

**Spring 2014
Industry Study**

**Final Report
*Agribusiness Industry***



**The Dwight D. Eisenhower School for
National Security and Resource Strategy**

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AGRIBUSINESS 2014

ABSTRACT: The 2014 Eisenhower School Agribusiness Industry Study analyzed elements of the domestic and international agribusiness sector through discussions with analysts, business leaders, and industry experts, as well as visits to domestic and foreign farms, markets, research facilities, and government organizations. Our findings show that, as the world population grows to an estimated nine billion people by 2050, food security and food safety will become critically important factors to population security and stability. Moreover, as the world population grows in both numbers and prosperity, the demand on the world's food production and supply chain systems will become more intense than ever before. Technologies, such as genetically enhanced crops, can be leveraged to ensure food demands are met, but government policies and civil society can impede the use of much of these technologies. Furthermore, the inability of countries to produce food at near max-capacity levels has the potential to drive global food prices higher, as demand increases and production doesn't keep up with that demand. While many countries seek to internally produce enough food to feed their own populations, there are almost no countries that have this ability. Interdependence for food security in the world is increasing, not decreasing as many countries now rely on other countries to grow and supply at least a portion of the food needed and desired. US government and Department of Defense efforts to help countries maximize food production, encourage free and robust trade of agricultural products, improve transportation systems and keep them secure, and help to build more effective governance will help reduce the spikes in food prices that can fuel instability and violence as the world's population grows and demands for more and different types of food increases.

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PLACES VISITED

Domestic:

United States Department of Agriculture (USDA) Outlook Forum, Arlington, VA
Smithfield Foods, Smithfield, VA
Beltsville Agricultural Research Center, Beltsville, MD
United Nations Food and Agriculture Organization, Washington, DC
United Nations World Food Programme, Washington, DC
North Carolina State University, Raleigh, NC
Bayer CropScience, Raleigh, NC
BASF Corporation, Raleigh, NC
Monsanto Company, Raleigh, NC
CME Group, Chicago, IL
Chicago Board of Trade, Chicago, IL
Iron Street Urban Farm, Chicago, IL
The Plant, Chicago, IL
Chicago High School for Agricultural Science, Chicago, IL
Pinney-Purdue Agricultural Center, Wanatah, IN
Smoker Farm, Wanatah, IN
Abbett Farms, LaCrosse, IN

International:

Office of the U.S. Minister-Counselor for Agricultural Affairs, Beijing, China
Beijing Agricultural Carnival, Xiaotangshan/Changping District, China
Sun Cherry Orchard, Beijing, China
Shared Harvest Organic Farm, Beijing, China
Huaxia Dairy Company, Beijing, China
Syngenta AG, Beijing, China
U.S. Consulate, Guangzhou, China
U.S. Agricultural Trade Office, Guangzhou, China
Jiangnan Fruit and Vegetable Market, Guangzhou, China
Qingping Dried Goods Market, Guangzhou, China
Guangdong Natural Healthy Food Company, Ltd., Guangdong Province, China
Cargill Dongguan Oil Crushing Plant, Dongguan, China
Machong Port, Dongguan, China
Office of the U.S. Minister-Counselor for Agricultural Affairs, New Delhi, India
U.S. Defense Attache, New Delhi, India
Tyagi Farm, Badshahpur, New Delhi, India
Azadpur Subji Mandi Fruit & Vegetable Market, New Delhi, India
Khari Baoli / Chandni Chowk Wholesale Nut Market, New Delhi, India
Karnal Grain Mandi (Wholesale market), New Delhi, India
John Deere Sirhind Works, Patiala, India
Chandigarh Roller Flour Mills Pvt. Ltd., Chandigarh, India
Big Bazaar Supermarket, Elante Mall, Chandigarh, India



Office of the Punjab Ministry of Agriculture, Chandigarh, India
Wal-Mart Cash and Carry Store, Chandigarh, India

Organizations that Provided Presentations at NDU:

Land O'Lakes, International Development Division
United States Department of Agriculture, Economic Research Service (ERS)
American Farm Bureau
Produce Marketing Association
AGree
Woodrow Wilson International Center for Scholars
Bunge North America
McLarty Associates
Johns Hopkins University, The Paul H. Nitze School of Advanced International Studies
McCormick and Company



Introduction

This report is based on the research and study conducted by the sixteen members of the 2014 agribusiness seminar group, who collectively examined agribusiness and its related impact on US national security and global interests. Adequate provision of food is a commonly acknowledged societal challenge for the 21st Century, but it is also important for national security professionals to recognize that food security is also linked to instability and conflict. As this report is intended for national security professionals, information on the humanitarian element of food security is outlined, but limited in detail. Humanitarian challenges are well documented in other publications and reports. This report focuses specifically on the health of the agribusiness industry and the nexus between food insecurity and sociopolitical instability. Within this context, this report attempts to provide an executive summary of two key findings and several policy recommendations. The first key finding is that the US agribusiness sector provides a major strategic advantage to the United States and has underpinned much of the country's success over the past century. The second major finding is that global economic and social trends are creating a world where food security will play an increasingly important role in affecting sociopolitical instability that can result in violence. The efforts of the United States to strengthen its domestic agriculture industry and improve the agriculture industries in other countries will help improve global food security help create a more secure and prosperous world. These are clearly objectives that are in the best overall interests of the United States and its people.

Following the violence that occurred in conjunction with the 2007-08 record global food prices, the United Nations World Food Programme (WFP) conducted research to determine if there was a link between food insecurity and violent conflict. The research suggests that future social unrest is likely if the global community does not address food security in the coming decades. A recent report on food security in Asia suggests that, “[t]he spike in global food prices in 2007–08 not only led to riots on several continents, it also reawakened fears about the world's future ability to feed itself, as growing populations place greater demands on agricultural systems operating in increasingly difficult environmental and climatic conditions.”¹ The failure to focus efforts to develop sustainable food security may impact global security and could adversely affect the national interests of the United States. It is, however, important to recognize that the link between food insecurity and violence is often ambiguous, complex and highly situational dependent, yet strong correlations often exist.²

Food security is defined as a situation “when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life.”³ As the world population is expected to increase by 1 billion over the next 10 years and rise above nine billion by 2050,⁴ the challenges of feeding this population, while keeping food prices from spiking to levels that may fuel civil unrest, will provide significant challenges for governments of developing countries and policy makers in the more developed world. The growing populations of the world, coupled with many developing economies and rising per capita income, suggest that the demand for both greater quantities and different types of food will greatly increase in coming decades. The United Nations Food and Agriculture Organization (FAO) predict that by 2050, food availability and access must increase by as much as 70% in order to provide for a dramatic spike in population.⁵

Food security, and efforts to reduce food-related violence, will not only require increased food production to keep up with the increasing and changing dietary demands of the food



market, but also improvements in getting food to the people who need it. Furthermore, good governance remains one of the key elements of enabling food security and minimizing potential destabilizing effects. Trade policies, investment in infrastructure, choices of regulation and subsidies, and the ability to provide physical security will drive many of the food security solutions for the coming decades. Conflict and political uncertainty, weak governance, poor infrastructure, limited use of available technologies, and the effects of climate change will likely continue to be sources of food insecurity. The solutions for improving food security and reducing its destabilizing effects will likely be found in solutions for these underlying and more broad sociopolitical problems.

Industry Defined

IBIS World defines agribusiness industry as “businesses that directly engage in or directly benefit from agricultural activities. Businesses in this industry may produce agricultural commodities; buy agricultural produce or supply goods and services to farms and the agriculture industry. This industry focuses on the food-supply chain up to, but not including, the point of retail sale.”⁶ (See Appendix 1, Figure 1, *Agriculture Value Chain*.) The cumulative value of all revenue from agribusiness – from farms to the table – exceeded \$20 trillion in 2012, or nearly 30 percent of the world’s entire economy.⁷ According to the United Nations Food and Agriculture Organization (FAO), nearly one in three people work in agriculture worldwide.⁸

The United States and other developed countries have relatively mature agribusiness industries while agribusiness in most developing countries have significant gaps, but are improving. In fact, the solutions to many of the world’s food and related economic challenges lie in the agribusiness sector within many of the developing countries, particularly in Asia and Africa.

Current Conditions and Outlook

The agribusiness industry is a vital, yet often underappreciated element of human security and economic development. The period following World War II, in particular, saw tremendous improvements in food production, processing, and distribution infrastructure, resulting in food prices dropping by 35 to 66 percent from the early 1900s to today.⁹ (See Appendix 1, Figure 2, *Agricultural Price Index and Population Trend, 1900-2010*.) While the world as a whole has made progress towards greater food security and reduced poverty, the rising income levels of the growing population and the associated demands for more food, water, and energy are creating greater stresses on the global food systems. Even though population growth rates are slowing, agricultural productivity is also slowing and food demand may remain close to supply over the next several decades, resulting in less stable food prices and, potentially, greater instability as a result. This section outlines a few key elements of the current and projected food security situation and provides some insight into the associated challenges that can spark or possibly even fuel sociopolitical violence. Additional detail and analysis on US strengths and weaknesses, as well as global opportunities and threats can be found in Appendix 2, Strengths, Weaknesses, Opportunities, and Threats (SWOT) Analysis.



Domestic Situation.

Over the past 100 years, the United States has experienced impressive advancements in the agribusiness industry resulting in an abundant, affordable, and safe food supply for its people. Good governance, innovation, and industriousness drove the vitality of America's agriculture industry during the 20th century and underpinned much of its security and prosperity. Some of the primary innovations include the mechanization of modern farm equipment, seed research and development, advancements in chemistry, and trade policy and strong government support that promote global exports of American agricultural products. These advancements resulted in a globally connected, industrialized food production system, which is able to maximize crop production capacity.

The dynamism of America's agriculture industry during the 20th century was a model of exceptional scientific and technical innovations as well as public and private partnerships. The industry started to transform in the latter part of the 19th century from its conventional form as a result of the nation's second industrial revolution (or technological revolution). The process of transformation gained momentum after the end of WWII as military personnel returned home and began migrating from rural areas to urban areas seeking a better quality of life for their families. During this period the nation experienced technological advances in materials and manufacturing, developments in business practices and banking, and strategic federal monetary and fiscal policy that strengthened infrastructure for energy, water, transportation, and commerce. Collectively, these societal advancements set the anchors for agronomic and economic structures that endure to enable extremely high domestic agricultural productivity, economic prosperity, and the ability to project power and influence abroad.

The transformation of America's agriculture industry benefitted significantly from executive and congressional security and resource strategy priorities that led to the establishment of an independent Department of Agriculture in 1862 and later, in 1889, the department's full cabinet-level status.¹⁰ Among the many noteworthy acts were the Morrill Act of 1862, which established the Land-Grant college system (still used today for research, development, and agribusiness education); the Plant Act of 1930, which provided patent protection for asexually reproduced plant varieties;¹¹ the Agricultural Adjustment Act of 1933, which initiated America's first subsidies after the great depression to counteract the overproduction of agricultural commodities that were causing farmers to fail as a result of the lowest agricultural prices in America since the 1890s (although beneficial when enacted, these early subsidies led to inefficiencies into the 21st century);¹² the Farm Credit Act of 1933, which helped farmers receive loans for agricultural endeavors;¹³ the Agricultural Act of 1948, which enacted mandatory price supports for basic commodities (90 percent of parity);¹⁴ and the Patent Act of 1952, which provided patent rights for agricultural innovations (equipment and processes).¹⁵

Scientific and technological innovations led America's agricultural industry to become the world standard for efficient farming. Some of these innovations included advancements in agricultural processes and techniques, evolutions in farming machinery, improvements in irrigation technology, innovations in seed breeding and treatment, advancements in weed and pest control, the application of information technology and automation, and the growth of the biotechnology industry. Collectively, these advancements enabled America's farmers to double output between 1948-2011 with only a .07 percent annual growth in inputs (this equates to an average annual growth rate of 1.49 percent).¹⁶ The increased productivity of the US agriculture industry was impressive, with corn yields increasing 700 percent, cotton yields increasing 400 percent, soybean yields increasing 300 percent, and wheat yields increasing 250 percent from



1930-1990.¹⁷ As an example, "...the United States average corn yields increased from 34 bushels an acre in the 1940s up to 121 bushels per acre by the 1990s and then up to 156 bushels per acre by 2007. Yields of corn greater than 200 bushels an acre are now common among farmers using the best new seeds and the most sophisticated practices."¹⁸ Although other challenges have emerged as a result of this growth, the impact of these changes has ultimately resulted in an advanced state of food security in the United States and other developed nations.

Today, agribusiness in the United States is considered a mature industry and, both directly and indirectly, contributes to the economic vitality and security of the United States. According to the USDA's Economic Research Service (ERS), agriculture and related industries contributed \$775.8 billion, or 4.8 percent, to the US gross domestic product in 2012. (See Appendix 1, Figure 3. *Value Added to GDP by Agriculture and Related Industries, 2005-12.*) Farms contributed \$166.9 billion, about one percent of GDP. Agriculture is also a strong export business where approximately 20 percent of total production goes to the export market accounting for a \$37.1 billion trade surplus in 2013. Of note, China became the largest importer of US agricultural products in 2010 and accounted for \$25.9 billion in 2013, which is almost double from the \$4.6 billion in 2009. Additionally, agriculture and related industries provide about 9.2 percent of employment in the United States with on-farm employment accounting for about 2.6 million jobs and about 13.9 million jobs in related industries.¹⁹

While US agribusiness is practically the strongest in the world, the USDA estimates that only 85.5 percent of US households were food secure in 2012. The remaining 14.5 percent of households were food insecure at least some time during the year, including 5.7 percent (7.0 million households) that had very low food security. For US households with incomes at or near the poverty line, the degree of food security appears to have a strong correlation with national economic trends.

Global Situation.

Agriculture, as the largest employment sector in most developing countries, is critically important in efforts to reduce poverty and hunger and increase food security throughout the world. Factors such as production shortfalls, distribution limitations, price volatility, and trade disruptions are global food security risks that contribute to food insecurity challenges.²⁰ As commodity prices fluctuate and the market is stressed by growing populations, higher incomes, urbanization, changing diets, and increased consumption of the main agricultural commodities, agricultural policies will need to address the volatility of food markets to mitigate the risk of food insecurity. Challenges such as the limited availability of agricultural land, rising production costs, growing resource constraints (particularly energy and water) and changing climate conditions are expected to impact global agricultural production levels.²¹ The inconsistent nature of the business environment, rule of law, government policies, and social customs around the world will generate additional challenges for agriculture and agriculture production that will continue to be a serious threat to food security around the globe.

Today, the world agricultural system produces enough food to provide food security throughout the world, yet questions remain about the future. The current world population of 7.2 billion is projected to increase by 1 billion over the next 12 years and reach 9.6 billion by 2050, with more than half in Africa.²² The UN FAO projects that the world must nearly double its food supplies by 2050, with 70 percent of the increase coming from technology, 20 percent coming from new arable farming land - probably in South America and Africa, and 10 percent coming from more efficient farming cycles.²³



Production growth has also been slowing over the past decade. Gains in production are expected to increase by approximately 1.5 percent per year over the next decade, which is much lower than the 2.1 percent growth between 2000-2010. While the population growth rate is also declining - estimated at 1.5 percent per year currently and dropping to 0.5 percent per year in 2050 - the increase in average incomes and changing diets will have a significant impact on increasing demand.²⁴ As incomes increase, people tend to eat fewer grains and increase their consumption of meat and high value foods. Therefore, a productivity growth rate that just keeps up with population growth rates will not likely be enough to meet demand.

In addition, people will continue to move from rural to urban areas. Currently, about half of the world's population lives in rural areas, but by 2050 over 70 percent of the population is expected to live in urban areas.²⁵ (See Appendix 1, Figure 4. *By 2030, Nearly Two-thirds of the World's Population Will Live in Urban Areas.*) The significant increase in urbanization will mean a change in lifestyles and consumption patterns for many people. When urbanization is combined with rising incomes, people will further diversify their diets, resulting in less consumption of grains and other staples, and more consumption of meat, dairy products, vegetables, fruits and fish. Consumption in Eastern Europe, Central Asia, and Latin America is expected to rise more rapidly than other areas.²⁶

Food insecurity is a major challenge in the world today. The UN FAO reports that about 840 million people, or about one in eight people, suffer from chronic hunger, which, in turn, affects productivity and human security. This is, however, a 17 percent decline in total numbers of people since 1990. This situation is especially true for Asia and Sub-Saharan Africa, which accounts for 43 percent of the total affected population.²⁷ (See Appendix 1, Figure 5. *Food Security Risk Index 2013* for a graphic of affected regions.)

Additionally, many experts expect prices to remain above average for both crop and livestock products. These predicted higher prices drive concerns that a significant number of people will remain undernourished or malnourished because of the financial inability to buy food. Even today, about 20 percent of the world's population lives on less than \$1.25 per day. Although this income equality challenge will not be completely resolved, the number could decline by 2050. Research indicates that in lower income-level countries people spend a higher percentage of their disposable income on food.²⁸ Thus, if there is a shock to the food system and commodity prices rise, those in low-income countries, who already spend a disproportionately large amount on food, will be the hardest hit, which could cause social instability and violence.

Food Security and Sociopolitical Conflict

The instability in North Africa and the Middle East in 2008 and 2011 that occurred in conjunction with spikes and record high food prices has generated significant interest in the nexus between food security and violence. While the underlying causes of unrest are highly complex and very situational dependent, there appears to be two key elements to the nexus between food security and violence. The first is that spikes in food prices, particularly in countries where food subsidies are prevalent, can ignite or fuel grievances associated with the perceived failure of governance. The second is that, despite the more severe impact that higher food prices have on the more poor rural populations, civil unrest and violence often occurs within the higher income urban demographic that has a greater ability to mobilize protests.

The violent protests that spread across North Africa and the Middle East in 2007-8 and again in 2011 are often blamed, to some degree, on the sharp increases in food prices that occurred at the same time. A report produced by the New England Complex Systems Institute in



2011 suggests that the spike in food prices created the “precipitating condition for social unrest.”²⁹ (For a graphic representation, see Appendix 1, Figure 6. *Food Price Shocks and Violence*.) The report points out that people expect their governments to look out for the well being of their citizens. This expectation includes food security, which is one of the keys elements of government legitimacy. The report further explains that, in today’s increasingly interdependent world where many countries rely on imports for food needs and suffer from poverty, “...political organizations may be perceived to have a critical role in food security.” Additionally, [f]ailure to provide security undermines the very reason for existence of the political system. Once this occurs, the resulting protests can reflect the wide range of reasons for dissatisfaction, broadening the scope of the protest, and masking the immediate trigger of the unrest.”³⁰

In the book *Food Security and Sociopolitical Stability*, an in-depth study on this issue, the authors explain that,

Strong correlations between food availability or food access and sociopolitical stability often exist – but certainly not always and everywhere. The linkages are, however, variable across space and time, highly conditional on the responses of multiple private and state actors, and difficult to pin down causally. Sociopolitical unrest, like market shocks, often has strong behavioral foundations that intersect with underlying structural pressures to spark extreme social events... Governments that have previously employed policies, such as food subsidies, intended to make people feel secure about their access to food are sometimes perceived as renegeing on that commitment when food prices rise sharply...leading to unrest that is at once food- and politically-based.³¹

This book also points out that, while many people believe food price shocks cause violence due to the impact on the poor, this is not usually the case. The author explains, “riots in response to a staple food price spike rarely occur among the most food insecure and politically marginalized peoples...Rather, it appears that rioters are disproportionately better-off, predominately urban populations.”³² Younger populations with fewer or poor job opportunities may also be more sensitive to food price shocks. “[O]rganized violence might also emerge in response to attractive profit opportunities where individuals with a low opportunity cost of time...become willing to fight when the prospective spoils from rebellion become sufficiently attractive. Regardless of whether greed or grievance accounts for unrest, both should be strongly correlated with exogenous shocks to food prices.”³³ As urbanization increases, overall income levels rise, yet high un- or under-employment exists in lower income developing countries, the risk of violence fueled by food price spikes may increase.

While agriculture has made tremendous advances over the past 50 years, there remains uncertainty about the future as human society evolves and puts greater stresses on the agriculture industry. The current conditions, outlook, and challenges outlined above provide just a brief glimpse of some of the impacts that the strength or weaknesses of agriculture can have on society’s stability and prosperity. Moreover, our agriculture industry study group was consistently reminded of the critical role of good governance.

Government Goals

As highlighted above, agriculture is often the foundational sector of a thriving economy. Therefore, governments, especially those in developing countries, must make a concerted effort



to develop and implement fact-based and economically sound agriculture policies that stimulate productivity and improve distribution systems. Meeting the food needs of tomorrow's society will require improvements to farming practices in less developed countries, acceptance of more transgenic plants, less restrictions to trade, improved storage and transportation infrastructure, and increased stores of commodities to help dampen price shocks.

The real challenge for low-income countries to secure stable access to food, either presently or in 2050, is mostly dependent upon whether an appropriate market mechanism works properly or not. Reducing corruption and establishing governance in failing countries is key to this goal. It is difficult to expect a healthy market mechanism to work if a country fails to establish effective governance. Although the United States and other international agencies have many programs in place to ensure global food security, establishing effective governance in failing states must take center stage. Stable governance is necessary to attract the private investment required to build the infrastructure and logistical systems upon which a reliable food supply depends. In order to achieve food security goals, international organizations and private companies must work together to ensure availability, access, utilization and stability.

The US Government's primary role in agribusiness is to enact, execute and enforce those laws and policies that ensure a safe, sustainable food supply for America's citizens, and promote free and open agricultural trade with the global community. Multiple departments within the Executive Branch share primary responsibility for fulfilling these roles including the Departments of State, Agriculture, and Health and Human Services, the Environmental Protection Agency, and the Office of the United States Trade Representative. The Department of Defense (DoD) largely plays a supporting, but crucial, role in agribusiness by ensuring unfettered access to the global commons and providing security for foreign aid operations. Congress plays the most vital role by enacting the trade, health, and environmental laws under which firms conduct agribusiness in the United States and on the world stage, and appropriates the funds to support sound agriculture practices at home and abroad. Because so many US government agencies share responsibility for managing agribusiness, the difficulty of orchestrating agricultural reforms and implementing policy either domestically or internationally cannot be overstated.

Policy Recommendations

Given the correlation between food price volatility and sociopolitical instability and violence, the question must be asked – how can the United States leverage its strengths, hedge against its weaknesses, capitalize on global opportunities, and counter global threats? This section outlines a few broad policy recommendations for the United States and the countries it is trying to help.

Science and Technology. Increased support for agriculture focused science and technology, particularly research and development (R&D), will be an important component to ensuring that the United States does not become complacent or fall behind in its position as a major producer of the world's food. This strength, a source of national security, should be maintained. The growth rate in US R&D funding has slowed down in recent years while demand for food and better technologies are on the rise. The USDA's ERS has conducted analysis to determine the effects of US public R&D funding and found that, at current spending levels, agriculture productivity growth will fall to only 0.75 percent per year, nearly half of what is has been over the past decade and nearly half of the rate of growth for the world's population. At this



rate, the US production would only increase 40% by 2050. The ERS research also shows that increasing R&D spending by 3.73 percent annually, the historical rate of inflation, would increase US agriculture output 73 percent by 2050.³⁴ Additionally, the US government should continue to help and push foreign governments to invest in developing new technologies. An FAO report suggests that a 13 percent increase in global public spending for agricultural research globally could produce a 1.43 percent annual growth rate in yields resulting in a production level that would likely keep grain prices on a downward trend as they have been over the past 50 or more years. FAO also believes this level of production could halve the number of malnourished children by 2050.³⁵ Increased investments in public R&D funding would likely improve food security and add more stability to food prices and support more stability in the world, not less.

One particular facet of technology that must be expanded is the use of transgenic, or genetically modified organism (GMO) plants. The world community must embrace more GMOs in order to achieve the crop yields necessary to meet global demand. Education is the key to overcoming the anxiety surrounding GMO safety and it is toward this end that organizations such as the Food and Agriculture Organization of the United Nations can do the most good. Stigma often accompanies new technologies, but this must be overcome by a global education campaign to inform people of the true science and safety of GMOs. If the world is to have any hope of meeting its long-term food production needs, GMOs must be part of the solution.

More Free and Open trade. Maintaining America's global competitive edge in agriculture requires a multifaceted approach that synergizes domestic and international agricultural policy to promote fair trade and protect health and safety. Internationally, the US must establish itself as the champion of fair trade by rolling back its own protective tariffs while aggressively pursuing *quid pro quo* tariff, subsidy and quota measures with developed nations that resist trade parity. Furthermore, America must encourage the World Trade Organization (WTO) to adopt qualitative standards that reflect sound environmental and health standards as an essential part of free trade agreements. In so doing, the true cost of negative externalities from agriculture, such as air and water pollution, can be borne globally instead of nationally. Eliminating global barriers to trade will not only open additional markets to US farmers, it will also improve the security of America's food supply by increasing access to seasonal produce.

As the world grows more interdependent and countries rely on each other to provide desired foods, the need for more open and free trade on agricultural products increases. Christopher Barrett, one of the authors of *Food Security and Sociopolitical Stability*, points out that, "[t]he use of trade policy instruments holds obvious appeal for states looking to placate restless urban constituents. But it becomes especially problematic for food-importing countries growing ever more dependent on reliable trade partners to ensure food access...."³⁶ Additionally, the challenges described above – more demand, less supply, and more imported foods in developing countries – creates a global food system where unforeseen events such as droughts, floods, and other natural disasters can cause a spike in food prices. When prices spike, governments often face significant pressure to take action, such as export bans that keep prices lower for that particular country. These export bans often occur in higher income countries yet have a greater impact on stability in lower income countries. As mentioned above, the food price spikes that sparked riots throughout much of the Middle East and North Africa in the last few years were not directly caused by reduced production in the Ukraine and Russia, but by their export bans that resulted in a much more serious food price rise in the countries planning to import their wheat. Had they kept their export commitments and had enough stores to absorb the shock, the prices would not have spiked and the violent protests may not have occurred. Barrett



summarizes the need for more free and open trade by stating, “[i]nternational trade is supposed to dampen price fluctuations by spreading weather and other production risks across countries – a major reason why most economists advocate for agricultural trade liberalization.”³⁷ The United States should work to increase open trade agreements such as the Trans-Pacific Partnership agreement and Transatlantic Trade and Investment Partnership, and others. The United States should also work with the WTO, the G8, and the G20 to increase emphasis on trade policy with regard to price stabilization efforts and the goal of improving food security, increasing prosperity, and reducing associated violence.

Improve Immigration Policy. The availability of labor to meet the needs of farmers and agribusiness enterprises also merits attention. In the US, hired labor costs make up approximately 17 percent of production expenses for all agricultural commodities and up to 40 percent of expenses for crops such as fruits, vegetables, and nursery products.³⁸ Increasing the labor pool with access to cheaper labor is important. Unfortunately, significant bureaucratic barriers hinder the United States from fully capturing the economic potential of this labor force. The current H-2A visa process is simply too cumbersome for farmers to follow.³⁹ The complexity of current policies does little to encourage compliance, while incentivizing hiring undocumented workers and exacerbating border security concerns. By streamlining the H-2A visa program to allow more legal migrant workers to work on farms would improve the agriculture labor market and allow farmers to plan future harvests assuming the use of legal labor. The current administration estimates that expanding the number of agricultural workers eligible for the H-2A program would increase agricultural production and exports by around 1.6 percent and 2.5 percent respectively.⁴⁰

Improve Supply Chain Resiliency. Our third recommendation area, supply chain resiliency, is also critically important. Internally, our interconnected transportation system’s four modes – rail, barge, truck and ocean vessels – all have challenges. Transportation is a key node in a sustainable food supply system. Domestically, the bulk of our basic food commodities move via the inland waterway system and barge transport. The water network’s lock and key system must be renovated to ensure its continued viability. Investment in the nation’s trucking industry is needed as well, most notably in highway infrastructure and in developing alternative fuels to control rising costs. But perhaps the most significant area of concern is the country’s rail system. Heavy regulation stifled railway growth and investment for years. The Staggers Act lifted this regulatory burden, resulting in consolidation and increased efficiency, but also reduced competition. Today’s rail system is optimized to move bulk cargo great distances, but has lost flexibility as local rail lines have diminished. Consequently additional investment in technology and infrastructure are needed to meet the rising demand for rail cargo. Sound investment in our transportation network within the constraints of our current budget will ensure the viability of America’s food delivery network. As transportation of competing cargo like oil and liquid natural gas increases, expansion of our transportation network becomes even more important.

Improvements in supply chain infrastructure are also critically needed abroad. Improvements to warehouses, silos, farm-level storage and transit systems could all be enhanced by US government intervention or assistance. Advising foreign governments, such as India’s, to invest in transportation, storage, and other supply chain infrastructure can also bolster more stability in food prices.

Improve Nutrition and Food Aid. Solving the problems of malnutrition – over or under shooting caloric intake goals – remains a key concern in the consumer portion of the value chain. Within the US, consolidation of the various programs within the DoD, USDA, Center for



Disease Control, the Office of the Surgeon General and others that aim to fight obesity and under-nutrition could help save money and target the most effective areas of research and outreach. This is another area in which global outreach should be a priority, mainly for under-nutrition, but countries like India are also experiencing obesity problems.

Nutrition significantly affects the physical and mental development of a child during the first 1,000 days of a child's life—from the mother's pregnancy through two to three years of age. "The right nutrition during this 1,000 day window can have an enormous impact on a child's ability to grow, learn, and rise out of poverty. It can also have a profound effect on the long-term health, stability, and development of entire communities and nations."⁴¹ Lack of proper nutrition of the mother and the developing child can result in stunting, infections, lasting effects of mental development, and even death. By focusing food aid and agricultural assistance programs on delivering and producing not only the necessary quantity, but also the right type of food, international organizations can curb hunger among the poor at its genesis. The US Agency for International Development and the Department of State should receive more funding from Congress to increase both nutrition education as well as food aid abroad.

Essays on Major Issues

The following essays provide insight into three aspects of agribusiness that may be of interest to those concerned with US national security. The first discusses the importance of the transportation system to agriculture and food security. Without an effective and secure transportation system, the entire world population ends up paying more for food as food is wasted and not delivered where it is needed. The second essay looks at an important, but rarely thought about aspect of security – microorganisms that can have grave consequences to food security and safety. The last essay provides more insight into the debate surrounding the critically important bio-technology innovations surrounding GMOs, which are one of the vital components needed to feed the growing world population.

ESSAY #1 – Agricultural Transportation System

Lt Col Grant Izzi, US Air Force

The US agricultural transportation system is an integrated network, and agriculture is the largest user of freight transportation. Effective transportation has been vital to the development of agricultural productivity and the overall economic health of the agribusiness industry. The three major internal modes of transportation (rail, barge, and truck) work together in a system that cooperates and competes in a relatively balanced and complimentary way. The availability of viable transportation options has allowed the flexibility for farms to be located where the soil, climate and other factors are more favorable for crop production. Institutional, technological, and regulatory changes in transportation also influence where commodities are grown and processed. Influence has also come from the government, which has played a longstanding role in highway and waterway maintenance, as well as improvements and oversight of rail transportation.⁴²

Technology, particularly biotechnology, has revolutionized agricultural. Over the last 25 years, several thousand new agricultural products have been tested and many have been brought to market. These new agricultural products have resulted in improvements like herbicide tolerant and insect resistant crops, which are increasing yields and reducing farm operating costs. The biotech companies are now focusing more on improvements in seed genomics which will bring



new varieties of commodities and specialty crops to the market with characteristics tailored more for what the customer desires. For instance, the ability to produce corn and soybeans with specific amino acids and protein characteristics offers the potential for better and cheaper feed for livestock and poultry. Improvements in oilseeds also have the potential to improve the health and nutritional qualities of products such as vegetable oil and margarine. However, these improvements may stress the current agricultural transportation system that will be necessary for producers, processors and consumers to take full advantage of these new products. Transporting these new and improved products from the fields and the farms to the processor or consumer will present a major challenge for a system that has evolved to primarily move various bulk agricultural products like grains and oilseeds. Moreover, a major shift away from bulk grain and oilseed production may be right around the corner with new seed varieties for specialty crops coming on the market in the near future. This means that it may be necessary to adapt some parts of the existing agricultural transportation system or develop entirely new marketing channels and distribution systems which will ultimately create new agri-logistics challenges.⁴³

As agricultural production has increased due to new technologies and improved transportation, much of this new yield has traveled out of the country as global demand for food has increased with the developing countries and growing middle class. Much of the export products travel from the middle of the country; therefore, the need for effective agricultural transportation will continue to increase based on projected growth in the demand both domestically and overseas. And, since many agricultural commodities are perishable (especially specialty crops), an efficient transportation system is critical to the needs of the farmers and consumers during the varying growing seasons. The transportation system is also vital in supporting rural economies by reducing the prices farmer's pay for inputs, such as seed, feed and fertilizer. These rural economies are intertwined, and the interaction of agriculture and the off the farm jobs it supports provides a solid economic base for rural communities. Consequently, effective transportation is necessary in the rural areas to stimulate the local farms and businesses and improve the standard of living.⁴⁴ Effective agricultural transportation internal to the United States comes in the form of barge, truck and rail, and each of these have challenges that will need to be addressed, especially the current rail system.

Barge. One of the greatest natural resources and benefits we have for transporting goods in this country is our inland waterway system. This system provides a low-cost transportation capability for shippers to move agricultural products as operational and maintenance costs and half the capital costs are paid for by the government and the waterways are maintained by the US Army Corp of Engineers. That said, over the past several years the market share of barges has been decreasing and with less traffic, the attention on upkeep of the waterways has also waned. The aging locks and dams on the system are generally reliable, but repairs and maintenance are becoming more extensive and expensive.⁴⁵ According to the American Society of Civil Engineers, costs attributed to waterway passage delays reached \$33 billion in 2010 and are projected to rise to \$49 billion by 2020.⁴⁶ In addition to infrastructure repairs, the Inland Waterway System has also been challenged by concerns over the environmental impact to the natural habitat.⁴⁷ An economist from the CME Group has stated that the condition of our inland waterway and our continued ability to exploit the competitive advantage of this critical transportation system are primary concerns for the viability of the US agricultural system.⁴⁸

Truck. The trucking industry is critical as it transports approximately 70 percent of the tonnage of agribusiness products throughout the US, Canada and Mexico. The agriculture supply chain starts and ends with transport of goods by truck from the farm to the store. Trucks link



farmers, ranchers, manufacturers, and service industries to grain elevators, ethanol plants, processors, feedlots, markets, and ports. And, more than 80 percent of cities and communities are served exclusively by trucks as many agricultural products are perishable and time sensitive, which require the efficiency, special handling, or refrigerated services that are best provided by trucks.⁴⁹ The cost of fuel is the most significant issue affecting truck transportation and can have immediate impacts on food price levels and volatility. Since consumer demand for fruits and vegetables has been proven to be price-sensitive, fuel price surges could also significantly reduce consumption of fresh produce. In addition, price margins are increasingly sensitive to fuel prices as the distance traveled from the growers to the consumers continues to get longer.⁵⁰

The trucking industry is also burdened by regulations governing vehicle weight and safety. Industry advocates argue that agricultural products are heavy and low value and therefore, they would like to see weight limits increased on the nation's interstates. Opponents argue that the trucking industry does not cover the full cost of the damage caused to highways, and heavier weights would only increase highway maintenance costs even more. Also, they assert that the existing bridge structures may not have the capacity to allow for increased weight and could significantly shorten the life of bridges.⁵¹ Nevertheless, the trucking industry provides the most flexibility to our agriculture transportation system and is extremely important to the integrated network that is leading the way in helping to provide global food security.

Rail. The Staggers Rail Act of 1980 deregulated the railroad industry, encouraging greater reliance on free markets and reliance on competition to protect shippers and the public. However, as mergers happened in the railroad industry after deregulation, the loss of competition increased the market power of the railroads. Before deregulation, the rail industry was considered to have excess capacity and after the mergers, the number of rail lines decreased. Hence, the railroads reduced costs by eliminating excess capacity and many of the shorter branch lines were abandoned. Even though the mergers increased railroad market power and profitability, rates for many shippers fell after 1980 until 2004. Since that time, however, rates started to increase as the railroads reached the limits of their capacity.⁵²

These new limits in capacity are characterized by a system and rates that favor larger movement over longer distances. Thus, it's understandable that there would be a significant rate advantage for the largest trainload shipments, especially for bulk items like grain and oilseeds. Higher rates were also a result of the merger costs, to include additional investments in rail cars and infrastructure. The increase in rates has also been a response to rising operational costs such as fuel surcharges.⁵³

The subsequent closure of many rail branch lines and a shift to shuttle-like service by the railroads has resulted in grain moving longer distances by truck on rural roads to the train terminals. With the closure of grain branch lines, the railroads have subsequently restricted market choices for some shippers and farmers, thus lowering the price the product can attain due to the additional cost of transportation. Conversely, having fewer grain loading points has increased the efficiency and the profitability of the railroads, while at the same time the subsequent movement of grain over local roads for longer distances is resulting in higher road maintenance costs for many rural communities. Since the 1990s, the railroads have also been moving to larger capacity grain cars as a way to reduce costs. While these cars permit mainline movement of grain at a lower cost, many of the branch lines still in use cannot accommodate the heavier weights and smaller railroads often lack the resources to make necessary investments in their infrastructure to handle the heavier cars.⁵⁴



The share of the grain and oilseed harvest moved by rail has been declining since 1980, and even though the large structural changes took place by 2000, the rail market share of grain and oilseed transportation continued to decline. There were three prominent reasons for this decline:

... the growth of ethanol production, the growth of biodiesel production, and increases in animal feeding. Ethanol plants are usually located close to corn producing areas, so trucks are used to haul corn to ethanol plants. As a result, in Iowa, the leading ethanol-producing state, rail market share dropped by approximately 20.9 percent between 2000 and 2010. In addition, biodiesel production has increased from 2 million gallons in 2000 to almost 1 billion gallons in 2010. As more soybeans were transported by truck to biodiesel refineries, Missouri's rail market share decreased 6.8 percent. The increased geographic concentration of animal feeding operations (CAFOs) has resulted in feed grain hauls being interstate, which favor rail transportation; however, the increased use of dried distillers grains and soymeal in feed rations has resulted in less grain and oilseeds being transported to animal feeding regions. Again, in Iowa as an example, the number of grain consuming animals increased by 15.2 million between 2001 and 2010, resulting in a decrease in its rail market share of 3.9 percent as more Iowa grain was moved by truck to the feeding locations.⁵⁵

These decreases in market share are indicative of the current state of the rail system; as profits have gone up, rail congestion and lack of flexibility have occurred.⁵⁶ For example, there is a current rail crisis in Canada that should cause us to take pause because the circumstances can be related to the situation in the United States. With near-perfect growing weather leading to bumper crops of wheat, barley, oats and soybeans, coupled with an extremely harsh winter, grains are piled up due to the lack of rail transport. Cargo ships to take canola to China and Japan and wheat to Mexico, Japan and Iraq were left stranded in port. With orders for approximately 60,000 railcars not being filled, there is talk of a backlog of oat shipments to U.S. cereal manufacturers. Although the railways blame the weather, the farmers claim the railways lack the capacity to deal with unexpected events like a record harvest or prolonged cold weather because they have reduced crews, locomotives and cars. Of the 340 inland grain terminals on the Prairies, only both major Canadian railways serve six and another 22 are within 30km of both. The farmers also complain that the railways are favoring more profitable shipments of petroleum products.⁵⁷ Apart from not having the capacity and flexibility to react and help Canada ship oats within the US, the re-purposing of the rail system for petroleum products is indicative of what is happening with our rail system as well. This point was brought home again during our domestic couplet when an economist from the CME group commented on the Canadian oat issue and our inability to provide rail transport due to increased demand from the North Dakota oil fields.⁵⁸

With the expected growth in demand for food, significant and sustained growth in freight demand is expected as well and could double by 2035. Investment in the railroad industry, however, is not currently projected to keep up with demand once the economy fully recovers, especially in agricultural areas. This shortfall of investment could threaten the United States' competitive position as a low-cost supplier of high quality grain and other agricultural products required in developing countries. Transportation investment increases markets for goods, raises the revenue farmers receive and lowers their costs, lowers consumer prices and increases consumer choices. With the recent increase in profits over the past few years, railroads have



attempted to meet the rising demand by spending \$420 billion on infrastructure, but according to a recent study, another \$89 billion by 2035 may be needed to meet future demand.⁵⁹

In summary, transportation is been critical in facilitating the development of agriculture and economic growth of the United States. To ensure food security and meet future global and domestic demand for agricultural products, all our internal transportation modes will need improvement and focus. For the inland waterway system and barge transport, the most obvious thing that needs to be addressed is the updated the structure of the lock and key system. Ensuring the viability of this network is one of the key and unique ingredients in maintaining our competitive advantage in agriculture. For the trucking industry, the main issues are safety, highway infrastructure and the cost of fuel. Trucks provide the most flexibility and are pivotal for an effective hub and spoke distribution system. The most significant improvements/opportunities the Unites States needs to address is the rail system. The railroad industry was heavily regulated for years, stifling growth and investment. The Staggers Act lifted this regulatory burden, however, the industry has reduced competition and given the railroads greater market power. Although the rail system has evolved and is optimized to move bulk cargo great distances, there has been a loss of flexibility in the system as local rail lines have diminished as well as the ability to react to new shipper or market demands. Railroad companies will likely need to continue to invest in infrastructure to provide more options for not only the growing demand for current agricultural products, but also for the next generation of specialty items on the horizon. The Unites States can continue its leadership role in promoting food security by addressing these transportation infrastructure challenges. As an economist at North Carolina State University put it during a recent visit, “In agriculture, transportation is everything!”⁶⁰

ESSAY #2 – Protecting Agriculture from Invasive Species and Agroterrorism

Ms. Juanita Broennimann, Military Sealift Command

It has been suggested that one of the threats that the United States needs to worry about is agroterrorism. Since agriculture is one of the exports that generates net gains for the United States economy, and one of the objectives of terrorists is to disrupt the economy, there is a valid concern that agriculture could be a target of terrorists. What is not being taken into account is that, while there have been no significant, verified agroterrorism events in the United States at the producer level, we are currently under attack by organisms acting against our food supply. We need to counter this attack even if there are no terrorists behind it, and the methods we use will also be effective for agroterrorism as well. The only piece that we would be missing would be the law enforcement actions and those can be added after the threat is resolved.

So what is agroterrorism and how does it differ from other threats we are currently facing? Agroterrorism is “the deliberate introduction of an animal or plant disease with the goal of generating fear, causing economic losses, and/or undermining social stability. The goal of agroterrorism is not to kill cows or plants. These are the means to the end of causing economic damage, social unrest, and loss of confidence in the government.”⁶¹ The difference between this and the problems we are currently facing is really a matter of human intent. The organisms we currently fight were not intentionally introduced into our food supply, but they are nonetheless creating a significant economic impact regardless of the intent. We simply call the current threat “invasive species.” There have been numerous incidents impacting United States agriculture which can be used to investigate the issues surrounding invasive species.



Citrus Greening. In 1998, the introduction of the Asian psyllid, an insect of only 3-4mm in length, initiated the problem of citrus greening in Florida, which caused a tremendous economic impact on Florida citrus growers, approximately \$3.63 billion in losses from 2006 to 2012.⁶² There is no indication that this was the result of an intentional introduction of the insect into the United States. One of the most likely ways this insect entered the United States is on ornamental plants like the orange jasmine or the box orange, which are considered co-hosts for the Asian psyllid.

Porcine Epidemic Diarrhea (PEDV). On the animal side of the agricultural equation, one of the major diseases that is currently facing hog producers is Porcine Epidemic Diarrhea Virus (PEDV). Unlike citrus greening, it is completely unknown how the disease was introduced but it is not believed to be intentional. The National Animal Health Laboratory Network estimates that that 4-5 million piglets have been lost from PEDV in the U.S. during the past 9 months.⁶³ As the industry tries to recover this lost production by introducing more breeding sows, they run the risk of spreading the disease to currently uninfected areas.

High Risk Diseases. Neither of the diseases described above can be transmitted to humans and therefore are considered to be diseases that agroterrorists would not be likely to choose if they are targeting United States agriculture. While they both are impacting the United States agricultural sector, they are not causing a mass exodus from a sector of United States agriculture like Bovine Spongiform Encephalopathy (BSE) or Mad Cow Disease did. In 2003 there was one confirmed case of a cow with BSE in Washington State. That one case closed almost all international markets to US beef sales. The U.S. Meat Export Federation estimated the cumulative loss in U.S. beef trade at about \$16 billion over the past 10 years.⁶⁴ The reason that just one case had such an impact on the beef industry is that it is believed that a variant of this BSE causes Creutzfeldt-Jakob disease (vCJD) in humans.

As we have seen, there is a huge financial impact from invasive species even without the incidence of agroterrorism. The most effective method of preventing the occurrence of an incident of agroterrorism would be to minimize the economic impact of the act. The methods of doing this would be the same as the methods that are being used to combat invasive species that are entering the country unintentionally.

Public-Private Partnerships. Because of the wide-spread nature of agriculture and the varied interests involved there is no single entity, either governmental or private, that can effectively address any of these invasions. The most effective means of combatting the invaders is through the use of public/ private partnerships. This would include a wide range of different arrangements which would include the United States Department of Agriculture (USDA), industry organizations, research universities including the Land Grant Universities, and private companies such as Monsanto. There are so many variables involved in trying to find the right pesticide, herbicide, fungicide or phytosanitary measures that will eradicate the problem that a multi-front approach is needed. These measures include monitoring the spread of the disease, research into the cure, funding the research, and ensuring that the cure does not have unintended consequences of harming humans or helping plants or animals. Because multiple entities can be working on the same aspect of the solution-- research for example may be conducted by the government, universities, or private industry-- partnerships need to be in place to ensure that efforts are not being duplicated.

Education. The single most effective manner of combating invasive species is the spread of knowledge. There is a two part approach that needs to be taken with respect to education. The first is that the key to combatting the invasive species is educating people, both in the



agricultural industry and in the general public what to look for. Those in the industry know to reach out to their industry specific and state agricultural outreach forums. We need to ensure that these groups have a way to reach back into the information that the USDA and other governmental and agricultural research entities develop to get accurate information out to the growers.

An effective method of doing that is by using cooperative agricultural extension programs which are a part of the Land Grant universities in each state. This is an effective way of taking government funding, combining it with research from the university and distributing the resulting knowledge to the public. This also allows a reach back into the research community to validate which measures are generating overall benefit. Most states realize the benefit derived from these linkages and ensure that there is at least one extension program in each county in the state. Unfortunately, some of the states are moving toward regionalized extension programs to save money. Many of the pests are entering the country on goods intended for the general consumer. Additionally there is a resurgence in crop production in urban areas in the form of urban farms and backyard poultry growing. These small producers can provide the pests a foothold habitat and often the growers have limited knowledge of the pests that may be attacking their crops. In these areas it is important for the extension services to reach out to the public so that small producers know that there is an asset available to help them. In predominantly agricultural counties, the farmers know that the extension service is there for them to access. In urban areas the extension service is an under-realized asset and therefore, to ensure that this high risk area has the appropriate resources to fight invasive pests, the outreach extensions need to be maintained and be given the means to advertise the service they offer.

The second part of education is to encourage students to go into entomology and agricultural disease fields. It has been suggested that there are up to 30 million different species of insects in the world and approximately 10 quintillion individual bugs.⁶⁵ With the current levels of worldwide trade there is no reasonable expectation that we can keep all of the ones that generate risk to our agricultural production out of the country. While the USDA has the Animal and Plant Health Inspection Service (APHIS) inspectors to help combat the problem, there are few true experts in the field. For example, at the USDA Agricultural Research Center in Beltsville, Maryland, the Systemic Entomology Laboratory provides expert assistance to the APHIS inspectors. This is a group of only seventeen research scientists who in 2013 provided over 6,600 urgent identifications for APHIS.⁶⁶ These identifications are the final determination that the government relies on to decide if a shipment that contains opportunistic insects will be allowed into the country or not. It should be noted that each of these different scientists specializes in a specific type of insect and therefore they are not able to provide identification for other species. This leaves the United States vulnerable if we should suddenly lose one of these experts. Students need to be incentivized to enter this field so we can rebuild our pool of talent.

Management of the Risk. While agroterrorism may not be a problem that we have faced, we need to know how to fight it because we are facing what is effectively the same threat to our economy just by participating in the global market. There is no way that we can have a global economy without risking the introduction of invasive species. We need to learn how to manage these risks and “learn” is the key word. The only effective way to deal with these problems is to know what we need to look for and how to fight these pests effectively. This includes both general knowledge for producers as well as specialized knowledge for researchers and government inspectors and scientists. There also needs to be a network to spread this knowledge across the agricultural spectrum because the insects turn up where they want to and



not where we would like them to. We need to get the information on how to combat them to every corner of the agricultural sector and incentivize students who are capable of this type of detail oriented work to enter this field. We may not be able to prevent the first act of agroterrorism from occurring, but if we can prevent the spread of invasive species we can deter follow-on attacks by making it too difficult to effectively disrupt the system. We need to fight the threat we are facing and worry about possible later threats, later.

Essay #3 – Policies for Genetically Modified Organisms
COL Charles Walters, US Army

The term genetically modified organism (GMO) evokes a wide spread of emotions in society today. Defined by the USDA as “an organism produced through genetic modification,” GMOs are associated with the plants and animals that have received a gene from an unrelated species.⁶⁷ GMOs are prevalent in today’s agriculture allowing for unprecedented production, especially in the United States. If nations are going to feed their populations, GMOs have to be part of the solution. Yet not all countries have embraced this technology. Each country approaches GMO regulations and policy implementation differently. Current policies run the gamut from GMO free to almost no restrictions. One reason for the divergence is the spectrum of arguments both for and against GMO use. A review of these arguments and policy development clarify why nations are challenged to openly embrace GMOs. Ultimately, GMO solutions are needed to ensure the food demand is met with the necessary supply.

GMOs provide definite advantages for the farm industry when viewed through the scientific lens. GMOs provide increased agricultural productivity for a growing world population. GMO crops require less herbicides and pesticides, which benefits the environment. Finally, GMO products are as safe for human consumption as organic products. In some instances, the crop has been enhanced to be even more nutritious.

Increased productivity is a major benefit of GMOs. The world’s population continues to grow and hunger still exists. In order to meet the food security needs of all people, agricultural practices with increased yields are required. GMO technology can help to achieve these increased yields through a variety of ways. One means is through addressing potential diseases within the plants. Papaya is susceptible to a viral infection. To combat this, geneticists placed a snippet of the viral genome in the papaya to immunize the plant. This type of papaya is now grown by 99% of all Chinese farmers and has resulted in decreased crop loss.⁶⁸ In another example, Monsanto released a drought resistant corn seed for the US in 2013. This corn allows for enhanced yields in limited water environments.⁶⁹ Drought resistant corn enables farmers to overcome unforeseeable weather changes while still meeting food demands. In both cases food production has been enhanced due to the use of GMOs.

GMOs have been developed that reduce the environmental effects of herbicides and insecticides. Farmers use insecticides and herbicides to ensure a healthy and bountiful yield for their crops. In using genetically modified crops, the amount of these environmentally damaging products is reduced. One such common herbicide is glyphosate. Glyphosate kills weeds while reducing the amount of tillage required. Currently, it’s estimated that 80-90% of the US cotton, corn, soybeans, and sugar beets are herbicide resistant for glyphosate. The GMO effect is as much as 58% reduction in the tillage required.⁷⁰ This reduced tilling promotes soil conservation and reduced greenhouse gas emissions. These environmental benefits would not be achievable under conventional agricultural practices.



Finally, GMOs are safe to eat and may offer added nutritional values. GMOs have been used in the US over the last twenty years. During that time there has been no documented case of health related issues associated with their use.⁷¹ As stated by the Federal Food and Drug Administration (FDA), all “food and food ingredients derived from genetically engineered plants must adhere to the same safety requirements.”⁷² Current government regulations prohibit the use of such products if a risk is posed to the general public. The FDA evaluates all new products on the market to ensure its safety to the consumer. GMO crops can provide enhanced nutritional value. One example under development is golden rice. This GMO crop produces vitamin A enriched rice that would provide a much needed nutrient to the developing world.⁷³ GMO products have enormous potential to solve global food challenges.

The potential benefits of GMOs are not universally accepted. The opposition to their use is strong at all levels of society. There are three main arguments against the use of GMOs. First, consumers fear potential health issues from eating GMO foods. Second, there is concern over large corporations controlling the food industry through intellectual property controls. Third, GMOs provide technological solutions to agricultural problems but have the potential for environmental impacts that could prove to be more disadvantageous.

One of the most common arguments heard against GMO use is that they may cause health problems. There is no documented case of GMO foods causing a health issue in any country that has approved such products.⁷⁴ This very argument is used to challenge GMO use. Opposing views take the position that there is no evidence because there have been no epidemiological studies to disprove this notion.⁷⁵ Even if there were studies, scientists would be challenged to definitively determine the root cause of the health issue. This is because genetically modified (GM) food would have to meet specific conditions. An individual would have to show symptoms soon after eating a GM product. These symptoms would have to be distinct enough to warrant investigation.⁷⁶ The other challenge to proving health effects is the potential that they may be long term in development. This was the case for trans-fatty acids.⁷⁷ With the relative recent use of GMO products, more time is required to make an informed decision on the health risks.

Monsanto is the largest producer of GMO seeds in the world. Monsanto’s gross profit for 2013 was \$14.8 billion.⁷⁸ The company controls over 80% of the corn and 90% of the soy GMO seed market in the United States.⁷⁹ Monsanto’s ability to control seed prices coupled with the importance of corn and soy in the commodities market causes serious concerns. These concerns are voiced both in the US and internationally. Peng Guangqian, a retired Chinese general and prominent think-tank blogger/author, believes the use of US GMO seeds in China are a plot to control that nation’s food supply. Peng’s argument was directed to army officers but when leaked stimulated the anti-GMO movement within China.⁸⁰ Biotech firms will continue to draw the ire of consumers with their large span of control.

Finally, some argue that GMOs have had some negative impact on the environment. These risks include, but are not limited to, the transference of genes to non-GMO plants, development of insecticide resistant pests, and herbicide resistance weeds. These occurrences are often a result of improper agricultural techniques but in many ways are unavoidable. GMO seeds have been developed with a tolerance for the herbicide glyphosate. Farmers use these seeds to reduce the amount of herbicide required and to produce larger yields. If used continuously in the same field, resistant weeds will develop. Since 1996, twenty-four glyphosate resistant weeds have developed that now require a new herbicide for eradication.⁸¹ The fear is that herbicide resistant weeds will grow as the use of GMO seeds becomes more prevalent. Eventually the



biotech companies may be incapable of developing a herbicide resistant seed. This could lead to further environmental degradation because of herbicide use.

The GMO debate is at the center of international policy development. The pro-GMO nations use the principle of substantial equivalence. This term was first used by the Organization for Economic Cooperation and Development. The premise is that the safety assessment of a GMO product is compared to a non-GMO in order to identify differences.⁸² If the comparison results in both products being similar in nature, then the implication is that the product is as safe as the original. If the products are not the same, then product evaluation is required. Policies developed under this principle are more lenient on the use of bio-technological solutions. The United States has adopted this principle in the use of GMOs.⁸³

Other nations, such as many in the European Union (EU), are more apt to take a precautionary approach to regulation.⁸⁴ These two divergent views lead to trade imbalances and internal debates on the use of GMO products. The result is a diverse group of policies and laws that may or may not promote food security within a nation. The European Union (EU) based its regulations on the precautionary principle. This principle states that when a possible hazard exists but there is not enough scientific evidence to dispute its existence, action should be taken. The lack of full scientific evidence is required to enact this principle.⁸⁵ This position results in very restrictive measures against the use of GMO products. A 2008 study of international trade in relation to GMO regulations reveals the EU policies, on average, were almost twice as restrictive as US policies.⁸⁶ As other nations look globally for regulatory precedence, the EU's position has had negative influence on GMO use. This is particularly true in Africa where their use is very restrictive. Zambia and Zimbabwe have both declared themselves GM 'free'.⁸⁷

A review of China and India's GMO policies reveal differences. China has a slightly more restrictive policy than the US. However, China's policy is not as strict as the EU. India's policy is on par with the United States.⁸⁸ Currently both China and India are at a wait and see approach toward the use of GMOs. GMO crops are used sparingly and are limited by species. Government policy on their use is unlikely to change in the near future. The current policies enable both governments to effectively control GMO production and importation. By moderating GMO employment, each government reduces the risk of public backlash from opposing camps while buying time for further scientific research. The reality is that GMOs are not globally accepted and China and India recognize this fact. The lack of universal GMO acceptance provides the rationale for nations to move slowly in their implementation.

In order to eventually achieve full acceptance of GMOs, further scientific study and public education is required. Nations desiring to enhance food production through GMO use will need continued investment from the scientific community. Only through earnest studies with transparent results will the naysayers be swayed and public reassurance achieved. That is not to say that GMOs are a panacea to food security issues. Truly the solution is more than technological development, yet GMOs do provide an opportunity that if exploited could provide food security benefits to a nation.

In the end, governmental GMO policy is just one piece of meeting the food security challenge. If GMOs can continually bring better yield rates to the farmers while allowing for less than ideal growing conditions, this must be an option for growing nations. On the other hand, issues like food waste and distribution also contribute to world hunger. Norman Borlaug stated in his Nobel lecture of 1970, "Civilization as it is known today could not have evolved, nor can it survive, without an adequate food supply."⁸⁹ Nations cannot afford to meet the challenge of food security by eliminating viable options like GMO use. Effective policies will provide the



framework necessary to meet this challenge and the future of every nation is dependent on the global ability to feed the world.

Conclusion

The issues surrounding food security and the nexus to instability and violence are complex and may not be considered by national security experts often enough. The fact remains, however, that the growing numbers and growing income levels of the world population will likely increase the demand for food supplies and create additional food price shocks. As the violent protests and revolutionary movements in North Africa and the Middle East during the past several years have shown, has the potential for food security grievances to grow into social unrest and broad acts of violence may be increasing. The 2014 Eisenhower School Agribusiness Industry Study seminar analyzed the domestic and international issues surrounding food security through visits to US industries, academic and government institutions, as well as visits to the countries of China and India. After evaluating the entire industry and its challenges, there is one over-riding conclusion: governance matters more than any other factor. The world's agribusiness sector will likely be capable of producing the food needed to feed the population and meet most consumer demands, but the willingness and ability of governments to develop and adopt new technologies, invest in infrastructure needed for distribution, and provide the security needed for the agriculture system to flourish remains uncertain. More than anything, efforts by the United States should focus on helping other countries establish effective governance, both for agricultural advancements as well as all the other elements of good governance that are as important, or perhaps more important, than any other element of food security challenges.



Appendix 1

Figures

This appendix provides supporting figures that provide additional detail to the industry report.

Figure 1. *Agriculture Value Chain*. (Source: Research Into Use website, accessed May 16, 2014 at <http://www.researchintouse.com/nrk/RIUinfo/valuechain/valuechain.htm>.)

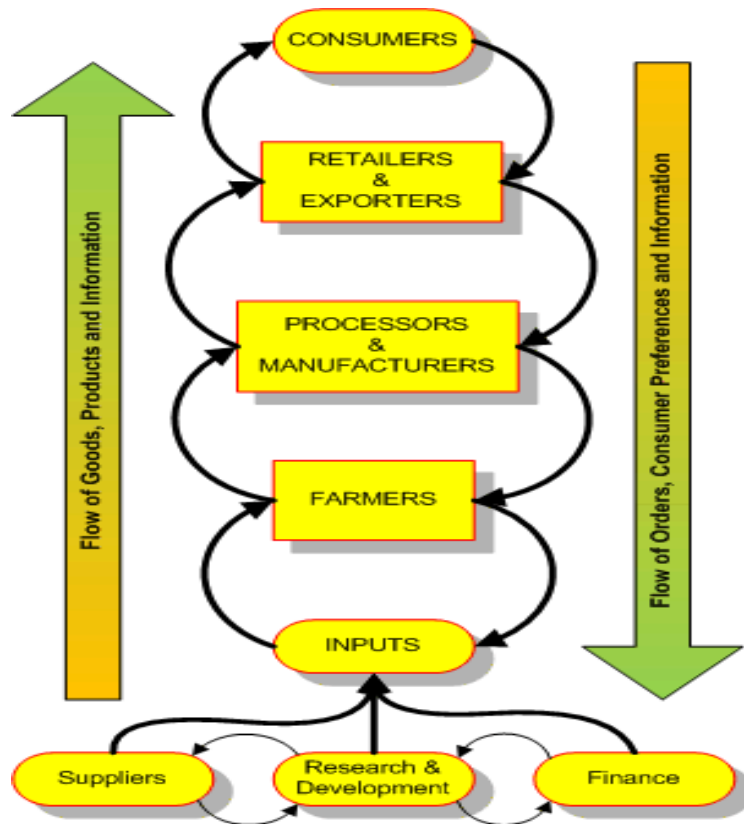


Figure 2. *Agricultural Price Index and Population Trend, 1900-2010.* (Source: K. O. Fuglie and S. L. Wang, “New Evidence Points to Robust but Uneven Productivity Growth in Global Agriculture,” *Amber Waves* 10, September 2012.)

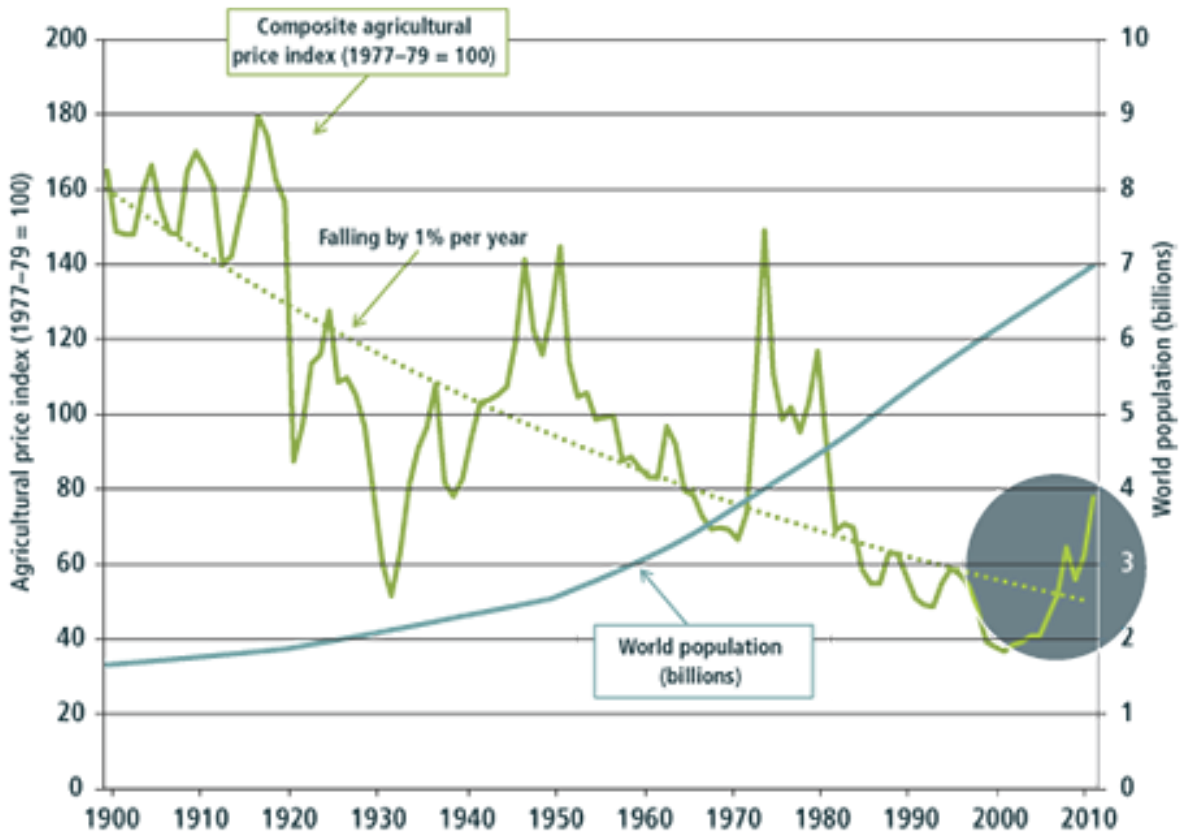
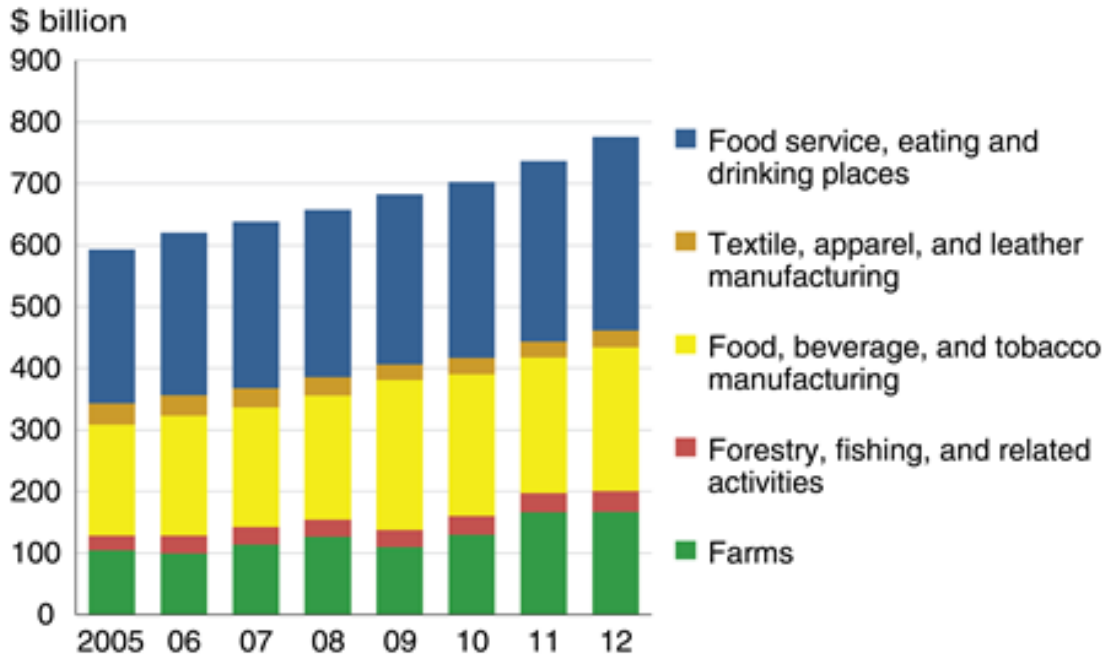


Figure 3. *Value Added to GDP by Agriculture and Related Industries, 2005-12.* (Source: United States Department of Agriculture, Economic Research Service, accessed May 16, 2014 at <http://www.ers.usda.gov/data-products/chart-gallery/detail.aspx?chartId=40037&ref=collection&embed=True#.U3pTcsZzMVt>.)

Value added to GDP by agriculture and related industries, 2005-12



Note: GDP refers to gross domestic product.

Source: USDA, Economic Research Service using data from U.S. Department of Commerce, Bureau of Economic Analysis, Value Added by Industry series.



Figure 4. *By 2030, Nearly Two-Thirds of the World's Population Will Live in Urban Areas.* (Source: United Nations, World Urbanization Prospects: The 2005 Revision (2006) and Carl Haub, 2007 World Population Data Sheet, accessed May 16, 2014 at <http://www.prb.org/Publications/Articles/2007/623Urbanization.aspx>.)

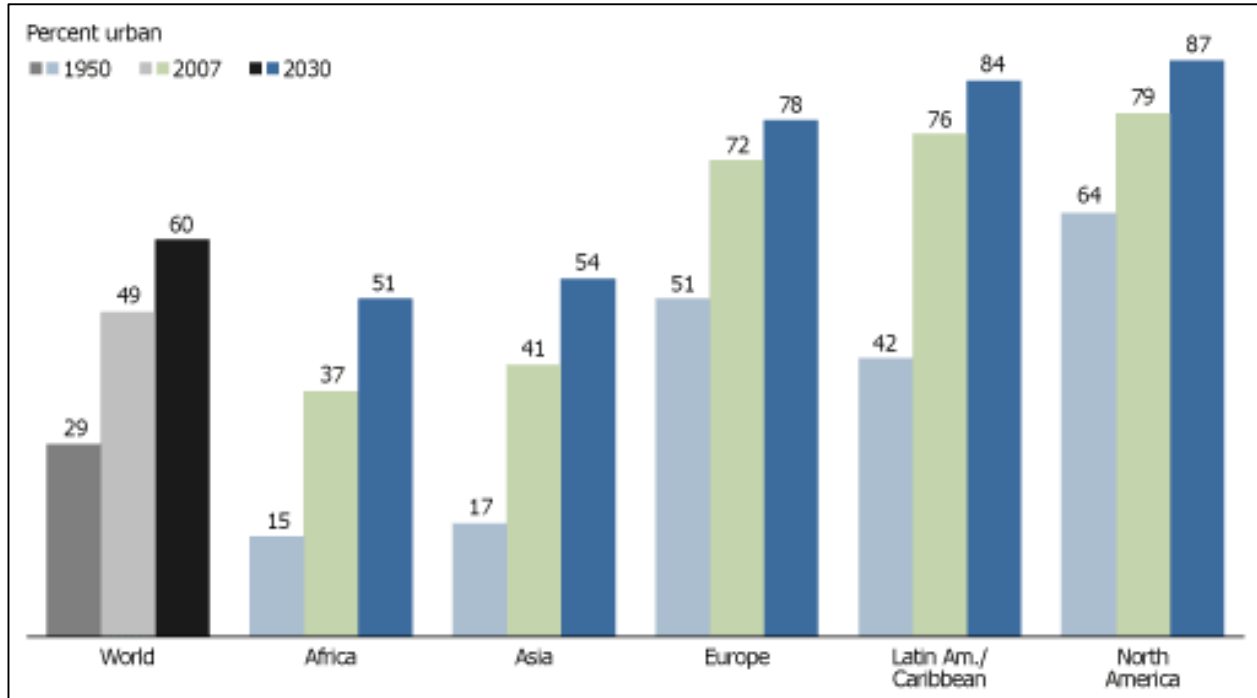


Figure 5. *Food Security Risk Index 2013.* (Source: Maplecroft Global Risk Analytics, accessed May 16, 2014 at http://maplecroft.com/about/news/food_security_risk_index_2013.html.)

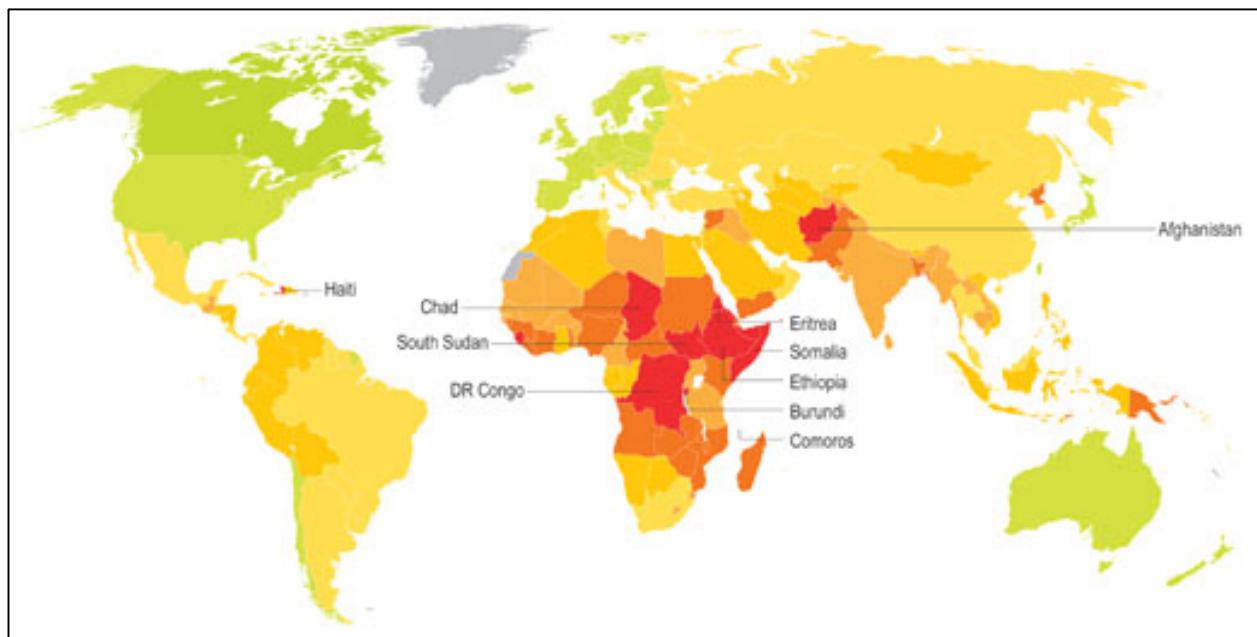
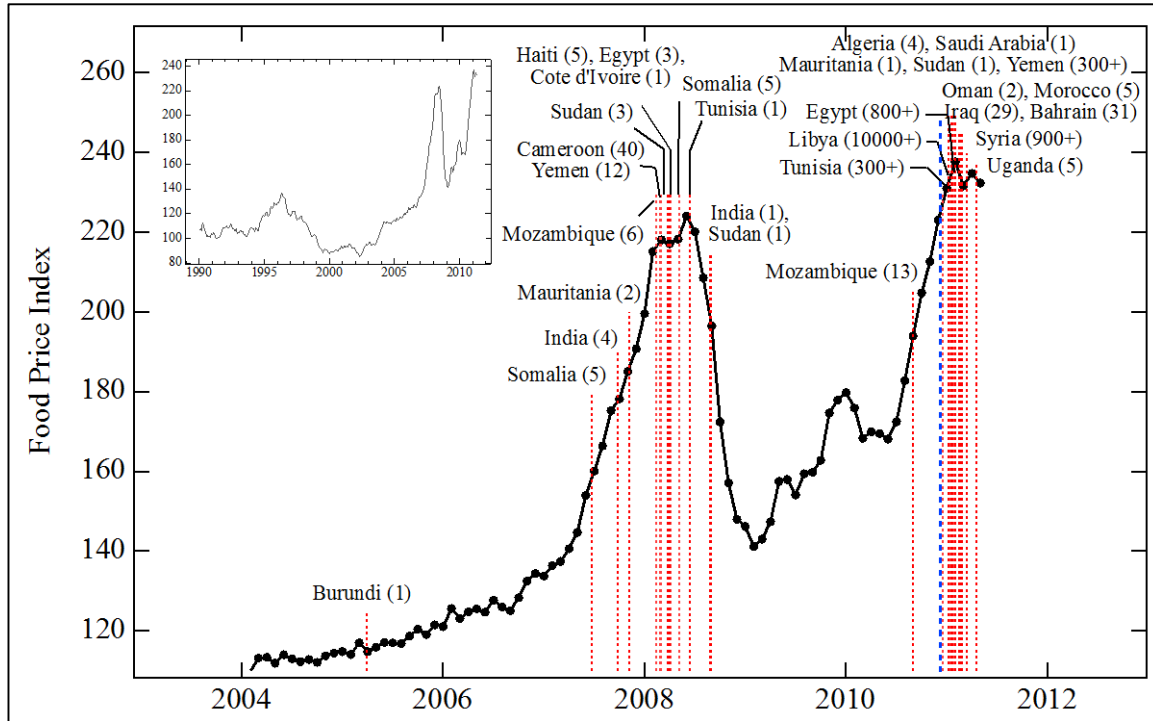


Figure 6. *Food Price Shocks and Violence*. This chart shows the time relationship of FAO Food Price Index from January 2004 to May 2011 and violence. Red dashed vertical lines correspond to beginning dates of “food riots” and protests associated with the major recent unrest in North Africa and the Middle East. The overall death toll is reported in parentheses. Blue vertical line indicates the date, December 13, 2010, on which the New England Complex Systems Institute submitted a report to the U.S. government, warning of the link between food prices, social unrest and political instability. Inset shows FAO Food Price Index from 1990 to 2011.

(Source: New England Complex Systems Institute, September 28, 2011, accessed May 16, 2014 at http://necsi.edu/research/social/food_crises.pdf.)



Appendix 2

Strengths, Weaknesses, Opportunities, and Threats (SWOT) Analysis

This appendix outlines analysis of agribusiness and food security using the strengths, weaknesses, opportunities, and threats methodology. Strengths and weaknesses identify internal factors and opportunities and threats identify some external factors. It is also important to understand that this analysis was conducted through the lens of United States national security only. It is not a comprehensive food security analysis. It only identifies issues that are deemed important to US national security – particularly those that affect stability and may contribute to outbreaks of violence. (Editor’s note: This appendix is intended as a compilation of analysis, not as a report or paper in itself. As such, it contains several long quotes from various sources that provide more background and detail for use in analysis, but would not normally be included in an academic paper or report.)

US Strengths

In general, the United States agribusiness industry is strong and underpins the entire economy and security of the country.

Geography. STRATFOR, a geopolitical intelligence firm, summarizes the key strengths of US geography as it relates to agriculture and national strength.

The American geography is an impressive one. The Greater Mississippi Basin together with the Intracoastal Waterway has more kilometers of navigable internal waterways than the rest of the world combined. The American Midwest is both overlaid by this waterway and is the world's largest contiguous piece of farmland. The U.S. Atlantic Coast possesses more major ports than the rest of the Western Hemisphere combined. Two vast oceans insulated the United States from Asian and European powers, deserts separate the United States from Mexico to the south, while lakes and forests separate the population centers in Canada from those in the United States. The United States has capital, food surpluses and physical insulation in excess of every other country in the world by an exceedingly large margin. So like the Turks, the Americans are not important because of who they are, but because of where they live.⁹⁰

Governance. American agricultural success is fostered by its stable, representative government that ensures security, a legal framework conducive to free commerce, and mostly agriculture-friendly regulation. Examples of US government strength include the food safety and inspection system, conservation programs improve the environment and help keep the water clean, the Forest Service manages national forests, rural development programs supports rural economy where much of the food is produced. The education and extension services of USDA are unparalleled, and their Foreign Agricultural Service has 170 foreign service officers in 102 offices in 82 countries as well as monitoring and reporting on agriculture trade matters of an additional 82 countries.⁹¹ Legislative actions also create a supporting environment overall. Dozens of laws have been passed to provide public support to ag research and education -- from the Morrill Act of 1862 which established the Land-Grant College Program to the more recent



Federal Agriculture Improvement and Reform Act in 1996) to the well known Farm Bill which helps to support farmers and reduce food insecurity in the US.

Markets. Capital markets provide easy access to funding needed for growth and efficient commodity markets seamlessly link producers and buyers and mitigate the risk of catastrophic loss by sharing risk across markets participants.

Infrastructure. Navigable inland waterways, as mentioned above, are a significant distribution infrastructure resource, as are the roads, ports, and strong logistics industry. The US has over 4 million miles of highway, 141,000 miles of rail, and over 25,000 miles of navigable channels. The U.S. Atlantic Coast also possesses more major ports than the rest of the Western Hemisphere combined. As a comparison, China has only about 100,000 miles of highway roads and about 41,000 miles of rail lines.⁹²

Distribution. The United States is a global leader in agricultural logistics and has the capacity to store and transport perishable and non-perishable commodities globally with minimal waste. It should be noted that additional investment on a national scale is necessary to maintain and expand current infrastructure to meet future requirements.

Science and Technology. The United States government has contributed significant public funding for agriculture research and development, and the United States economic environment promotes private investment as well as public-private partnerships that conduct agriculture-related R&D. One of the results of US government investment in R&D has been an average 1.5% per year increase in productivity levels over the past 50 years. As a result, total US agriculture output in 2008 was 2.5 times that in 1948.

Education. The United States has, arguably, the world's greatest agriculture education institutions that are built upon the land grant university system and programs such as the Future Farmers of America. The education programs in the United States provide it with a well-educated and productive workforce for the agribusiness industry.

Widespread Access to Food. The United States has a highly efficient production and distribution system. When combined with fairly liberal import rules and a relatively high-income population, the US population has an unparalleled access to quantities and varieties of food. Additionally, the high productivity levels, robust logistics infrastructure, and well-stocked supermarkets results in food readily available and prices being lower than any country in the world.⁹³

US Weaknesses

In the context of the rest of the world, there are very few weaknesses when it comes to the ability of the US to supply food to its population and meet most global demands. The few areas that warrant attention include:

Science and Technology Investment. While the United States invests more than many countries on agricultural research, the growth in public R&D investment has been slowing just when the need for innovation is rising. The growth rate in US R&D funding has slowed down in recent years while demand for food and better technologies are on the rise. The USDA's Economic Research Service (ERS) has conducted analysis to determine the effects of US public R&D funding and found that, at current spending levels, agriculture productivity growth will fall to only 0.75 percent per year, nearly half of what it has been over the past decade and nearly half of the rate of growth for the world's population. At this rate, the US production would only increase 40% by 2050. The ERS research also shows that increasing R&D spending by 3.73



percent annually, the historic rate of inflation, would increase US agriculture output 73 percent by 2050.⁹⁴

Regulatory Environment. Overall, political and special interest supported subsidies distort the market and can have damaging second and third order effects. A short report from the CATO Institute points out that, “the U.S. Department of Agriculture imposes extensive regulatory controls on agricultural markets. Some regulations are intended to promote safety and reduce disease, while others restrict commodity supplies and raise consumer prices. The Code of Federal Regulations includes 10,720 pages of rules for the USDA to enforce, covering everything from popcorn promotion to farmers’ markets.”⁹⁵ The report highlights the highly regulated dairy and sugar industries as two areas where more deregulation is needed, particularly with regard to price supports, income support programs, trade barriers and export subsidies.

Labor & Immigration. The availability of labor to meet the needs of farmers and agribusiness enterprises also merits attention is one of the more important challenges facing American agriculture. In the US, hired labor costs make up approximately 17 percent of production expenses for all agricultural commodities and up to 40 percent of expenses for crops such as fruits, vegetables, and nursery products.⁹⁶ Increasing the labor pool with access to cheaper labor is important. Unfortunately, significant bureaucratic barriers hinder the United States from fully capturing the economic potential of this labor force. The current H-2A visa process is simply too cumbersome for farmers to follow.⁹⁷ The complexity of current policies does little to encourage compliance, while incentivizing hiring undocumented workers and exacerbating border security concerns. By streamlining the H2a visa program to allow more legal migrant workers to work on farms would improve the agriculture labor market and allow farmers to plan future harvests assuming the use of legal labor. The current administration estimates that expanding the number of agricultural workers eligible for the H-2A program would increase agricultural production and exports by around 1.6 percent and 2.5 percent respectively.⁹⁸

Malnutrition. Despite an abundance of educational programs, obesity and “over nutrition” remain key health concerns. The Centers for Disease Control and Prevention states, “[m]ore than one-third of U.S. adults (34.9%) are obese. Obesity-related conditions include heart disease, stroke, type-2 diabetes and certain types of cancer, some of the leading causes of preventable death. The estimated annual medical cost of obesity in the U.S. was \$147 billion in 2008 US dollars.”⁹⁹

Waste. Post-consumer waste remains high in United States. A January 2013 article in *Businessweek* stated, “Americans threw out the equivalent of about \$180 billion worth of food—an 8 percent increase from 2008, the last time the USDA calculated the total value of food loss from households, supermarkets, restaurants, and other food-service providers.”¹⁰⁰

Global Opportunities

Potential to Increase Yields. In general, there is significant room for yield growth in developing countries, much more so than in industrial countries that already have good government policies, infrastructure, and farming practices. A large section of the conclusion of a report by the United Nations Food and Agriculture Organization is included here to provide more specific insight into this opportunity.

First, despite impressive gains in yields over the past 50 years in most of the world, large and economically exploitable yield gaps remain in many places, especially in the



developing world and nowhere more so than in sub-Saharan Africa where food supply is the most precarious. Second, in the short to medium term, there are many technologies that are in their early stage of adoption that promise a win-win combination of enhancing productivity and sustainably managing natural resources. These include conservation farming approaches based on no tillage and the GM technology revolution—both still only used on less than 10 percent of the world’s cropland—as well as the even earlier adoption phase of information and communication technologies (ICT) for more efficient and precise management of modern inputs. Third, yield gains are not achieved by technology alone, but also require complementary changes in policies and institutions. In much of the developing world, policies are now more favorable for rapid productivity growth, while a range of innovations in risk management, market development, rural finance, organizing farmers, and provision of advisory services, show considerable promise to make markets work better and provide a conducive environment for technology adoption. Indeed, in sub-Saharan Africa these innovations are a necessary condition for wider adoption of critical technologies such as fertilizer. Fourth, plant breeders continue to make steady gains in potential yield and water-limited potential yield, more slowly than in the past for wheat and rice, but with little slackening in the case of maize; there is no physiological reason why these gains cannot be maintained but progress is becoming more difficult with conventional breeding. Genomics and molecular techniques are now being regularly applied to speed the breeding in the leading multinational seed companies and elsewhere, and their costs are falling rapidly. As well, transgenic (GM) technology has a proven record of over a decade of safe and environmentally sound use and its potential to address critical biotic and abiotic stresses of the developing world, with positive consequences for closing the yield gap, has yet to be tapped. We believe that the next seven to ten years will see its application to major food crops in Asia and Africa and that after its initial adoption, the currently high regulatory costs will begin to fall. We note however that this will require significant additional investment, not least in the areas of phenotyping on a large scale, and that it still takes 10-15 years from the initial investment until resulting technologies begin to have major impact on food supply. Transgenics for greater water-limited potential yield may also appear by then, but transgenics for greater potential yield, arising from significant improvements in photosynthesis, may take longer than even our 2050 horizon.¹⁰¹

Climate change. Climate change has both benefits and drawbacks. Global warming will create opportunities in some regions like Canada, Scandinavia, and northern Russia by extending the growing season, while contracting it in others due to drought like the Southern United States, Europe, and much of Africa. The US Environmental Protection Agency summarizes the impact of climate change on agriculture as follows:

Agriculture and fisheries are highly dependent on specific climate conditions. Trying to understand the overall effect of climate change on our food supply can be difficult. Increases in temperature and carbon dioxide (CO₂) can be beneficial for some crops in some places. But to realize these benefits, nutrient levels, soil moisture, water availability, and other conditions must also be met. Changes in the frequency and severity of droughts and floods could pose challenges for farmers and ranchers. Meanwhile,



warmer water temperatures are likely to cause the habitat ranges of many fish and shellfish species to shift, which could disrupt ecosystems. Overall, climate change could make it more difficult to grow crops, raise animals, and catch fish in the same ways and same places as we have done in the past. The effects of climate change also need to be considered along with other evolving factors that affect agricultural production, such as changes in farming practices and technology.¹⁰²

Trade. As the world grows more interdependent, and countries rely on each other to provide desired foods, the need for more open and free trade on agricultural products increases. Christopher Barnett, one of the authors of *Food Security and Sociopolitical Stability*, points out that, “[t]he use of trade policy instruments holds obvious appeal for states looking to placate restless urban constituents. But it becomes especially problematic for food-importing countries growing ever more dependent on reliable trade partners to ensure food access....”¹⁰³ Additionally, challenges such as increasing total demand, production limitations, and increased reliance on imported foods in developing countries creates a global food system where unforeseen events such as droughts, floods, and other natural disasters can cause a spike in local food prices. When prices spike, governments often face significant pressure to take action, such as export bans that keep prices lower for that particular country. These export bans often occur in higher income countries yet have a greater impact on stability in lower income countries. The food price spikes that sparked riots throughout much of the Middle East and North Africa in 2007-8 and 2011-12 were not the direct result of reduced production in the Ukraine and Russia, but by their export bans that resulted in a much more serious food price rise in the countries planning to import their wheat. Had these countries kept their export commitments and had enough stores to absorb the shock, the prices would not have spiked and the violent protests may not have occurred. Barnett summarizes the need for more free and open trade by stating, “[i]nternational trade is supposed to dampen price fluctuations by spreading weather and other production risks across countries – a major reason why most economists advocate for agricultural trade liberalization.”¹⁰⁴

Improvements to Logistics. Producing the food is not enough. It has to be delivered with minimal waste to the where the people need it, often to large urban areas, but also to more rural areas where roads, rail, and other transportation infrastructure is often poor. Urbanization in developing nations has accelerated the need for infrastructure development and logistical capabilities, particularly cold-chain logistics, to transport food from field to market as well as industrial products and imports back to the rural areas. Additionally, increasing long-term storage capacity to facilitate the stockpiling of key food staples is another means to offset the impact of temporary food shortages and mitigate price spikes.

Transportation infrastructure remains a significant impediment to food security. In highly developed countries, transporting products from the fields and the farms to the processor or consumer will present a major challenge for a system that has evolved to primarily move various bulk agricultural products like grains and oilseeds. In developing countries, the challenge will continue to be the storage and distribution of food products to prevent waste prior to reaching the retailer or consumer. To meet this requirement it may be necessary to adapt some parts of existing agricultural transportation systems or develop entirely new marketing channels and distribution systems which will ultimately create new agri-logistics challenges.¹⁰⁵

Rising Incomes and Growing Middle Class. Demand is the ultimate driver of supply, even when it comes to agriculture and the rising population levels of the world are only one



element of the increased demand on food systems. Perhaps an even greater impact will come from the rising income levels and growing middle class across the globe, which presents both an opportunity and a threat to food security and associated instability. The Organization for Economic Cooperation and Development (OECD) provides some key statistics.

In 2009 the middle class included 1.8 billion people, with Europe (664 million), Asia (525 million) North America (338 million) accounting for the highest number of people belonging to this group. This expansion continues. The size of the “global middle class” will increase from 1.8 billion in 2009 to 3.2 billion by 2020 and 4.9 billion by 2030. The bulk of this growth will come from Asia: by 2030 Asia will represent 66% of the global middle-class population and 59% of middle-class consumption, compared to 28% and 23%, respectively in 2009. The developing world’s “emerging middle class” is a critical economic and social actor because of its potential as an engine of growth, particularly in the largest developing countries such as China and India but also in sub-Saharan Africa. History tells us that those in the middle have in the past vigorously accumulated capital, be it physical (plant, equipment or housing) or human (education or health). Consolidating this incipient middle-income group into a stable middle class could provide a solid foundation for economic progress by driving consumption and domestic demand.¹⁰⁶

Global Threats

Weak Governance. Good governance remains one of most important elements of enabling food security and minimizing potential destabilizing effects. Trade policies, investment in infrastructure, choices of regulation and subsidies, and the ability to provide physical security will drive many of the food security solutions for the coming decades. Conflict and political uncertainty, weak governance, poor infrastructure, limited use of available technologies, and the effects of climate change will likely continue to be sources of food insecurity. Additionally, agriculture is often the foundational sector of a thriving economy. Therefore, governments, especially those in developing countries, must make a concerted effort to develop and implement fact-based and economically sound agriculture policies that stimulate productivity and improve distribution systems. Meeting the food needs of tomorrow’s society will require improvements to farming practices in less developed countries, acceptance of more transgenic plants, less restrictions to trade, improved storage and transportation infrastructure, and increased stores of commodities to help dampen price shocks.

The real challenge for low-income countries to secure stable access to food, either presently or in 2050, is mostly dependent upon whether an appropriate market mechanism works properly or not. Reducing corruption and establishing governance in failing countries is key to this goal. It is difficult to expect a healthy market mechanism to work if a country fails to establish effective governance. Although the U.S. and other international agencies have many programs in place to ensure global food security, establishing effective governance in failing states must take center stage. Stable governance is necessary to attract the private investment required to build the infrastructure and logistical systems upon which a reliable food supply depends. In order to achieve food security goals, international organizations and private companies must work together to ensure availability, access, utilization and stability.



Spikes in food prices, particularly in countries where food subsidies are prevalent, can ignite or fuel grievances associated with the perceived failure of governance. The violent protests that spread across North Africa and the Middle East in 2007-8 and again in 2011 are often blamed, to some degree, on the sharp increases in food prices that occurred at the same time. A report produced by the New England Complex Systems Institute in 2011 suggests that the spike in food prices created the “precipitating condition for social unrest.”¹⁰⁷ The report points out that governments are expected, by their population, to look out for the well being on their citizens and that food security is one element of government legitimacy. The report further explains that, in today’s increasingly interdependent world where many countries rely on imports for food needs, “...political organizations may be perceived to have a critical role in food security.” Additionally, the “[f]ailure to provide security undermines the very reason for existence of the political system. Once this occurs, the resulting protests can reflect the wide range of reasons for dissatisfaction, broadening the scope of the protest, and masking the immediate trigger of the unrest.”¹⁰⁸

In the book *Food Security and Sociopolitical Stability*, an in-depth study on this issue, the authors explain that,

Strong correlations between food availability or food access and sociopolitical stability often exist – but certainly not always and everywhere. The linkages are, however, variable across space and time, highly conditional on the responses of multiple private and state actors, and difficult to pin down causally. Sociopolitical unrest, like market shocks, often has strong behavioral foundations that intersect with underlying structural pressures to spark extreme social events... Governments that have previously employed policies, such as food subsidies, intended to make people feel secure about their access to food are sometimes perceived as reneging on that commitment when food prices rise sharply...leading to unrest that is at once food- and politically-based.¹⁰⁹

Food Price Volatility. Food price volatility is probably the number one driver of instability that can lead to civil unrest and violence. A report produced by the Organization for Economic Cooperation and Development (OECD) and the UN Food and Agriculture Organization warns,

Production shortfalls, price volatility and trade interruptions remain a threat to global food security. As long as food stocks in major producing and consuming countries remain low, the risk of price volatility is amplified. A wide spread drought like that experienced in 2012 in the United States and CIS countries, on top of low stocks, could raise crop prices by 15%-40%. A statistical analysis projecting past uncertainty patterns on relevant model drivers into the baseline period, shows crop yield variability to have the largest impact on world prices for wheat, coarse grains and oilseeds with rice somewhat less sensitive. Meat, dairy and biofuel prices are more affected by macroeconomic assumptions such as economic growth and exchange rates. Energy prices add another source of uncertainty, affecting both biofuel markets and input costs. World trade is even more sensitive than production to yield variability and macroeconomic drivers.¹¹⁰

Energy Impact. Energy is a key element in agricultural production that affects both price and productivity. A report by the UN FAO suggests that rising oil prices will drive increased



food prices as agriculture relies heavily on fossil fuels to power machinery and produce fertilizers. This report specifically states,

Looking out to 2050, the potential for sharply increasing prices of non-renewable resources that have no close substitutes could have major implications for crop yields and food prices. The two resources of most concern are fossil fuels for manufacture of nitrogenous fertilizers and provision of farm power, and reserves of phosphates, an essential macro-element for soil fertility. All indications are that fossil fuels have entered a new era of higher and more volatile prices with an expected upward trend.

Farming practices. Effective farming practices are an important element in improving yields. Soil management, fertilizer and pesticide employment, and irrigation must be scientifically employed to ensure the long-term sustainability of cropland. The challenge to improved farm practices is often farmer education, information, and technical skills, which are more advanced in industrial countries and less so in developing countries. More education programs for farmers in lower income developing countries will help increase yields as well as help them use less inputs (primarily energy and water) to produce these higher yields.¹¹¹

Poor distribution. Food storage and distribution systems are woefully inadequate in nations where population growth is projected to be greatest. Many lack paved roads to reliably transport food stuffs and fewer still have effective cold-chain systems to preserve produce from field to market. Most lack the bulk storage facilities necessary to stockpile cereals and other staples to offset food shortages.

Waste. More developed countries waste most food after purchasing, whereas many developing countries suffer food loss and waste prior to reaching the consumer. The FAO estimates that “...roughly one-third of food produced for human consumption is lost or wasted globally, which amounts to about 1.3 billion tons per year. This inevitably also means that huge amounts on the resources used in food production are used in vain...”¹¹² Curbing food loss and waste can help increase food availability (supply) and help mitigate price swings due to other shocks such as those caused by adverse weather.

Resistance to biotech. Widespread misinformation and emotionally-based arguments are impeding the potential benefits of transgenic crops, commonly known as genetically modified organisms (GMOs). A coordinated effort from the scientific, government and media communities is necessary to reveal the promise of GMOs and the truth behind GMO safety. The debate on GMOs is covered in more detail in an essay in the main industry report.

Climate Change. As mentioned above, the effects of climate change can be both positive and negative. There are obvious risks associated with a changing climate, but there are also some benefits. In total, food productivity will likely suffer from the changing climate, but some countries will see benefits, while others will see significant negative impacts. These changes will likely drive the need for increased trade and may become another source of international mistrust and controversy.

Poverty. Poverty is often viewed as a humanitarian or human security issue, not necessarily a national security issue. There is, however, a direct relationship between poverty, food security, and the potential for civil unrest. Although extreme poverty has decreased significantly over the past several decades, today, about 20 percent of the world’s population lives on less than \$1.25 per day (as opposed to more than 50 percent in 1981). Christopher Barnett, in *Food Security and Sociopolitical Stability*, also explains that, “...although the most



severe food insecurity is typically associated with disasters such as drought, floods, war, or earthquakes, most food insecurity is not associated with catastrophes, but rather with chronic poverty....”¹¹³

Malnutrition. Solving the problems of malnutrition – over or under shooting caloric intake goals – remains a key concern in the consumer portion of the value chain. Within the US, consolidation of the various programs within the DoD, USDA, Center for Disease Control, the office of the surgeon general and others that aim to fight obesity and under-nutrition could help save money and target the most effective areas of research and outreach. This is another area in which global outreach should be a priority, mainly for under-nutrition, but countries like India are also experiencing obesity problems.

Nutrition significantly affects the physical and mental development of a child during the first 1,000 days of a child’s life—from the mother’s pregnancy through two to three years of age. “The right nutrition during this 1,000 day window can have an enormous impact on a child’s ability to grow, learn, and rise out of poverty. It can also have a profound effect on the long-term health, stability, and development of entire communities and nations.”¹¹⁴ Lack of proper nutrition of the mother and the developing child can result in stunting, infections, lasting effects of mental development, and even death. By focusing food aid and agricultural assistance programs on delivering and producing not only the necessary quantity, but also the right type of food, international organizations can curb hunger among the poor at its genesis. The US Agency for International Development and the Department of State should receive more funding from Congress to increase both nutrition education as well as food aid abroad.

Conclusion

The issues outlined above capture only part of the overall strengths, weaknesses, opportunities, and threats related to food security. This list, again, is intended to provide an outline of the analytical model used to evaluate the agribusiness industry in the context of US national security interests and food security issues across the globe. The data from this SWOT analysis was then used to develop the main industry report. The overriding conclusion from this analysis is that food security directly impacts stability, can lead to widespread violence, and should therefore be of significant interest to the United States government and national security practitioners.



Report Notes

¹ Monika Barthwal-Datta, *Food Security in Asia*, (Adelphi Books, 2014), accessed March 15, 2014 at <http://www.iiss.org/en/publications/adelphi/by%20year/2013-7c11/food-security-in-asia-d8fc>

² For an excellent and in-depth look at the impact of food security on instability, see Christopher B. Barrett, *Food Security and Sociopolitical Stability*, (New York, NY: Oxford University Press, 2013).

³ “Food security statistics,” Food and Agriculture Organization of the United Nations, accessed April 29, 2014 at <http://www.fao.org/economic/ess/ess-fs/en/>.

⁴ United Nations report, “World Population Prospects: The 2012 Revision”, June 13, 2013, accessed May 16, 2014 at http://esa.un.org/wpp/Documentation/pdf/WPP2012_Press_Release.pdf.

⁵ “How to Feed the World in 2050,” United Nations Food and Agriculture Organization, 2009, accessed April 10, 2014 at http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf.

⁶ Antal Neville, “IBIS World Industry Report NN004: Agribusiness in the US,” IBISWorld, (March 2014): 2.

⁷ “Food and Agribusiness Industry,” QFinance Newsletter, accessed May 16, 2014 at <http://www.qfinance.com/sector-profiles/food-and-agribusiness>.

⁸ “Our Food and Agriculture in Numbers,” Food and Agriculture Organization of the United Nations, October 25, 2013, accessed on May 16, 2014 at <http://www.fao.org/resources/infographics/infographics-details/en/c/203558/>.

⁹ K. O. Fuglie and S. L. Wang, “New Evidence Points to Robust but Uneven Productivity Growth in Global Agriculture,” *Amber Waves* 10 (September 2012), accessed May 16, 2014 at <http://www.cabi.org/bookshop/book/2499>.

¹⁰ “United States Department of Agriculture,” Wikipedia, accessed April 29, 2014 at http://en.wikipedia.org/wiki/United_States_Department_of_Agriculture.

¹¹ “Plant Patent Act of 1930,” Wikipedia, accessed April 29, 2014 at http://en.wikipedia.org/wiki/Plant_Patent_Act_of_1930.

¹² “Agricultural Adjustment Act,” Wikipedia, accessed April 29, 2014 at http://en.wikipedia.org/wiki/Agricultural_Adjustment_Act.

¹³ “Farm Credit Act of 1933,” Wikipedia, accessed April 29, 2014 at http://en.wikipedia.org/wiki/Farm_Credit_Act_of_1933.

¹⁴ “Agricultural Act of 1948,” Wikipedia, accessed April 29, 2014 at http://en.wikipedia.org/wiki/Agricultural_Act_of_1948.

¹⁵ “Patent Act of 1952,” Wikipedia, accessed April 29, 2014 at http://en.wikipedia.org/wiki/Patent_Act_of_1952.

¹⁶ “Agricultural Productivity in the U.S.,” Wikipedia, accessed April 29, 2014 at <http://www.ers.usda.gov/data-products/agricultural-productivity-in-the-us.aspx#28247>.

¹⁷ Jorge Fernandez-Cornejo, “The Seed Industry in U.S. Agriculture: An Exploration of Data and Information on Crop Seed Markets, Regulation, Industry Structure, and Research and Development,” February 2004, accessed April 29, 2014 at http://www.ers.usda.gov/publications/aib-agricultural-information-bulletin/aib786.aspx#.U1_wK1x4HRp.

¹⁸ Robert Paarlberg, *Food Politics: What Everyone Needs to Know* (New York, NY: Oxford University Press, 2010), 10.



¹⁹ “Ag and Food Statistics,” United States Department of Agriculture Economic Research Service, “accessed May 5, 2013 at <http://www.ers.usda.gov/data-products/ag-and-food-statistics-charting-the-essentials.aspx#.U3ZLo8ZzMV>s.

²⁰ “OECD-FAO Agricultural Outlook 2013-2022,” Organization for Economic Cooperation and Development and the United Nations Food and Agriculture Organization, (2013), accessed April 28, 2014 at <http://www.oecd.org/site/oecd-faoagriculturaloutlook/publication.htm>.

²¹ “OECD-FAO expect slower global agricultural production growth,” Organization for Economic Cooperation and Development and the United Nations Food and Agriculture Organization, OECD-FAO Agricultural Outlook, accessed April 28, 2014 at <http://www.oecd.org/site/oecd-faoagriculturaloutlook/oecd-fao-expect-slower-global-agricultural-production-growth.htm>.

²² “World Population Prospects: The 2012 Revision,” United Nations, June 13, 2013, accessed April 29, 2014 at http://esa.un.org/wpp/Documentation/pdf/WPP2012_Press_Release.pdf.

²³ Jose Luiz Tejon Megido, *The seven challenges of agribusiness – the journey of the next 10 years*, January 30, 2012, accessed April 29, 2014 at <http://labexkorea.wordpress.com/2012/01/30/the-seven-challenges-of-agribusiness-the-journey-of-the-next-10-years/>.

²⁴ Paul Heisey, Sun Ling Wang, and Keith Fugile, “Public Agriculture Research Spending and Future U.S. Agricultural Productivity Growth: Scenarios for 2010 -2050,” Economic Brief no. EB-17, U.S. Department of Agriculture, Economic Research Service (July 2011), accessed May 16, 2014 at <http://www.ers.usda.gov/publications/eb-economic-brief/eb17.aspx#.U3lYx8ZzMV>s.

²⁵ “How to Feed the World in 2050,” Food and Agriculture Organization of the United Nations, October 12, 2009, accessed April 29, 2014 at http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf.

²⁶ Organization for Economic Cooperation and Development and the United Nations Food and Agriculture Organization, “OECD-FAO Agricultural Outlook 2013-2022,” (2013), accessed May 16, 2014 at <http://www.oecd.org/site/oecd-faoagriculturaloutlook/publication.htm>.

²⁷ Food and Agriculture Organization of the United Nations, “The State of Food Insecurity in the World,” (2013), accessed May 16, 2014 at <http://www.fao.org/publications/sofi/en/>.

²⁸ Ibid

²⁹ Marco Lagi, Karla Z. Bertrand, and Yaneer Bar-Yam, “The Food Crisis and Political Instability in North Africa and the Middle East,” New England Complex Systems Institute, September 28, 2011: 2.

³⁰ Ibid.

³¹ Christopher B. Barrett, *Food Security and Sociopolitical Stability*, (New York, NY: Oxford University Press, 2013), 10.

³² Ibid.

³³ Ibid., 11.

³⁴ Heisey, Wang, and Fugile, “Public Agriculture Research Spending.”

³⁵ R.A. Fischer, Derek Byerlee, and G.O. Edmeades, “Can Technology Deliver on the Yield Challenge to 2050?,” Expert Meeting on How to Feed the World in 2050, Food and Agriculture Organization of the United Nations, Economic and Social Development Department, June 2009, accessed May 16, 2014 at <ftp://ftp.fao.org/docrep/fao/012/ak977e/ak977e00.pdf>.

³⁶ Barrett, *Food Security*, 24.



³⁷ Ibid.

³⁸ U.S. White House, “Challenges and Opportunities in U.S. Agriculture,” in *Economic Report of the President*, (Washington, DC: United States Government Printing Office, March 2013), 259.

³⁹ Andorra Bruno, “Agricultural Guest Workers: Legislative Activity in the 113th Congress,” Congressional Research Service, July 13, 2013: 1.

⁴⁰ U.S. White House, “Challenges and Opportunities,” 260.

⁴¹ “Why 1,000 Days,” 1,000 Days Partnership, 2014, accessed March 15, 2014 at <http://www.thousanddays.org/about/>.

⁴² U.S. Department of Agriculture, “Study of Rural Transportation Issues,” 2010: 1-2, accessed March 15, 2014 at <http://www.ams.usda.gov/AMSV1.0/getfile?dDocName=STELPRDC5084108>.

⁴³ Jerry Norton, “Transportation and Logistical Challenges of Biotechnology,” *Agricultural Transportation Challenges for the 21st Century*, 1998, accessed March 15, 2014 at <http://ntl.bts.gov/lib/000/000/26/ch4a.htm>.

⁴⁴ Ibid., v.

⁴⁵ Ibid., xi.

⁴⁶ “United States: The Problem of Aging Infrastructure on Inland Waterways,” Stratfor Global Intelligence, Nov 2013, accessed March 15, 2014 at <http://www.stratfor.com/analysis/united-states-problem-aging-infrastructure-inland-waterways>.

⁴⁷ Charles Stern, “Inland Waterways: Recent Proposals and Issues for Congress.” *Congressional Research Service*, May 2013, accessed March 15, 2014 at <http://www.fas.org/sgp/crs/misc/R41430.pdf>.

⁴⁸ Chicago Board of Trade representative, interviewed by author, Chicago, March 2014.

⁴⁹ U.S. Department of Agriculture, “Study of Rural Transportation,” xii.

⁵⁰ Richard Volpe, Edward Roeger and Ephraim Leibtag, “How Transportation Costs Affect Fresh Fruit and Vegetable Prices,” U.S. Department of Agriculture Economic Research Service, Nov 2013, accessed March 15, 2014 at <http://www.ers.usda.gov/publications/err-economic-research-report/err160.aspx>.

⁵¹ U.S. Department of Agriculture, “Study of Rural Transportation,” xii.

⁵² Ibid., viii.

⁵³ Ibid., ix.

⁵⁴ Ibid., x.

⁵⁵ Marvin Prater, Adam Sparger, Pierre Bahizi and Daniel O’Neil, Jr., “USDA Agricultural Marketing Service; Rail’s Loss of Grain Transportation Market Share,” U.S. Department of Agriculture – Agricultural Marketing Service, Dec 2103, accessed March 15, 2014 at <http://www.ams.usda.gov/AMSV1.0/getfile?dDocName=STELPRDC5105745>

⁵⁶ U.S. Department of Agriculture, “Study of Rural Transportation,” x.

⁵⁷ M.D., “Canada’s Grain Crisis – Prairie Pile Up,” *The Economist*, March 5, 2014, accessed March 15, 2014 at <http://www.economist.com/blogs/americasview/2014/03/canadas-grain-crisis>.

⁵⁸ Chicago Board of Trade representative, interviewed by author, Chicago, March 2014.

⁵⁹ U.S. Department of Agriculture, “Study of Rural Transportation,” xi.

⁶⁰ Edgar Woods, interviewed by author, North Carolina State University, February 2014.

⁶¹ Jim Monke, *CRS Report for Congress*, “Agroterrorism: Threats and Preparedness,” March 12, 2007, accessed March 18, 2014 at <http://www.fas.org/sgp/crs/terror/RL32521.pdf>.



⁶² Tom Nordlie, “Citrus greening costs \$3.63 billion in lost revenues and 6,611 jobs, new UF study shows,” *News University of Florida*, January 24, 2012, accessed March 18, 2014 at <http://news.ufl.edu/2012/01/24/greening-cost/>.

⁶³ Kent Theisse, “PEDV impact on the swine industry,” *Corn + Soybean Digest*, March 18, 2014, accessed March 14, 2014 at http://www.aphis.usda.gov/publications/wildlife_damage/content/printable_version/feral_swine.pdf.

⁶⁴ Phillip Seng, “10 Years Later, BSE Still Frustrates U.S. Beef Industry,” *Beef Magazine*, December 11, 2013, accessed March 14, 2014 at <http://beefmagazine.com/beef-exports/10-years-later-bse-still-frustrates-us-beef-industry>.

⁶⁵ “Numbers of Insects (Species and Individuals),” Smithsonian Institution, National Museum of Natural History, Department of Systematic Biology, Information Sheet 18, accessed March 14, 2014 at http://www.si.edu/Encyclopedia_SI/nmnh/buginfo/bugnos.htm.

⁶⁶ Gary Miller, “The Systematic Entomology Laboratory: Research, Information and Service,” briefing slides, USDA Agricultural Research Service, February 7, 2014.

⁶⁷ United States Department of Agriculture, “What are GMO’s?,” *Research*, February 23, 2005, accessed March 30, 2014 at <http://ars.usda.gov/Research/docs.htm?docid=7205>.

⁶⁸ Pamela Roland, “The Truth about GMOs,” *Boston Review* 38, no. 5 (2013): 17.

⁶⁹ “Genuity DroughtGard Hybrids,” *Monsanto*, accessed March 30, 2014 at <http://www.monsanto.com/products/pages/droughtgard-hybrids.aspx>.

⁷⁰ Roland, “The Truth about GMOs,” 17-18.

⁷¹ *Ibid.*, 17.

⁷² “FDA’s Role in Regulating Safety of GE Foods,” *U.S Food and Drug Administration*, accessed March 30, 2014 at <http://www.fda.gov/forconsumers/consumerupdates/ucm352067.htm>.

⁷³ Roland, “The Truth about GMOs,” 18.

⁷⁴ World Health Organization, “20 Questions on Genetically Modified Foods,” *Programmes*, accessed March 30, 2014 at <http://www.who.int/foodsafety/publications/biotech/20questions/en/>.

⁷⁵ “GMO Myths and Truths Report,” *Earthopensource*, accessed March 31, 2014 at <http://earthopensource.org/index.php/3-health-hazards-of-gm-foods/3-5-myth-no-one-has-ever-been-made-ill-by-a-gm-food>.

⁷⁶ *Ibid.*

⁷⁷ *Ibid.*

⁷⁸ “Monsanto Company (MON),” *Yahoo Finance*, accessed March 30, 2014 at <http://finance.yahoo.com/q/is?s=MON+Income+Statement&annual>.

⁷⁹ Peter Whoriskey, “Monsanto’s Dominance Draws Antitrust Inquiry,” *Washington Post*, November 29, 2009, accessed March 31, 2014 at <http://www.washingtonpost.com/wp-dyn/content/article/2009/11/28/AR2009112802471.html>.

⁸⁰ Anonymous, “Food Fight,” *The Economist*, December 14, 2013, accessed March 30, 2014 at <http://www.economist.com/news/china/21591577-fierce-public-debate-over-gm-food-exposes-concerns-about-america-food-fight>.

⁸¹ Roland, “The Truth about GMOs,” 18.

⁸² Marianna Schauzu, “The Concept of Substantial Equivalence in Safety Assessment of Foods Derived from Genetically Modified Organisms,” *AgBiotechNEt* 2 (2000):1, accessed March 30, 2014 at <http://www.bfr.bund.de/cm/349/schauzu.pdf>.



⁸³ Mauro Vigani, Valentina Raimondi, and Alessandro Olper, “International Trade and Endogenous Standards: the Case of GMO Regulations,” *World Trade Review*, 11, no. 3(2012): 418, accessed March 30, 2014 at <http://search.proquest.com/docview/1023785519>, last accessed March 30, 2014.

⁸⁴ Vigani, Raimondi, and Olper, “International Trade and Endogenous Standards,” 418.

⁸⁵ Natasja Borjeson, “WTO, GMO and the Precautionary Principle – the Conflict between Trade Liberalisation and Environmental Protection,” *Södertörn University College*, (2007): 29, accessed March 30, 2014 at <http://www.diva-portal.org/smash/get/diva2:15723/FULLTEXT01.pdf>.

⁸⁶ Vigani, Raimondi, and Olper, “International Trade and Endogenous Standards,” 421.

⁸⁷ Vigani, Raimondi, and Olper, “International Trade and Endogenous Standards,” 418.

⁸⁸ Vigani, Raimondi, and Olper, “International Trade and Endogenous Standards,” 419.

⁸⁹ Norman Borlaug, “The Green Revolution, Peace and Humanity,” *Nobel Lecture*, December 11, 1970, accessed March 31, 2014 at http://www.nobelprize.org/nobel_prizes/peace/laureates/1970/borlaug-lecture.html.

Appendix 2 Notes

⁹⁰ STRATFOR Global Intelligence, “The Geopolitics of the United States, Part 1: The Inevitable Empire,” (May 28, 2012), accessed May 18, 2014 at http://www.stratfor.com/analysis/geopolitics-united-states-part-1-inevitable-empire?0=ip_login_no_cache%3D86f6d9e3c585bb42946bd7ce7d7a2b17.

⁹¹ US Department of Agriculture, “USDA Preserves \$4 Billion in Agricultural Exports in 2012 by Knocking Down Barriers to Trade,” (February 1, 2013), accessed May 16, 2014 at <http://www.usda.gov/wps/portal/usda/usdamediaafb?contentid=2013/02/0018.xml&printable=true&contentidonly=true>.

⁹² These statistics were pulled from The World Bank’s website, accessed May 18, 2014 at <http://data.worldbank.org>.

⁹³ Mark J. Perry, “Food in America is more affordable than ever before because the US farm sector keeps getting more and more productive,” American Enterprise Institute, (March 4, 2014), accessed May 18, 2014 at <http://www.aei-ideas.org/2014/03/food-in-america-is-more-affordable-than-ever-before-because-the-us-farm-sector-keeps-getting-more-and-more-productive/>.

⁹⁴ Paul Heisey, Sun Ling Wang, and Keith Fugile, “Public Agriculture Research Spending and Future U.S. Agricultural Productivity Growth: Scenarios for 2010 -2050,” Economic Brief no. EB-17, U.S. Department of Agriculture, Economic Research Service (July 2011), accessed May 16, 2014 at <http://www.ers.usda.gov/publications/eb-economic-brief/eb17.aspx#.U31Yx8ZzMVs>

⁹⁵ Chris Edwards, “Agricultural Regulations and Trade Barriers,” (CATO Institute: June 2009), accessed May 16, 2014 at <http://www.downsizinggovernment.org/agriculture/regulations-and-trade-barriers>.

⁹⁶ US White House, “Challenges and Opportunities in U.S. Agriculture.” In *Economic Report of the President*, (Washington, DC: United States Government Printing Office, March 2013), 259.

⁹⁷ Bruno, Andorra, Congressional Research Service: “Agricultural Guest Workers: Legislative Activity in the 113th Congress,” July 13, 2013: 1.



⁹⁸ US White House, “Challenges and Opportunities in U.S. Agriculture.” In *Economic Report of the President*, (Washington, DC: United States Government Printing Office, March 2013), 260.

⁹⁹ Centers for Disease Control and Prevention, “Overweight and Obesity,” (2012), accessed May 16, 2014 at <http://www.cdc.gov/obesity/data/adult.html>.

¹⁰⁰ Ira Sager, “Living in the United States of Food Waste,” BloombergBusinessweek, January 10, 2013, accessed May 16, 2014 at <http://www.businessweek.com/articles/2013-01-10/living-in-the-united-states-of-food-waste>.

¹⁰¹ R.A. Fischer, Derek Byerlee, and G.O. Edmeades, “Can Technology Deliver on the Yield Challenge to 2050?,” Expert Meeting on How to Feed the World in 2050, Food and Agriculture Organization of the United Nations, Economic and Social Development Department (June 2009), accessed May 16, 2014 at <ftp://ftp.fao.org/docrep/fao/012/ak977e/ak977e00.pdf>

¹⁰² “Climate Impacts on Agriculture and Food Supply,” US Environmental Protection Agency, accessed May 16, 2014 at <http://www.epa.gov/climatechange/impacts-adaptation/agriculture.html>.

¹⁰³ Christopher B. Barrett, *Food Security and Sociopolitical Stability*, (New York, NY: Oxford University Press, 2013), 24.

¹⁰⁴ Christopher B. Barrett, *Food Security and Sociopolitical Stability*, (New York, NY: Oxford University Press, 2013), 24.

¹⁰⁵ Jerry Norton, “Transportation and Logistical Challenges of Biotechnology,” *Agricultural Transportation Challenges for the 21st Century*: <http://ntl.bts.gov/lib/000/000/26/ch4a.htm>.

¹⁰⁶ Mario Pezzini, “An Emerging Middle Class,” OECD Observer, 2012, accessed May 16, 2014 at http://www.oecdobserver.org/news/fullstory.php/aid/3681/An_emerging_middle_class.html.

¹⁰⁷ Marco Lagi, Karla Z. Bertrand, and Yaneer Bar-Yam, “The Food Crisis and Political Instability in North Africa and the Middle East,” New England Complex Systems Institute, (September 28, 2011): 2.

¹⁰⁸ Marco Lagi, Karla Z. Bertrand, and Yaneer Bar-Yam, “The Food Crisis and Political Instability in North Africa and the Middle East,” New England Complex Systems Institute, (September 28, 2011): 2.

¹⁰⁹ Christopher B. Barrett, *Food Security and Sociopolitical Stability*, (New York, NY: Oxford University Press, 2013), 10.

¹¹⁰ “OECD-FAO Agricultural Outlook 2013-2022,” Organization for Economic Cooperation and Development and the United Nations Food and Agriculture Organization, 2013, accessed April 28, 2014 at <http://www.oecd.org/site/oecd-faoagriculturaloutlook/publication.htm>.

¹¹¹ R.A. Fischer, Derek Byerlee, and G.O. Edmeades, “Can Technology Deliver on the Yield Challenge to 2050?,” Expert Meeting on How to Feed the World in 2050, Food and Agriculture Organization of the United Nations, Economic and Social Development Department (June 2009), accessed May 16, 2014 at <ftp://ftp.fao.org/docrep/fao/012/ak977e/ak977e00.pdf>.

¹¹² “Global Food Losses and Food Waste,” Food and Agriculture Organization of the United Nations, 2011, accessed May 16, 2014 at <http://www.fao.org/docrep/014/mb060e/mb060e00.htm>.

¹¹³ Christopher B. Barrett, *Food Security and Sociopolitical Stability*, (New York, NY: Oxford University Press, 2013), 7.

¹¹⁴ “Why 1,000 Days,” 1,000 Days Partnership, 2014, accessed March 15, 2014 at <http://www.thousanddays.org/about/>.

