland and Somaliland.

Mainstream understandings of national security have to be put in perspective. If the structure of authority is the clan, there is no point for the international community to try to address grievances to a Ministry. On the other hand, there is sufficient evidence to show that Somalis have taken the responsibility of protecting their natural resources and the livelihood of their artisanal fishing communities.

But the fact that this form of "informal taxation" on the high seas makes passage dangerous and unpredictable has not been lost on advanced democracies. Real money is lost through to piracy, which has become the single most lucrative activity in Somalia.[61] The problem, of course, is that plunder has become more attractive than fishing.[62]

When pirates become bold enough to *threaten* trade (the number of successful attacks has dropped thanks to the escorting of vessels through the Gulf of Aden), the markets react through speculation, which hits the consumers in advanced economies. This impact can be felt in inflation, and in the price of commodities down the line, leading to a perception of relative deprivation in advanced economies' constituencies. This is how the internal stability of larger powers and developed nations is affected by Somali piracy, the root of which is foreign fishing companies taking predatory advantage of Somalia's lack of governance and means to enforce its sovereignty.[63]

Since 2007, the UN Security Council has multiplied resolutions calling for all necessary means to be taken to mitigate the scourge of piracy off the Somali coast, including the creation by the United States of a Maritime Security Patrol Area (MSPA), of a Close Support Protection System (CSPS) by the European Union (followed in 2008 by Operation ATALANTA), and lately, by the establishment of IMO regional anti-piracy centres in Yemen, Tanzania and Kenya.[64] So far, the involvement of foreign navies has not driven the pirates back to fishing and farming, but there is the hope that greater intervention and regional ownership of anti-piracy activities will lead to safer seas, as it has in the South China and Yellow Seas, for example.

Case Study: Conflict and structural undernourishment in Armenia and Azerbaijan

The structural relationship between food insecurity and national security can be traced by correlating the degree of undernourishment and military expenditures. The business of government is primarily one of making choices with limited resources. Those choices are

---

[61] "Combating Maritime Piracy in the Gulf of Aden", *Pacific Basin Economic Council*, Hong Kong, 3.April 2011, 7-12 billion USD is lost annually in cargo and valuables Onuoha,"Sea Piracy and Maritime Security…", 38 mentions 13-16 billion USD annually.

[62] Gettleman. This observation has merit in view of the increase in the Somali population, and the relative stagnation of fishing output, compared to the decrease in agricultural output.

[63] Mohammed G. Hassan, (Advisor to the Minister of Fisheries of Somalia), *IUU Fishing and Insecurity Impacts on Somali Fisheries and Marine Resources*, paper presented at the 4th IUU Fishing and Consultation, London, Chatham House, 31 March-1 April 2008.

[64] Onuoha,"Sea Piracy and Maritime Security…", 40-41, and Middleton, *Piracy in Somalia*, 8.

necessarily driven by the strategic environment. When a strategic environment is defined by open trade, collective like-mindedness and a common vision of security (human and national), the demand for "hard security" is not as pressing. This tends to release resources for social services such as health and education, but also helps in setting up reserve funds (and provide other mitigation measures) for agriculture and environmental protection. The latter often take the shape of subsidies to help farming in times of drought or economic crises to keep food costs down. The political and security environment of the European Union, as well as North America (epitomized by their free trade pacts) is an example of a non-confrontational relationship that obviates the need for force structures aimed at immediate neighbours.

Not all regions are blessed with such good-neighbourly relations. Since the end of the Cold War and the dissolution of the Soviet Union, two former Soviet republics from the Caucasus – Armenia and Azerbaijan – have seen their economic and social development hampered by their conflict and festering rivalry. The case study that follows examines how cases of undernourishment in both countries have evolved in correspondence with military expenditures, and the economic crisis of 2008. The intention here is to demonstrate that regional military competition can have the effect on one or both participants of forcing a decision on resource allocation, perpetuating undernourishment.

This argument is not new. The history of the Cold War is that of two adversaries trying to outspend each other not only to develop a dominant force structure, but also of forcing a government in making allocation choices detrimental to domestic stability. The dissolution of the Soviet Union is due in large part to the frustrated expectations of its constituents, or relative deprivation.[65]

Gustavo Lagos, writing in 1967, defines the situation where a collective entity perceives its relative inequality in terms of *social* underdevelopment as *atimia.* This is characteristic of societies that are not facing absolute deprivation (as in the case of Somalia, above).[66] Therefore the potential for domestic instability borne out of frustrated expectations (because resources are allocated towards non-social objectives) tends to increase.

The data between the status of undernourishment in Armenia and Azerbaijan can be taken independently of one another for a certain period. However, it can be argued that since the beginning of the economic crisis in 2008, the relations between the two countries – frozen since the early 1990s due to the conflict in Nagorno-Karabakh – have worsened, triggering a local arms race, accentuating the security dilemma. As we can see, this arms race has the effect of increasing the prevalence of undernourishment in the weaker of the two belligerents, Armenia.

[65] See Ted Robert Gurr, *Why Men Rebel*, (Princeton, NJ: PUP, 1970).

[66] Gustavo Lagos, "International Stratification and Atimia" in Richard A. Falk and Saul H. Mendlovitz, *The Strategy of World Order, Vol. 4: Disarmament and Economic Development*, (New York: World Law Fund, 1967), 596-598.

Correlating the kilocalorie availability and percentage of undernourishment between Armenia and Azerbaijan informs us little on the status of their relations, or how their relations influence these two variables. The data from UN reports on the *Status of Food Insecurity* (SOFI), which began to release such data only in 1999, shows that Azerbaijan fared significantly worse between 1996 and 1999 than Armenia, against which it had lost a short war but bitter war between 1992 and 1994.

Azerbaijan went to war against Armenia when the latter decided to support the secession from Azerbaijan of the Armenian-dominated region of Nagorno-Karabakh.[67] Armenia's military success spurred the displacement of some 600-700 000 Azeris from Nagorno-Karabakh, who had nowhere to go but to Azerbaijan proper.[68] With that many more mouths to feed, Azerbaijan earned a mention in the FAO's first SOFI report in 1999, as having a proportion of malnutrition far greater that Armenia's.[69] The Azerbaijani government sued for peace in the face of the well-organized Armenian onslaught, and also to calm the fears of large foreign investors, eager to cash in on the allegedly large oil reserves of the Caspian Sea.[70]

For two decades, the countries have been engaged in a rivalry that has hampered their respective development, and both sides have worked to keep the conflict between them frozen, but for different reasons. By playing for time, Armenia hopes to make its Nagorno-Karabakh success a fait accompli of international relations, while Azerbaijan has used the lull to replenish its forces and build up its arsenal.[71]

Dozens of peace talks have occurred over the last decade; all have come to naught. In 2005, there was genuine feeling in the expert community that a solution to the conflict could be found.[72] Subsequent rounds of negotiations have been less promising, with both sides tacitly accusing each other of bad faith, compounding the belief that both sides have an interest in stalling progress.

> The official negotiations have also not significantly tempered the great scepticism and cynicism among both Armenians and Azerbaijanis about a possible end to the conflict. There is deep distrust of the mediating process, and many on both sides are suspicious that the talks are little more than window-dressing.[73]

---

[67] Svante Cornell, "The Unruly Caucasus", *Current History*, 96:612, October 1997, 341.

[68] Steve LeVine, *The Oil and the Glory*, (NY: Random House, 2008), 187. See also International Crisis Group (ICG), *Tackling Azerbaijan's IDP Burden*, Europe Briefing 67, 27 February 2012, http://www.crisisgroup.org/en/regions/europe/south-caucasus/azerbaijan/B067-tackling-azerbaijans-idp-burden.aspx consulted 4 August 2012.

[69] FAO, *Status of Food Insecurity in the World*, (Rome: FAO, 1999), 16. Hereafter SOFI. Note that data for 2007 and some data for Azerbaijan regarding kCal availability and percentage of population undernourished was not made available by the FAO and is inferred here from past trends.

[70] Ibid., 200.

[71] Svante Cornell, op. cit., 343, see also International Crisis Group (ICG), *Nagorno-Karabakh: A Plan for Peace*, Europe Report 167, 11 October 2005, 11.

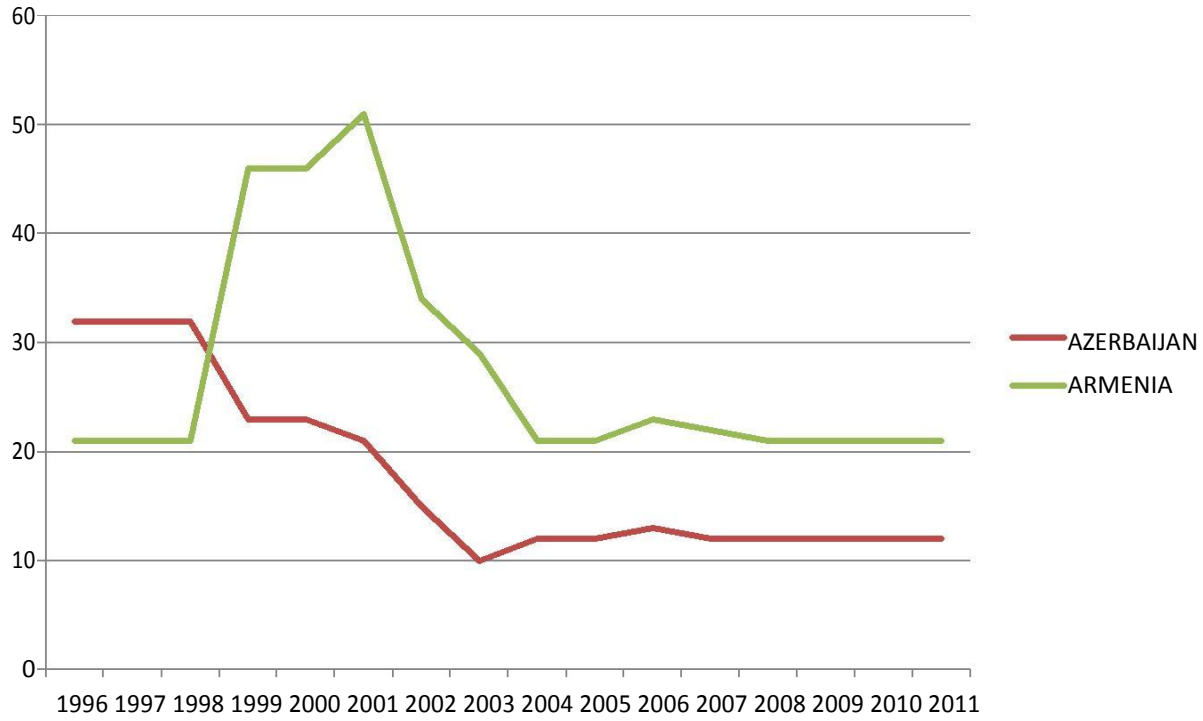
[72] ICG, *Nagorno-Karabakh: A Plan for Peace*, Europe Report 167, 11 October 2005, 29.

[73] ICG, *Nagorno-Karabakh: Risking War*, Europe Briefing 55, 7 October 2009, 1.

Azerbaijan is largely dependent upon the trade of its natural resources for domestic growth. The lack of foodstuffs reported by LeVine in Baku before the Azerbaijani economy could reap benefit from its oil exports is telling; even oil businessmen were reduced to "Fig Newtons ™, Coke™, peanuts and Saltines™" for dinner.[74]

Just how vulnerable the Azerbaijani economy is to oil prices is also revealing; when the Brent crude dropped below the break-even point for oil extraction and delivery in the late 1990s, the Azerbaijani economy started to implode.[75] We see from Figure 6 above that since 2001, however, when oil prices started rising, the percentage of undernourished in Azerbaijan fell.

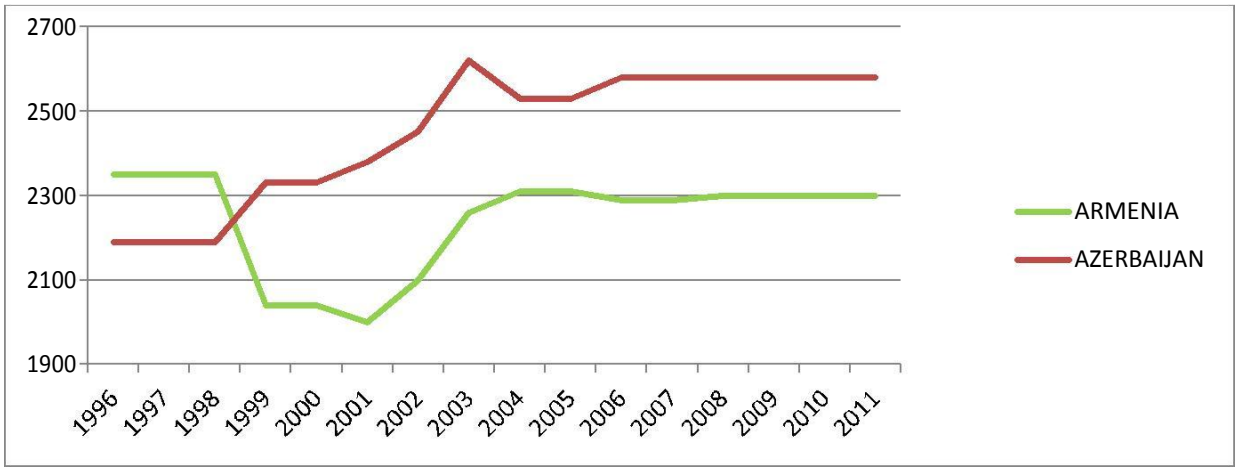
Figure 6. Percentage of undernourished population in Armenia and Azerbaijan[76]



The drop in availability of kilocalories in Armenia corresponds to an increase in the percentage of population suffering from undernourishment. Although this observation is logical, we must account for the demographic changes that have affected the two countries. While Armenia has suffered a great emigration (see Figure 9), Azerbaijan has enjoyed steady demographic growth, reversing the mutual positions on undernourishment by 2001.

[74] Steve LeVine, op.cit., 169.
[75] Ibid., 325. LeVine reports that in Azerbaijan and Kazakhstan, the Red Cross opened numerous soup kitchens.
[76] Source: SOFI Reports 1999-2006, 2008-2011. Data for 2008-2011 is an estimate.

Figure 7. Daily kilocalorie (kCal) availability for Armenia and Azerbaijan[77]



The fall in Armenian demographics can be attributed to the emigration of Armenians for work. This has enhanced the kCal availability for the population remaining behind, especially between 2001 and 2004. The opposite trend is visible in Azerbaijan which contended with a demographic increase at the same time.

The dramatic decrease in poverty and undernourishment percentage in Armenia between 2001 and 2004 is explained by the flow of remittances that Armenian families have enjoyed. Remittances are often used to feed the poorest segments of society.[78] This flow has been gravely hampered in the 2008 and 2009 economic crisis, which explains stagnation of availability and percentage of undernourished during that period.[79]

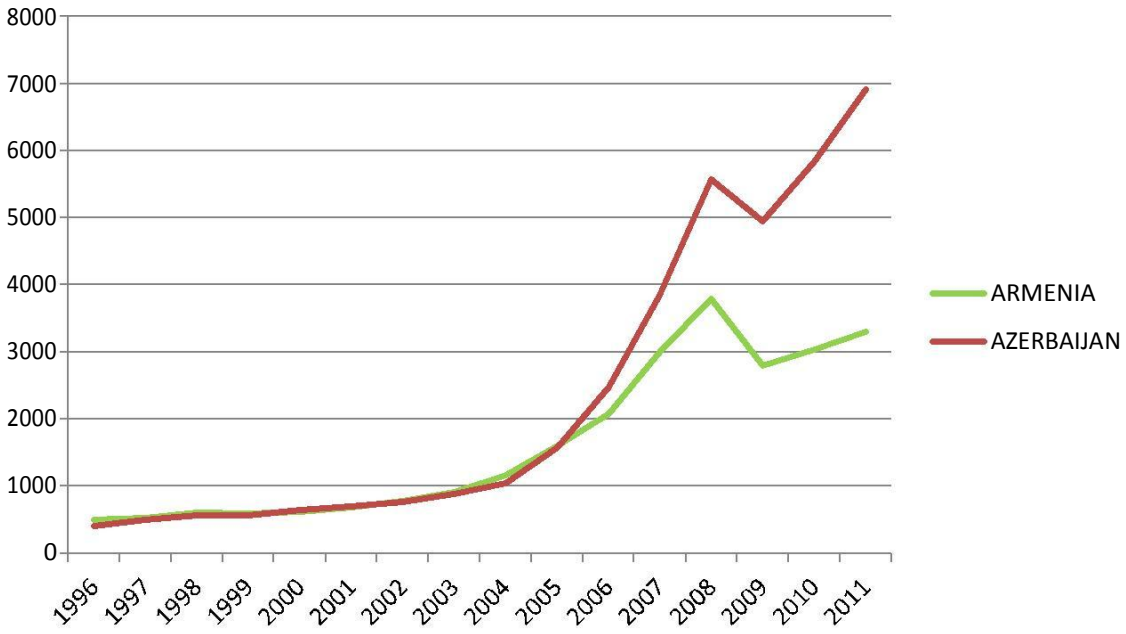
The GDP of both countries began a steady and parallel climb until 2006, when Azerbaijan began outpacing Armenia. This occurrence coincides with the gas dispute between Russia and the Ukraine in the winter of 2005-2006, and the inauguration of the Baku-Tbilisi-Ceyhan pipeline.[80] Russia's decision to deprive Ukraine of gas backfired when the downstream Western European countries that depended on the flow of oil and gas began a search for alternative supplies of energy.

---

[77] Source: SOFI Reports 1999-2006, 2008-2011. Data for 2008-2011 is an estimate.
[78] SOFI Report 2009, 24.
[79] Ibid., 16, 18-19.
[80] State Oil Company of Azerbaijan (SOCAR) website, http://www.socar-germany.de/eng/socar/scp.html consulted 4 August 2012.

The economic crisis has affected the GDP per capita of both countries (Figure 8), but the recovery has been faster in Azerbaijan than Armenia, thanks to natural resource export revenue. It must be noted that again, in the winter of 2009, Russia attempted to pressure Ukraine, this time without affecting Western European supply thanks to the presence of new pipelines from Azerbaijan, which also contributed to the quicker Azerbaijani recovery.

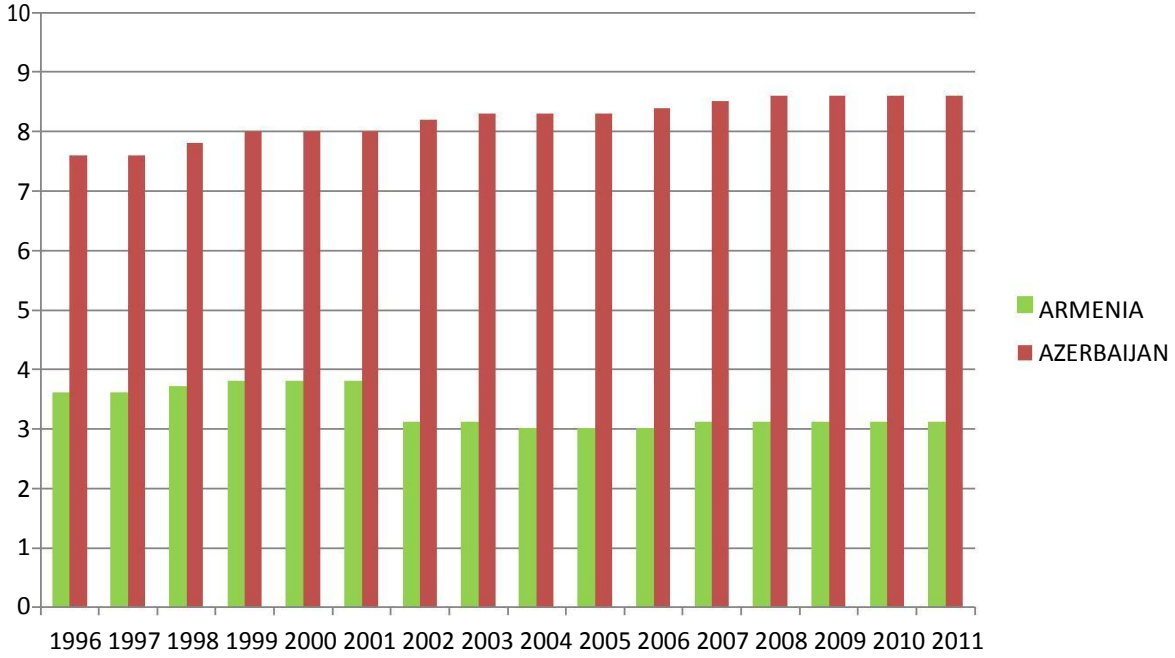
Figure 8. GDP per capita in US Dollars[81]



In comparing the two recoveries, we note severe variances in the rate of Armenian growth compared to before the economic downturn, whereas Azerbaijan's recovery has met with pre-crisis growth rates. The growth rates are a function of revenue origin. Whereas Azerbaijan can count on the high demand in oil and gas, Armenia continues to depend on remittances for revenue.[82]

[81] Source: World Bank
[82] SOFI Report 2009, 29.

Figure 9. Population growth in millions



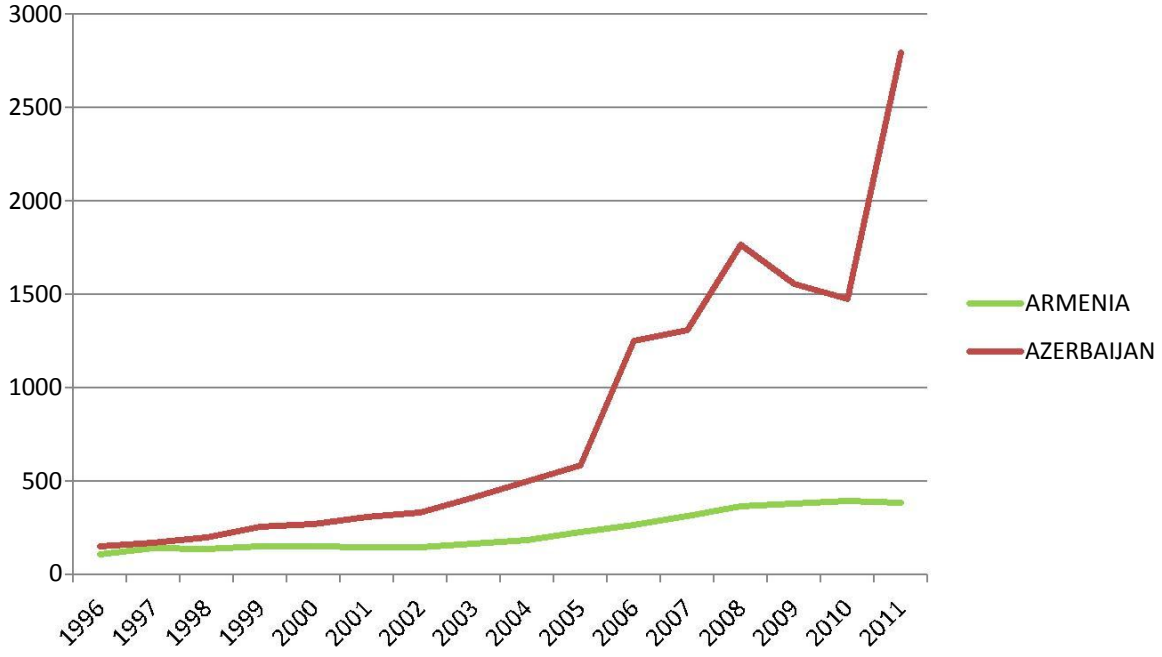
Demographics are an important variable of the equation. In that regard, the progress made by Armenia in stemming malnutrition and poverty has been less stellar than the percentages suggest, because neither the kCal availability nor population numbers have increased. Can the recovery of Armenia be dependent upon Azerbaijan's? Only indirectly, as the two countries engage in very little trade owing to their mutual animosity. However, Azerbaijan's success may influence the Armenian government's priorities.

This suggests that Armenia is at severe risk of internal instability, due to the possibility of perceived relative deprivation. Already this possibility existed in 2006, well before the crisis hit, but at a moment when Azerbaijan's progress could be seen and felt, most notably by its increase in GDP and military spending.[83] The post-election demonstrations of March 2008, which left 8 people dead and more than 450 injured in the streets of the Armenian capital Yerevan, are indicative of a reaction to perceived deprivation.[84] Relative deprivation is real, insofar as Armenia has had to devote a greater share of its national revenue to the buildup of its armed forces, to keep up with the level of expenditure of Azerbaijan.

[83] International Crisis Group (ICG), *Nagorno-Karabakh: Risking War*, Europe Report 187, 17 November 2007, 8.

[84] ICG, *Armenia: Picking up the Pieces*, Policy Briefing 48, 8 April 2008, 3. Although demonstrators protested allegedly fraudulent elections, reports of looting and vandalism prompted the government to declare a twenty-day state of emergency.

Figure 10. Military expenditure in constant 2010 million USD[85]



Again in 2009, Azerbaijan sought to increase its military dominance relative to Armenia by nearly doubling its military spending (Figure 10). Taken in absolute terms, the data does not suggest that "a dangerous arms race"[86] is underway. When one looks at the implication of defence spending as percentage of GDP, the picture is dramatically different.

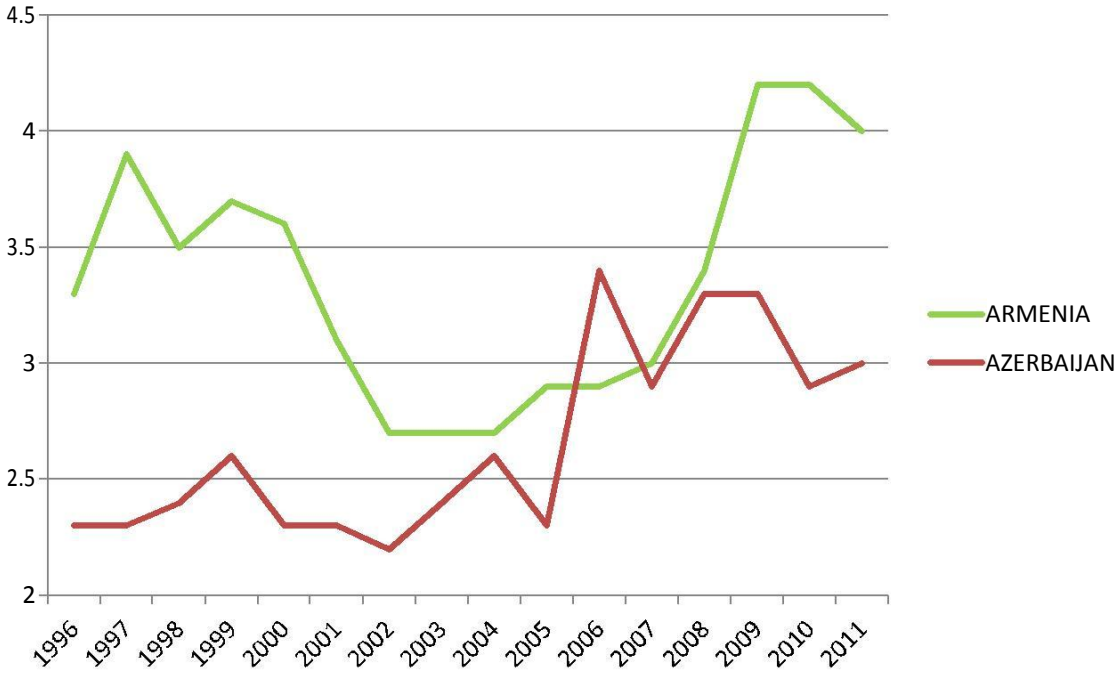
We see that although Azerbaijan has many times doubles its expenditures since 2005 (Figure 11), this does not represent a significant burden for the population. We can say with assurance that it is Azerbaijan's spending which has spurred Armenia's. This has profound implications when we compare Figure 11 with Figures 6 and 7; Azerbaijan, as the saying goes, *can* afford both "the guns and the butter", both the "swords and the ploughshares".

According to an International Crisis Group report, Azerbaijan's intention in 2007 was to make its defence budget equal to the *total* state budget of Armenia.[87] The point of the exercise seems to be to make the race onerous to Armenia by stressing the discrepancy between defence spending and social spending. Azerbaijan, by insisting on increasing its defence budget forces Armenia to divert its precious financial resources away from poverty alleviation measures. We can therefore imagine a causal relation between arms racing, poverty and the incidence of domestic instability

[85] Source: Stockholm International Peace Research Institute (SIPRI) Military Expenditures Database, www.sipri.org, consulted 31 July 2012.
[86] ICG, *Nagorno-Karabakh: Risking War*, 3.
[87] ICG, *Nagorno-Karabakh: Risking War*, 12.

that have erupted in March 2008. Indeed, the government believed that there was a "foreign hand" behind the post-election troubles.[88]

Figure 11. Defence spending as percent of GDP[89]



An escalation of aggressive rhetoric seems aimed at provoking Armenia into launching a pre-emptive strike, should the territories it holds in Nagorno-Karabakh come under threat.[90] This warning seems to have been put to execution on 4 March 2008, when Armenian and Azerbaijani troops struck a skirmish.[91] Although both sides blame each other for the March 2008 firefight, its ignition by Armenia would fit the theory of "linkage politics" whereby a national government attempts to divert attention away from pressing domestic issues and focus the public's anger towards a foreign actor.[92]

In other words, Armenia intends to point out to its constituents what Azerbaijan is doing, rather than on what Armenia is not doing. Armenia's increase in defence spending is thus as much a response to its domestic problems as it is an attempt to keep up with Azerbaijan. All the data taken together suggest that since 2006, Armenia's plight has worsened significantly. If she had maintained her share of defence spending at 2.7% of GDP, she would have freed up some 150 million USD per year for social service spending, for a population of some 700 000 in need.

[88] ICG, *Armenia: Picking up the Pieces*, 1.
[89] SIPRI Military Expenditures Database, www.sipri.org, consulted 31 July 2012.
[90] ICG, "Nagorno-Karabakh: Risking War", 12.
[91] ICG, "Nagorno-Karabakh: Getting to a Breakthrough", Europe Briefing 55, 1.
[92] See James N. Rosenau, *Linkage Politics*, (NY: Columbia University Press, 1969).

The rush to feed the army has surpassed the rush to feed the population; SOFI reports show that the total number of undernourished population in Armenia has fallen below 600 000 only during the 2004-2005 period.[93] From 2006 to 2008, the last data given show undernourishment figures oscillating between 600 000 and 700 000 Armenians.[94] Although this is a far cry from the 1.8-1.9 million undernourished of the early 1990s, it is clear that the government is not doing enough to mitigate poverty on its own. This realisation is likely to come from the large cities rather than from the countryside, itself less vulnerable to malnutrition.[95]

On the other hand, the security dilemma being what it is, there is little that the Armenians can do but to bolster their defences. In such a context, conceptions of national security become contradictory. For example, human security, such as freedom from want, falls secondary to the security of territory.

Armenia's Natural Disaster Vulnerability

More importantly, the pursuit of hard security, understood as strong military defences, takes up valuable GDP margins that could be better used not only to alleviate poverty, but to mitigate against natural disasters.

The region is prone to earthquakes. The United States' Geological Survey data for Armenia mentions ancient tremors having taken 20000 lives in 893 A.D., while another in 1667 took 80000 lives. An interesting fact is that earthquakes have been recorded as being more frequent recently. For example, earthquakes struck Armenia in rapid succession in the late 19th century and early 20th century; 1894, 1899, 1914, 1920 and 1926.[96] The latest one to hit Armenia direct was the Spitak earthquake of December 1988, at a magnitude of 6.2 on the Richter scale. The years 1894-1920 must have been trying for Armenia, first because the level of technology at the time did not permit a rapid recovery between the two first instances, and then the Bolshevik revolution, closely followed by the Russian civil war, both added complexity to these emergencies. The potential for a complex emergency is exemplified by the fact that it is in 1988 that Armenian-Azeri tensions erupted over Nagorno-Karabakh's decision to secede from Azerbaijan and link up with Armenia. The Soviet regime's heavy-handedness did not help matters, and the earthquake only compounded the poverty of the Armenians.[97]

Today, Armenia is at greater risk of earthquakes than ever before, also because of Azerbaijan. Recently, reports have emerged that link hydraulic fracturing (fracking), used in the oil and gas extraction, with earthquakes. The technique, according to the United States Department of Energy (DOE), can create "induced seismicity" defined as

---

[93] SOFI Report 2008, 48.
[94] SOFI Report 2009, 48, SOFI Report 2010, 50, and SOFI Report 2011, 45.
[95] Julia Berazneva and David Lee, "Explaining the African Food Riots…", 10.
[96] United States Geological Survey (USGS) http://earthquake.usgs.gov/earthquakes/world/events/1988_12_07_ev.php consulted 5 August 2012.
[97] Steve LeVine, *The Oil and the Glory*, 147-148.

> …earthquake activity that is the result of human activity which causes a rate of energy release, or seismicity, which would be expected beyond the normal level of historical seismic activity. For example, if there is already a certain level seismic activity before human activities begin one would expect that this "historical" seismic activity to continue at the same rate in the future. If, however, human activity causes a concurrent increase in seismic activity then one would consider this increase in seismic activity to be induced. In addition, if the seismic activity returns to background activity after the human activity stops then that is another sign that the seismic activity was induced. [98]

The DOE adds that the magnitude of seismic activity will be very small or very large depending on the geological environment where the hydraulic fracturing is taking place.

It is therefore ironic that oil and gas companies operating in Azerbaijan may be increasing that country and Armenia's exposure to earthquakes. The significance of this is far reaching; Azerbaijan is now an upper-mid level economy. To avoid popular dissatisfaction, continued growth remains necessary, which depends on oil and gas commercialisation.

From the Armenian point of view, fracking raises an additional national security risk; that of earthquake devastation. Armenia faces two man-made threats; earthquakes and invasion. We have seen that the threat of the latter forces Armenia to make choices that impede its social and economic development, because it has chosen military build-up instead.

With the threat of earthquakes now more present, Armenia would do well to follow GAR 2011's warning. As a lower middle income country, Armenia can count on a very low risk governance capacity. "For many governments faced with known and urgent risks, it may be difficult to justify investment in protecting against future unknowns." [99] Euphemistically, this means that Armenia will be more likely to continue to respond to Azerbaijan's escalation than to seek a solution to the conflict between the two countries. Owing to its diminutive size relative to its nemesis, it can solve only one of them unilaterally without detriment to the high poverty percentage of its population, but this would require a degree of compromise towards Azerbaijan that neither the Armenian leadership nor population is willing to accept as of yet.

The more Armenia will continue feeding its military machine, the less GDP margin it will have to mitigate future disaster, with the result that any state revenue will have to be spent on recovery rather than structural and non-structural prevention. As a low-middle income country, an earthquake the magnitude of what it suffered in 1988 could spell disaster for Armenia's pursuit of Millenium Development Goals and overall economic and social development.[100]

Conclusion

The nexus between food insecurity and national security cannot discount vulnerability to natural and man-made disasters. The preceding report has highlighted two cases where the concept of

---

[98] DOE, *About Induced Seismicity*, http://esd.lbl.gov/research/projects/induced_seismicity/primer.html#defined consulted 5 August 2012.
[99] GAR 2011, 9, 13.
[100] GAR 2011, 34.

national security could be applied with great flexibility. In the Somali case, the fight for basic survival has led coastal fishermen to improvise a form of maritime deterrent that prevented foreign vessels from abusing Somali waters. Once the tsunami destroyed the fishing infrastructure, however, maritime deterrence gave way to high seas robbery.

In the Armenia-Azerbaijan case, we have seen that one country can outspend the other militarily, creating a security dilemma whereby the poorer country has to make painful policy choices increasing nutritional vulnerability. To make matters worse, the source of wealth of the adversary is also a source of potential large scale disaster. Fracking for oil and gas in Azerbaijan accentuates the already difficult conditions in Armenia by adding a factor of known risks.

Applying modern definitions to social constructs that defy them is not useful in understanding how lives, livelihoods and hearths are defended, or why. The idea of "nation" is socially constructed. Under this definition, the Somali case appears less anarchical than popularly imagined. We have seen that Somali bands, fishermen and others have taken upon themselves to defend their fishing grounds. This is done not only to protect the resources or the territorial waters as we understand them to be components of national security, but to protect fishing as a coping mechanism against extreme events like droughts. The 2004 Tsunami informs us of the significance of fishing for the Somalis. Because the infrastructure was destroyed, piracy became the coping mechanism against the impossibility to fish despite the relative abundance of fishing stocks.

At the same time, we have also noted that piracy off the Somali coast and the Gulf of Aden has begun alarming advanced economies which depend on the flow of goods through those most frequently used waters. There is no way to divorce the plight of the Somali farm labourer-turned-fishermen-turned-pirate with the urgent need for sustained growth. Without this growth, advanced nations but mostly nations in transition, even if safe from malnutrition are vulnerable to internal unrest.

The Armenian-Azerbaijani conflict highlights their role as pawns in the rush for natural resources. This conflict has perpetuated a tendency by both sides to disregard the well-being of their most vulnerable constituents for territorial and political advantages. Not only are the two countries vulnerable to each other, but we have seen that oil and gas - a driver of growth for Azerbaijan - could also be a factor or risk for it and Armenia.

Azerbaijan appears to be forcing an arms race upon Armenia which diverts precious revenue away from poverty mitigation, and natural and man-made disaster mitigation. With no prevention or mitigation, it is Armenia's economic and social development, in addition to innocent lives, which are exposed to disaster. There is evidence, looking at Armenia's economic makeup, that a disaster the scale of the 1988 Spitak earthquake could set Armenia back by a decade. Meanwhile, the unattended nutrition crisis that has been chronic since independence has not abated.

A disaster in the Caucasus could serious ramifications for the economies of Western Europe. Although the majority of the fuels it needs come from the Arabian Peninsula, the current uncertainty in North Africa and in the Gulf of Aden makes the Caucasus a viable alternative for oil and gas. Whether this disaster takes the form of an earthquake or a conventional war matters little, as the latter has been convincingly demonstrated to be no less serious an occurrence than the former for the development of struggling economies and polities.

Bibliography

African Development Bank, The African Development Bank Group in East Africa: Consolidating the Present and Shaping the Future, (Tunis: AFDB, 2012).

Allen, Robert L., "State Trading and Economic Warfare", Law and Contemporary Problems, 24:2, State Trading Part 2, Spring 1959.

Azzam, J.-P., and Hoeffler, Anke, "Violence against Civilians: Looting or Terror?", Journal of Peace Research, 39:4, July 2002.

Berazneva, Julia, and Lee, David R., *Explaining the African Food Riots 2007-2010: An Empirical Analysis*, (Ithaca, NY: Cornell University, March 2011). Unpublished paper.

Besançon, Marie L., "Relative Resources: Inequality in Ethnic Wars, Revolutions, Genocides", *Journal of Peace Research*, 2:4, July 2005.

Buzan, Barry, *Peoples, States and Fear*, (Boulder, CO: Lynne-Rienner, 1991).

Conquest, Robert, *Sanglantes Moissons/La Grande Terreur*, (Paris : Flammarion, 1995).

Cornell, Svante, "The Unruly Caucasus", *Current History*, 96:612, October 1997.

Falk, Richard A. and Saul H. Mendlovitz, Saul H., *The Strategy of World Order, Vol. 4: Disarmament and Economic Development*, (New York: World Law Fund, 1967).

Food and Agriculture Organization (FAO), *Tsunami Reconstruction: Somalia Status Report*, (Rome: FAO, 31 January 2006).

FAO, *Status of Food Insecurity in the World (SOFI) 1999: When People must Live with Hunger and Fear Starvation*, (Rome: FAO, 1999).

- *SOFI 2000*: *When People must Live with Hunger and Fear Starvation*, (Rome: FAO, 2000).
- *SOFI 2001*: *When People Live with Hunger and Fear Starvation*, (Rome: FAO, 2001).
- *SOFI 2002*: *When People Live with Hunger and Fear Starvation*, (Rome: FAO, 2002).
- *SOFI 2003*: *Monitoring Progress towards World Food Summit and Millenium Development Goals*, (Rome: FAO, 2003).
- *SOFI 2004*: *Monitoring Progress towards World Food Summit and Millenium Development Goals*, (Rome: FAO, 2004).
- *SOFI 2005*: *Eradicating World Hunger – Key to Achieving Millenium Development Goals*, (Rome: FAO, 2005).
- *SOFI 2006*: *Eradicating World Hunger – Taking Stock Ten Years after the World Food Summit*, (Rome: FAO, 2006).

- *SOFI 2008: High Food Prices and Food Security – Threats and Opportunities*, (Rome: FAO, 2008).
- *SOFI 2009: Economic Crises – Impacts and Lessons Learned*, (Rome: FAO, 2009).
- *SOFI 2010: Addressing Food Insecurity in Protracted Crises*, (Rome: FAO, 2010).
- *SOFI 2011: How Does International Price Volatility Affect Domestic Economies and Food Security?*, (Rome: FAO, 2011).

Gartner, Scott S., *Strategic Assessment in War*, (New Haven, CT: Yale University Press, 1997).

Gettleman, Jeffrey, "The Pirates are Winning!", *New York Review of Books*, October 14, 2010.

Gurr, Ted R., *Why Men Rebel*, (Princeton, NJ: PUP, 1970).

Herodotus of Halicarnassus, *The Histories*, trans. By George Rawlinson (1858), (London: J. M. Dent's Everyman Library, 1996).

International Chamber of Commerce International Maritime Bureau (ICC-IMB), *Piracy and Armed Robbery Against Ships Annual Report 2009*, (London: ICC-IMB, January 2010).

- *Piracy and Armed Robbery Against Ships Annual Report 2010*, (London: ICC-IMB, January 2011).
- *Piracy and Armed Robbery Against Ships Annual Report 2011*, (London: ICC-IMB, January 2012).

International Crisis Group (ICG), *Armenia: Picking up the Pieces*, Europe Briefing 48, (Brussels: ICG, 8 April 2008).

- *Azerbaijan: Defence Sector Management and Reform*, Europe Briefing 50, (Brussels: ICG, 29 October 2008).
- *Nagorno-Karabkah: Getting to a Breakthrough*, Europe Briefing 55, (Brussels: ICG, 7 October 2009).
- *Armenia and Azerbaijan: Preventing War*, Europe Briefing 60, (Brussels: ICG, 8 February 2011).

ICG, *Nagorno-Karabakh: A Plan for Peace*, Europe Report 167, (Brussels: ICG, 11 October 2005).

- *Nagorno-Karabakh: Risking War*, Europe Report 187, (Brussels: ICG, 14 November 2007).
- *Azerbaijan: Vulnerable Stability*, Europe Report 207, (Brussels: ICG, 3 September 2010).

International Maritime Organization (IMO), *Information Resources on Piracy and Armed Robbery at Sea Against Ships*, (London: Maritime Knowledge Centre, 13 July 2012).

IMO Maritime Safety Committee (MSC), *Report on Piracy and Armed Robbery Against Ships*, Circular 577, 23 October 1991.

- Circular 577, addendum 1, 9 January 1992.
- Circular 577, addendum 2, 31 March 1992.
- Circular 577, addendum 3, 7 July 1992.
- Circular 577, addendum 4, 30 September 1992.
- Circular 577, addendum 5, 31 December 1992.
- Circular 577, addendum 6, 31 March 1993.
- Circular 577, addendum 7, 30 June 1993.
- Circular 577, addendum 8, 30 September 1993.
- Circular 577, addendum 9, 31 December 1993.
- Circular 577, addendum 10, 31 March 1994.
- Circular 577, addendum 11, 30 June 1994.
- Circular 577, addendum 12, 30 September 1994.
- Circular 577, addendum 13, 31 December 1994.

IMO MSC, *Report on Piracy and Armed Robbery Against Ships*, Circular 679, 31 March 1995.

- Circular 698, 30 June 1995.
- Circular 709, 30 September 1995.
- Circular 714, 31 December 1995.

IMO MSC, *Annual Report: Piracy and Armed Robbery Against Ships (1996)*, Circular 785, 17 March 1997.

- *Annual Report: Piracy and Armed Robbery Against Ships (1997)*, Circular 840, 13 March 1998.
- *Annual Report: Piracy and Armed Robbery Against Ships (1998)*, Circular 903, 15 March 1999.
- *Annual Report: Piracy and Armed Robbery Against Ships (1999)*, Circular 942, 17 March 2000.
- *Annual Report: Piracy and Armed Robbery Against Ships (2000)*, Circular 991, 31 March 2001.
- *Annual Report: Piracy and Armed Robbery Against Ships (2001)*, no.4, Circular 16, 31 March 2002.
- *Annual Report: Piracy and Armed Robbery Against Ships (2002)*, no.4, Circular 32, 17 April 2003.
- Annual Report: Piracy and Armed Robbery Against Ships (2003), no.4, Circular 50, 27 April 2004.
- Annual Report: Piracy and Armed Robbery Against Ships (2004), no.4, Circular 64, 5 May 2005.

- Annual Report: Piracy and Armed Robbery Against Ships (2005), no.4, Circular 81, 22 March 2006.
- Annual Report: Piracy and Armed Robbery Against Ships (2007), no.4, Circular 115, 10 April 2008.
- Annual Report: Piracy and Armed Robbery Against Ships (2009), no.4, Circular 152, 29 March 2010.
- Annual Report: Piracy and Armed Robbery Against Ships (2010), no.4, Circular 169, 1 April 2011.

Klare, Michael T., Resource Wars, (NY: Henry Holt and Co., 2001).

Krepinevich, Andrew, The Army and Vietnam, (Baltimore, MD: Johns Hopkins, 1986).

LeVine, Steve, The Oil and the Glory, (NY: Random House, 2008).

Machiavelli, Niccolo, Il Principe (1512), (Milan: Mondadori Ed., 1994).

- The Prince, Daniel Donno, trans. (NY : Bantam, 1981).

Marchal, Roland, "Somalie" in Hélène Arnaud, Bertrand Badie et al, L'État du Monde 1996, (Montréal : Boréal, 1996).

Middleton, Roger, Piracy in Somalia: Threatening Global Trade, Feeding Local Wars, Chatham House Briefing Paper AFPBP 08-02, October 2008.

Murray, Willamson, Bernstein, Alvin, and Knox, McGregor, *The Making of Strategy*, (Cambridge: CUP, 1994).

Nusbacher, Aryeh, "Civil Supply in the Civil War: Supply of Victuals to the New Model Army on the Naseby Campaign, 1-14 June 1645", *English Historical Review*, 115:460, February 2000.

Olson, Richard S., "Economic Coercion in World Politics, with a Focus on North-South Relations", *World Politics*, 31, July 1979.

Onuoha, Freedom C., "Sea Piracy and Maritime Security in the Horn of Africa: The Somali Coast and the Gulf of Aden in Perspective", *African Security Review*, 18:3, 2009.

Pacific Basin Economic Council, *Combating Maritime Piracy in the Gulf of Aden*, 3 April 2011.

Ramsay, Amber, *Alternative Approaches: Land-Based Strategies to Countering Piracy Off the Coast of Somalia*, Civil-Military Fusion Center, November 2011.

Rapley, John, *Globalization and Inequality: Neoliberalism's Downward Spiral*, (Boulder, CO: Lynne Rienner, 2004).

Rosenau, James N., *Linkage Politics*, (NY: Columbia University Press, 1969).

Sone, Emmanuel, *Piracy in the Horn of Africa: the Role of Somalia's Fishermen*, Master's Thesis, (Monterey, CA: Naval Postgraduate School, December 2010).

United Nations, *Global Assessment Report (GAR) 2009*, (NY: UN, 2009).

- *Global Assessment Report (GAR) 2011*, (NY: UN, 2011).

United Nations, Report of the Secretary General on the Protection of Somali Natural Resources and Water, S/2011/661, 25 October 2011.

Van Creveld, Martin, Supplying War, (Cambridge: CUP, 1976).

Walling, Carrie B., The United Nations Security Council and Humanitarian Intervention: Causal Stories about Human Rights and War, dissertation submitted in partial fulfillment of a Doctor of Philosophy degree, University of Minnesota, June 2008.

Wilber, Charles K. and Jameson, Kenneth P., eds., The Political Economy of Development and Underdevelopment, 5th ed., (NY: McGraw-Hill, 1992).

World Food Programme (WFP), Effects of the Financial Crisis on Vulnerable Households: Follow-up Study (Armenia), (Rome: WFP, March 2010).

Websites Consulted

Africa News : www.africanews.com

Department of Energy (US): www.doe.gov

Food and Agriculture Organization of the UN: www.fao.org

International Crisis Group (ICG): www.crisisgroup.org

Stockholm International Peace Research Institute: www.sipri.org

State Oil Company of Azerbaijan: www.socar-germany.de

United Nations (UN): www.un.org

UN Development Program: www.undp.org

United States Geological Survey: www.usgs.gov

World Bank: www.worldbank.org

World Food Program: www.wfp.org