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Industry Study**

Final Report
Agribusiness Industry



The Industrial College of the Armed Forces
National Defense University
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AGRIBUSINESS 2010

ABSTRACT: America's agricultural might is a source of national power. Food is a critical national security resource as well as a cause and a weapon of war. As an element of national resources strategy, food security is fundamental to national security. Any country's ability to nourish its citizens and Warfighters is a vital interest essential to national survival and military readiness. Yet, few appreciate this industry's fragility, complexity, and precarious sustainability. Further, while most Americans easily access food, this food is becoming less nourishing and increasingly detrimental to national health. Although the world produces enough food for over 150 percent of the world's population, many are undernourished, and the number of obese people worldwide has surpassed the number of undernourished. The goal of the Green Revolution was to prevent starvation in a growing domestic and global population. Goals now must be to provide adequate nutrition in a sustainable manner to growing populations while repairing the environmental damage caused by the Green Revolution and improving environmental health. This paper presents an executive summary of the industry starting with the current condition, challenges, and outlook, reviewing and evaluating the agribusiness industry's viability and response to challenges and its impact on national security resources. Then, it assesses the role of government and recommends strategies. It finishes with three essays regarding agroterrorism, food aid, and water.

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PLACES VISITED

Domestic:

International Food Policy Research Institute, Washington, DC
 Developmental Alternatives, Inc., Bethesda, MD
 U.S. Department of Agriculture, Agricultural Research Service, Beltsville, MD
 Smithfield Meat Processing Plant, Smithfield, VA
 Virginia Poultry Growers Cooperative, Hinton, VA
 Office of the U.S. Trade Representative, Washington, D.C.
 Purdue University, College of Agriculture, West Lafayette, IN
 Purdue Animal Disease Diagnostic Laboratory, West Lafayette, IN
 Purdue Forest Products Laboratory, West Lafayette, IN
 Purdue Agronomy and Animal Sciences Farm, West Lafayette, IN
 Fair Oaks Dairy Farm, Fair Oaks, IN
 Revolution Foods, Berkeley, CA
 Berkeley Edible School Yard, Berkeley, CA
 Corison Winery, St. Helena, CA
 Benden Farms, Colusa, CA
 Sacramento River State Park, Colusa, CA
 Lundberg Family Farms, Richvale, CA
 Greenleaf Farms, Dinuba, CA
 Orange Cove – Sanger Citrus Association, Orange Cove, CA
 Sun-Maid Growers of California, Kingsburg, CA
 SYSCO/BSCC Produce, Salinas, CA
 Tanimura & Antle Farms, Salinas, CA
 Mann Packing Co. Inc., Salinas, CA
 Rancho Cielo, Salinas, CA
 U.S. Senate Agricultural and Foreign Relations Committee Staff Members, Washington, D.C.
 Mason Dixon Farms, Gettysburg, PA
 Penn State Fruit Research and Extension Center, Adams County, PA
 Hollabaugh Brothers Fruit Farm & Market, Biglerville, PA
 Bear Mountain Orchards, Aspers, PA
 Clagett Farm, Upper Marlboro, MD

International:

Luanping Huadu Broiler Slaughter and Processing Plant, Chengede, Hebei Province, China
 Sheng Bao Tai Trading Company, Beijing, China
 Qing Shan An Nong Trading Company, Beijing, China
 Beijing Yuan Fa Yao Trading Company, Beijing, China
 U.S. Embassy Country Team, Beijing, China
 Wang Jing Wal-Mart, Beijing, China
 China Academy of Agricultural Sciences, Beijing, China
 Jingyang agricultural region, Shaanxi Province, China
 Caotan Dairy Farm, Yangling, Shaanxi Province, China

Institute of Policy and Strategy for Agriculture and Rural Development, Hanoi, Vietnam

Hung Yen Province agricultural region, Vietnam

Cargill Animal Feed Mill, Hung Yen Province, Vietnam

Northern Mountainous Agriculture and Forestry Science Institute, Phu Tho Province, Vietnam

U.S. Embassy Country Team, Hanoi, Vietnam



ICAF

“So an army perishes if it has no equipment, it perishes if it has no food and it perishes if it has no money.”

-Sun Tzu

INTRODUCTION

Military strategists have long recognized the relationship between victory and food. Food is a critical national security resource as well as a cause and a weapon of war. As an element of national resources strategy, food security is fundamental to national security. Any country's ability to nourish its citizens and Warfighters is a vital interest essential to national survival and military readiness. Yet, few appreciate this industry's fragility, complexity, and precarious sustainability. Further, while most Americans easily access food, this food is becoming less nourishing and increasingly detrimental to national health. Although the world produces enough food for over 150 percent of the world's population, 842 million people suffer from chronic undernourishment;¹ two billion are micronutrient deficient;² and the number of obese people worldwide has surpassed the number of undernourished.³ The goal of the Green Revolution was to prevent starvation in a growing domestic and global population. Goals now must be to provide adequate nutrition in a sustainable manner to growing populations while repairing the environmental damage caused by the Green Revolution and improving environmental health.

The agribusiness industry study at the Industrial College of the Armed Forces (ICAF) overlaps with many other industry studies that the college offers—biotechnology, education, electronics, energy, environment, healthcare, manufacturing, transportation, and reconstruction and nation building. In addition to the domestic market, we studied global markets and competitors, particularly China and Vietnam. Our five-month course roused us from our food unconsciousness and displaced our dreams of contented cows grazing on green grasses. This paper presents an executive summary of the industry starting with the current condition, challenges, and outlook, in which we review and evaluate the agribusiness industry's viability and response to challenges and its impact on national security resources. Then, we assess the role of government and recommend strategies. We finish with three essays that focus on agro-terrorism, food aid, and water.

THE INDUSTRY DEFINED

Agribusiness is a complex and frangible system of systems. The agribusiness industry comprises many sectors and encompasses “all economic activity that supports farm production and the conversion of raw farm products to consumable goods—for example, machinery repair, fertilizer production, farming itself, food processing and manufacturing, transportation, whole and retail trade, distribution of food and apparel, and product for eating establishments.”⁴ “Farming itself” includes many functions requiring specialized expertise, including seed, horticulture, pest management, and soil and water management.

CURRENT CONDITION

The agricultural landscape in the U.S. has changed dramatically over the past century with the conversion from multiple, small, polyculture farms that formed communities to large industrial farms that form one stage of a production cycle. U.S. agriculture is among the most prolific in the world and is itself a source of national power. U.S. agribusinesses have technological advantages with substantial experience in using innovation to increase production and profits. From the introduction of oil-based fertilizers in the 1940's through the development of large-scale monoculture industrial farms and hybrid seed innovations; large agribusiness transnational corporations (agro-TNCs) have dominated agribusiness for the last fifty years.

Although agriculture accounts for less than one percent of the U.S. gross domestic product (GDP),⁵ agribusiness—the total food and fiber system—represents 13 percent of the GDP and employs 24 million people or 17 percent of total U.S. employment.⁶ U.S. consumers spend about 9.6 percent of their disposable income on food⁷ and the industry receives substantial direct and indirect subsidies. U.S. agribusiness revenues are over a trillion dollars per year. The global financial crisis and subsequent economic downturn that began in 2008 caused losses in some agribusiness sectors, but falls were cushioned by the relatively inelastic nature of the demand for food.⁸ Food price volatility has since occurred and is expected to continue.⁹

Agribusiness sectors differ in competitive structure from near perfect competition for farm production to near monopoly in a growing number of seed markets. In 2009, the U.S. had 2.2 million farms with 919,800,000 acres.¹⁰ While the number of farms has fallen during the past several decades, average farm size has risen. The bottom 60 percent of family farms accounts for two percent of total agricultural income. The top ten percent of family farms account for 81 percent. In 2010, the average family farm household income is expected to be \$80,766, but only 10.3 percent is from farm sources.¹¹ The two percent of U.S. farms that are not classified as family farms have higher revenues than family farms.¹² The trend toward fewer, larger farms has resulted in slight growth overall in farm profits over the past several decades. 2009 average farm profit fell due to lower demand during the recession but is forecasted to rise in 2010. Still, with many farms, many buyers, and identical or easily substitutable products, no single entity can affect price and profits are low.

Food manufacturing and processing (FMP) is between perfect competition and oligopoly. Over 25,000 “domestic and foreign food processors handle over 90 percent of the value of U.S. farm production, with the remainder reaching consumers in unprocessed form.”¹³ FMPs sell to “over 32,559 wholesalers, 112,662 food and beverage retailers, and 377,717 foodservice companies for distribution to over 111 million households.”¹⁴ Although this market is highly competitive, FMPs can differentiate and build brand equity, allowing them to charge a premium. Farmers receive about nineteen cents of each dollar of profit in agriculture, with processors taking a greater share.¹⁵ Barriers to entry for FMP are the highest in the industry. Government regulations set uniform food processing standards¹⁶ that are designed for large operations.¹⁷ The USDA can refuse entry to FMPs¹⁸ and may refuse to inspect small facilities, making them unusable.¹⁹

Market share in the livestock, dairy, and seed sectors is highly concentrated.²⁰ U.S. livestock and dairy production have been shifting to large Concentrated Animal Feeding Operations (CAFOs).²¹ In a growing number of seed markets, one company, Monsanto, has been all but eliminating substitutes and competitors.²² Monsanto has used legal maneuvers and patents to

gain significant market power and preclude farmers from using non-patented seeds as well as from replanting patented seeds.²³ The Justice Department is investigating alleged agribusiness monopolies, viewing “erosion of competitive markets as a significant threat to the U.S. economy, thus a national security issue.”²⁴

After falling for seven years, the debt/equity (D/E) ratio for farm production rose in 2009 to 14.7, which is considered high and causes concern for sustainability.²⁵ Farm asset values declined, owing to “farm investors’ lower expected future net returns, declining cash flow, and tighter credit conditions.”²⁶ However, total farm debt-to-asset ratio was nine in 2008 and 12 in 2009, which is considered low.²⁷ “Farm financial ratios monitoring liquidity, efficiency, solvency, and profitability” show generally favorable financial performance in 2008-09.²⁸ At the same time, small farmers have higher debt levels endangering local food security and self-reliance.

D/E ratios at the FMP level have been low, indicating excellent performance and low risk.²⁹ FMPs have increased their cash-on-hand over the last two years and showed constant or growing total revenue. This growth demonstrates product strength in markets, especially given the distressed economy. Except for the meat sector, net incomes rose or remained stable over the last three years. Net incomes for the meat processing sector have steadily declined over the last three years.³⁰ The meat sector took losses in 2009 but is expected to see revenues of \$1.8 billion in 2010. Relatively strong performance during a deep recession and potential for future gains indicate industry health at the FMP level.

Although U.S. agribusiness exports were \$96.6 billion in 2009, U.S. imports were \$73.4 billion and are rising.³¹ These growing imports cause some concern that U.S. may be losing self-reliance for domestic consumption. That said, agribusiness accounted for eight to ten percent of all U.S. exports each year for the last several decades. Exports have continuously grown except in 2009.³²

Approximately 70 percent of total world agricultural exports are accounted for by only nine World Trade Organization (WTO) members—the EU, U.S., Canada, China, India, Brazil, Australia, Argentina, and New Zealand.³³ These countries run significant surpluses in their agricultural trade balance and are aggressive in maintaining their share of world trade. Subsidies in wealthy countries have created surpluses that agribusinesses dump into less developed countries that were previously food secure. Local farmers cannot compete with free or subsidized imports and are driven out of farming into dependency. Even worse, wealthier countries, especially China, are leasing land in less developed countries and employing their own citizens to produce and directly import those agricultural products from leased lands.³⁴

The most significant trend in productivity and in the industry overall has been the establishment of large agro-TNCs and the implementation of their specific business strategies—vertical integration and the application of technology and industrial practices to food production.³⁵ They also have used access to credit and their own financial capital to hedge against future price increases by contracting agricultural inputs and outputs at defined rates.³⁶ Government policies to encourage growth in agribusiness complement agro-TNCs’ business strategies.³⁷ The application of industrial practices to agriculture has resulted in higher crop yields and livestock production and in development and expansion of food processing and the uses of processed food products.

Customer-based regional local-food movements and demand for organic food pose a threat to

these strategies. Less than five percent of U.S. farming is organic. Despite higher prices for organic food, demand in the U.S. has far exceeded domestic supply for over a decade.³⁸ The difference is met through imports. Some foreign governments subsidize organic farming for purposes of incorporating social benefits into food costs and prices.³⁹ The 2008 Farm Act included new provisions to help farmers grow organically to meet demand.

To a large extent U.S. government policies coupled with the agro-TNCs own financial capacities have positioned firms to capture opportunities to expand into foreign producer and consumer markets. However, foreign countries' protectionist policies and some U.S. agribusiness practices impede success. A rule-based open market trade system is vital for U.S. agribusiness to access foreign producer markets. Regional and bilateral free trade agreements benefit U.S. agro-TNCs, opening access to markets where they apply their business strategies, adapting as required for local considerations, to gain market share.⁴⁰ Smaller, unsubsidized foreign competitors cannot as readily implement these strategies even in their own domestic markets, especially on a large scale, ensuring an inherently asymmetrical advantage in these agreements.⁴¹ Large U.S. agro-TNCs control production in many countries.⁴²

Every nation desires the ability to feed its citizens. Consequently, countries enact policy—including subsidies, quotas, and trade restrictions—to safeguard this strategic resource. Two such policies that ensure a high level of food security are the U.S. Farm Act⁴³ and EU Common Agriculture Policy (CAP).⁴⁴ Agribusinesses are adept at using these and similar policies to maximize market share. Under existing regimes, developing nations are unable to offset the advantage that protectionist government policies provide for large agro-TNCs.

The U.S. Farm Act endows agribusinesses with direct and indirect subsidies. U.S. agribusiness has many permanent supports from federal, state, and local governments that impart competitive advantage internationally and generally add to the industry's productivity and profitability. Land grant universities and extensions receive federal and state funds to conduct world-leading research and push benefits of research and best practices to end users. Agribusiness benefits from high domestic consumer demand, efficient financial markets, available and inexpensive capital, and a consistently pro-business legal system. Significant agribusiness representation in all three branches of government has ensured generous treatment.

U.S. agro-TNCs, recognizing limited growth potential in the developed world, have focused expansion initiatives on underdeveloped and developing countries. Growing populations, rising incomes, and rapid urbanization in developing countries such as Brazil, China, India, and Indonesia, have significantly altered food consumption from traditional staples to more meat proteins and processed foods, straining local resources that have proven unable to satisfy demand.⁴⁵ U.S. agro-TNCs leverage domestic production advantages and the weakened U.S. dollar to export their products to foreign consumer markets.⁴⁶

U.S. food production practices have created food safety concerns, resulting in international sanctions against U.S. meat and poultry. The U.S. has thus adopted regulations and practices to preserve market access. Moreover, U.S. government agencies have negotiated to reopen markets and have achieved qualified successes with beef exports to Asia following a BSE incident.⁴⁷ U.S. agribusiness firms expend considerable resources to create the perception, both domestically and abroad, that their brands consistently represent food quality and safety, employ environmentally sound food production methods, engage in fair trade and labor practices, and humanely treat agricultural animals.⁴⁸

CHALLENGES

U.S. agribusiness faces major domestic and global challenges. Agroterrorism, foreign food assistance, and water are addressed in the essay section of this report.

Overpopulation imperils food security, global stability, and national security. World population has exploded to nearly seven billion and is projected to surpass nine billion by 2050, predominantly in less developed regions.⁴⁹ The U.S. is forecasted to grow by 44 percent to 449 million people.⁵⁰ Current overpopulation puts untenable pressure on infrastructure and natural resources. Since 1970, over 30 million U.S. farm acres have been lost to development due to urban and suburban sprawl, which exacerbates environmental degradation and food insecurity.⁵¹ In China population pressures and massive development have decreased arable land, dried rivers, and made toxic the air, land, and water. China's toxins contaminate many countries, spreading even to the U.S. A growing population may increase short-term profits, but consequent environmental damage and social instability will reduce productivity and disrupt trade in the long term. What is more, the U.S. may feel pressured to intervene where rising food prices or food scarcity results in unrest and failed governments.

Climate change. Moreover, climate change is primarily caused by human activity.⁵² Climate change has resulted in rising sea levels, increasing the salinity of water tables and decreasing crop production throughout the world. This challenge is profound in Vietnam where much rice is grown along the coast. Globally, under current regimes food production capabilities may diminish “due to the combined impact of climate change, land degradation and loss, water scarcity and species infestation.”⁵³ While the U.S. federal and state governments have enacted limited measures to protect the environment, such as the Clean Air Act, government response to climate change has been inadequate.

Sustainability. The “volume of food produced is more than one and a half times what is needed to provide every person on earth with a nutritious diet.”⁵⁴ Thus, world problems of food insecurity and over consumption are rooted in poor food quality and distribution combined with excessive production. Moreover, conventional and industrial agriculture have placed unsustainable strains on ecosystems and natural resources. Under current monoculture and nitrogen and carbon based farming practices, the U.S. risks losing its competitive advantage in natural resources.⁵⁵ Genetically modified (GM) seeds have increased crop yields⁵⁶ with negative consequences, including reduced competition and biodiversity.⁵⁷ The most heavily subsidized crops are those most subject to genetic engineering and overproduction.

Nutrition transition. Rising GDPs⁵⁸ lead to reduced consumption of traditional staples and increased consumption of processed foods and meat, which is far more resource intensive than crop production⁵⁹ and leads to increased health problems and health care costs. Many Americans are addicted to cheap, unhealthy food. The percentage of U.S. households' disposable income allocated for food fell from nearly half in 1901 to just 9.6 percent in 2008.⁶⁰ This dramatic decrease in allocation for food results primarily from market failure—food prices no longer incorporate the full social costs of production and consumption. Artificially lower prices promote unhealthy eating habits. 35 percent of American youths are medically disqualified from serving in our military primarily due to obesity.⁶¹

The Commodities Program. The Commodities Program—a patchwork of inefficient and often contradictory subsidies—has many downsides counter to national interests at an annual

cost of over \$16 billion.⁶² Direct and indirect subsidies unfairly redistribute wealth; cause distortions in the economy; cause overproduction with deleterious effects for the health of our soil, water, air, and food; incentivize unwholesome industry practices and consumer diets, decreasing societal productivity and increasing health care costs; add bureaucracy and invite fraud; weaken U.S. trade relations; and undercut agricultural sectors and entire economies in developing nations. By enacting commodities programs that are linked to production, government has skewed the supply and demand equations for large segments of commodities markets. U.S. commodity programs have largely disadvantaged smaller diversified crop and livestock farms that contribute significantly to the sustainability of U.S. agribusiness.⁶³ Just seven percent of all farms collect more than 54 percent of subsidies.⁶⁴ The bottom 80 percent receive just 19 percent of all farm subsidies.⁶⁵

Labor and Immigration. Current labor demand, social welfare programs, and immigration laws are not strategically planned and balanced. The failure to stabilize the agribusiness labor force threatens food security and broader national security. Although U.S. unemployment is officially near ten percent, many industry sectors do not employ U.S. citizens for low-wage manual labor but rather recruit predominantly illegal immigrant labor.⁶⁶ Absent this workforce and significant social and legislative change, agribusiness would experience a production crisis. Food prices incorporate low labor costs but omit the full social costs of maintaining this labor force, including health care and education.

Dependence on Fossil Fuels. Not only does agribusiness use oil-based products for fuel for farm equipment and transportation, oil is also a major component in manufacturing fertilizer. Oil is expected to continue to be volatile and may reach record levels in the near future due to demand from developing countries, notably China and India. Unless we shift dependence from fossil fuels to renewable energy sources, dependence on foreign fuel will grow and oil prices will fluctuate and rise, decreasing food security and increasing costs of food production and distribution.

Energy v. Food. Some alternative fuels that are being researched for purposes of energy security are food based, including ethanol from corn, sugar, soy, switch grass, and biowaste. The federal and state governments mandate minimum levels for biofuels, which are resource intensive.⁶⁷ Planting biofuel crops precludes planting food crops on limited arable land. Additionally, production and processing costs for biofuels may disqualify them as an economical solution. Moreover, corn-based ethanol appears to result in higher CO₂ emissions than fossil fuels. Elevated fossil-fuel prices combined with the 2007-2008 market correction to increase food prices as rising quantities of bio-feedstock in a supply tight market were directed to the production of biofuels.⁶⁸

Global Recession. Government response has been effective in helping the industry respond to the economic downturn. The American Recovery and Reinvestment Act of 2009 has provided extensive assistance to help farmers and rural communities. Title I—Agriculture, Rural Development, Food And Drug Administration, and Related Agencies—provided appropriations to assist with needs ranging from farm operating loans to child nutrition programs. Additionally, President Obama established by Executive Order the National Export Initiative for purposes of helping businesses, particularly farmers and agribusinesses, increase exports and expand their markets.⁶⁹ One example of implementation is the USDA's Dairy Export Initiative, which assists U.S. dairy farmers who are unable to sell their dairy products in a foreign market due to the presence of subsidized product from other countries.

OUTLOOK

U.S. agribusiness is a global force that is positioned to remain a preeminent player in the global marketplace. This industry is able to support national security resource requirements to the extent that it is able to adjust its practices to overcome challenges and that the government makes appropriate adjustments to policies. As the domestic population and income grow, so will food consumption. Simultaneously, developing countries projected food production will not keep pace with their consumption.⁷⁰ Developed countries' entrenched, highly productive agro-TNCs are well situated to feed this rising demand. Agribusiness exports will continue to benefit from a weakened U.S. dollar and rising export opportunities to growing populations in less developed and developing countries.⁷¹

Simultaneously, mounting agribusiness production in developing countries such as Brazil, China, India, and Vietnam will continue to intensify global competition. These countries will have growing influence in future global agribusiness trade both as import markets and as competitors. U.S. agro-TNCs' competitive advantages—such as innovation, experience, and production and distribution efficiencies—facilitate future progress and profitability and safeguard their ability to remain competitive.

As world economies recover from the recession, domestic and international economic growth are projected to provide steady gains for U.S. agribusiness. Crop sales are projected to grow annually through 2025 and will become increasingly important in terms of the export share of production and the import share of consumption. U.S. agribusiness will more rapidly recover from the recession than other U.S. industries and has a relatively healthy outlook in the short and long terms. Grain prices are projected to remain elevated due to higher demand associated with biofuels and animal feed use.⁷² The value of U.S. agricultural trade and cash receipts to farmers is expected to grow through 2019, with increases in production costs partially offsetting gains.⁷³ Thus, farm net income is projected to rise moderately from 2011 through 2019.⁷⁴

High cost inputs, such as oil, will increase farm production costs to the degree that farmers rely on these inputs. Commodity crop prices are especially sensitive to fluctuations in oil prices. Energy-related production expenses for fuels and synthetic fertilizer are expected to rise faster than the general inflation rate reflecting increases in crude oil prices.⁷⁵ Research and development of biomass and more efficient energy technologies are being pursued but is unlikely to bear fruit in the short term.

Global food production exceeds demand one and a half times over—a fact that belies the “feed the world” pretense for maximizing profits.⁷⁶ However, conventional, industrial, and monoculture farming exact an unsustainable environmental toll. The long-term outlook assumes the U.S. will continue to be a dominant food producer through 2025. This optimistic outlook depends in part on reducing environmental destruction.

Agriculture and agribusiness will remain at the fore of the global marketplace due to protectionist government policies and the difficulties that the 153 member nations of the WTO have in reconciling cultural and individual national security requirements with world trade. The WTO provides significant support to large agro-TNCs, contradictory to its stated goal of fairer markets for farmers. The WTO has an agreement that specifically protects intellectual property,⁷⁷ and agribusiness worldwide aggressively protects patents. Prevalent throughout the industry, patents convey to developed nations' agro-TNCs competitive advantages. Indeed the

threat to large agro-TNCs may come not from developing nations but from anti-trust legislation in the corporation's home country.⁷⁸

“An important goal of the [WTO] Doha Round negotiations is to liberalize trade in... agricultural products.”⁷⁹ Under the latest set of meetings, the proposed modalities would further open market access to developing countries while reducing or eliminating U.S. export subsidies. The USDA forecasts that mounting domestic and international demand will hold prices for most agricultural products above levels that would result in marketing loan benefits or counter-cyclical payments under the 2008 Farm Act.⁸⁰

Despite the unlikelihood of exceeding support limits proposed in the latest Doha Round, Congress has expressed skepticism regarding the proposed agriculture modalities and wants more market access for U.S. products in large developing countries, such as China and India. If a Doha Round agreement is reached during 2010, Congress will likely not have it for consideration until 2011. If bilateral progress is made and Doha modalities similar to the latest round are approved and ratified, then several market distorting subsidies will be eliminated or significantly decreased. The implication is that U.S. agribusiness would adapt to global market demands and allocate production resources more effectively and use natural resources more propitiously.

Sustainable, robust agricultural capacity that minimizes negative externalities is the key to long-term food security. Industrial, conventional farming practices developed during the Green Revolution from 1943 to the 1970's along with genetically modified seeds provided crop yields to exceed food demands of the post-World War II population explosion. However, these practices have damaged natural resources and threatened public health and long-term food security. Recognizing the role of the land grant university and extension system in partnering with local farmers, agribusiness industry leaders, environmental experts, and public officials, the applied science of agroecology can become more mainstream where “farmers are key participants in the process of innovation and where knowledge creation is driven by the interests of farmers and environmental and public good will.”⁸¹ Issues such as water allocation and land conservancy can be addressed using a holistic approach to develop long-term strategies and business plans for balancing economic growth with environmental sustainability and quality of life. The rise of regional local-food movements will engender more local, organic farming. Still, “industrial farming” is currently projected to produce 80-90 percent of U.S. agricultural output.

Sustained investment in green energy technologies will advance more effective biomass energy conversion capabilities making biomass fuel more economical to produce. The U.S. Departments of Energy and Transportation are pursuing public/private partnerships with transportation, energy, and agribusiness industries to expand and upgrade infrastructure associated with sustainable energy and moving bulk biomass. Long-term investment in infrastructure will substantially reduce the U.S. carbon footprint while resolving logistical limitations to generating biomass fuels. Use of synthetic fertilizer is also projected to decline, reducing GHG emissions, based on advances in farming techniques and technologies. To maintain U.S. preeminence in agribusiness and food security, long-term investments in agronomy and agroecology will fuel sustainable agricultural production for the U.S. and the world.

GOVERNMENT GOALS AND ROLE

While topography and technology have formed U.S. agribusiness, its primary landscaper by act and omission has been the federal government. However, the constituent interests that helped shape sundry policies past and present are ill-suited to take U.S. agribusiness into the future. The government needs to balance agribusiness desires with sovereign responsibilities to its citizens and neighbors. Only after addressing a broader set of stakeholders and challenges will agribusiness remain a source not only of economic but of national power.

The Farm Act is the federal government's political manifesto regarding agribusiness. The 2008 Farm Act, officially called the "Food, Conservation, and Energy Act of 2008," sets current rules governing nearly every dimension of the industry. The 1,770-page document provides 136 federal programs with which farmers must comply or for which they must determine the economic benefits.⁸² One might be impressed by the pervasive government care of the industry or may be dismayed by its pervasive hand and expense.

The agribusiness industry gets more government attention than most others in the U.S. Most industries—manufacturing, media, steel—do not have legislative committees to look after them. However, when the USDA was founded in 1862, 58 percent of the population were farmers and called for special support.⁸³ Given that just two percent of the population are farmers today⁸⁴ and that the average farmer's total wellbeing is higher than that of the average citizen,⁸⁵ the impetus for policy today is different from what it was in 1862. Still, farming and agribusiness have unique interests, and the industry's viability is critical to national security.

Government should establish an overarching strategy for agribusiness that incorporates goals for promoting adequate nutrition in a sustainable manner for growing, changing populations while improving the health of the environment. As described in this report, the government is active in the industry, and in some areas this activity is driving market failures. Critical areas where the government can make improvements concerning U.S. agribusiness policy are food safety, labor and immigration, sustainability, and the Commodities Program.

Recommendation 1—Food Safety. The government should give greater attention to the long-term environmental and health impacts of GM products intended for human consumption. At a minimum, ingredients lists should state that an ingredient is GM, e.g., "genetically modified soy," and should list in parentheses the contents of the GM ingredient.

Discussion. A striking failure to perform sovereign duties is found in the application of biotechnology to consumable products. The government allows the biotechnology industry "an unusually generous policy of self-policing... The control [Monsanto—and by extension the biotechnology industry] exerted over its own regulatory destiny—through the Environmental Protection Agency, the Agriculture Department and ultimately the Food and Drug Administration—was astonishing."⁸⁶ This peculiar absence of government regulation allows firms to market GM products without accurate labeling and without rigorous research or safety testing to understand long-term environmental or health impacts.⁸⁷ Food production, processing, and labeling should be transparent and based on science and responsibility rather than political and economic power. A GM seed is patentable, because it is by legal precedent a "human-made" organism⁸⁸ and not a product of nature.⁸⁹ However, GM products are not required to be labeled as GM. Producers assert that people will choose not to buy a GM product if the label accurately states its contents. This assertion may be true. People may not purchase food based on the

presence of any given ingredient that they prefer to avoid. However, the consumer's health, safety, and free will should be respected. Consumers should have the information and the choice.

Recommendation 2—Labor and Immigration. The government should press for a solution in which, at minimum, workers are documented and the agribusiness industry remains healthy.

Discussion. Mismanaged and illegal immigration on its current scale causes a multitude of growing social and fiscal problems. Many agribusiness sectors depend on illegal immigration, but disregarded laws serve to undermine the rule of law. The current confluence of FTAs, U.S. agribusiness labor requirements, social welfare programs, and immigration law incentivizes a thriving traffic in illegal workers. Any solution to the current, unstable situation must deal with the status of illegal immigrants now employed in the U.S. and with the conditions under which foreign workers may be employed.

Recommendation 3—Sustainability. Increased government regulation and enforcement should mandate beneficial, sustainable practices; and incentivize farmers to process manure, capture methane, and take additional measures to improve current pollution conditions. Government policy should adequately address sustainability issues, such as crop diversity, biodiversity, water use, carbon emissions, erosion, pollution, climate change, and energy. Such policy should include promoting local food security and traditional, organic farming practices. The government should use market mechanisms to regulate water use by creating water markets that price water at its cost.

Discussion. To protect agribusiness, a properly functioning government must deliberately anticipate threats and make policy to address those threats. Sustainability issues are problems that worsen over time if not addressed and threaten the entire system of systems. To what extent and on what timeline sustainability issues are addressed is a judgment within government control.

The trends toward concentration in seed markets and fewer, larger, industrial farms practicing monoculture are alarming. Food security requires crop diversity to prevent devastation by invasive, damaging pests and weeds and to protect the environment. Diversity must be retained to safeguard against the vagaries of nature and the adaptation of pests and weeds.

As arable land is projected to contract, sustainable production, effective distribution, and responsible food consumption are critical. Social benefits of local, organic, and management-intensive farming include reduced water use, carbon emissions, soil erosion, and contamination to soil and water from synthetic fertilizers, pesticide and herbicide residue in water and food; increased biodiversity; improved pest control, soil quality, and worker and inhabitant health; and decreased dependence on off-farm inputs and thus on credit.

Recommendation 4—Commodities Program. The government should reform subsidies in order to incorporate social costs and benefits into product costs and prices, thus incentivizing a healthier industry and populace. That said, an abrupt change in the Commodities Program would cause a burst in what is the farm asset bubble, as subsidized incomes have distorted fair market land values. Thus, the government should devise a one-time method of compensation to lessen the shock of certain drops in farm land prices.

Essay 1: Agroterrorism

Because agriculture encompasses the growth and nurture of living animals and plants, it is always susceptible to disease. Naturally occurring disease has historically had large scale impact when combined with weather phenomena or movement of exposed people or animals into unexposed or “clean” areas. Diseases that once took months or years to spread and become pandemic now take only days due to the volume of worldwide traffic and food trade. In addition, the industrial practice of keeping large, immobile herds in close proximity allows disease to spread quickly through contact and excretions. Disease organisms, also known as pathogens, take time to incubate, cause the host to show symptoms, and then kill or incapacitate the host. Due to the incubation period of a disease a deliberate attack may not be determined in time to stop massive physical and economic damage. Epidemiologists and law enforcement investigations are required to determine whether the incident caused was one of the three categories of disease occurrence in agriculture: natural, deliberate, or accidental.

A natural occurrence is when a microbe evolves over time into a pathogenic strain. Also naturally occurring are pathogenic microbes normally present in the soil or water of that region (endemic to that region). A deliberate disease occurrence is the deliberate introduction of pathogenic organisms, or their biologically produced toxic byproducts, to food, water, bedding, animals, or plants with the intent to cause harm. Terms to describe this include biological attack, bio-attack, or if it is against an agricultural sector specifically, agroterrorism. The U.S. Federal Bureau of Investigation (FBI) defines agroterrorism as “the deliberate introduction, use, or threatened use, of a biological, chemical, toxic, nuclear, radiological, or explosive (CBRNE) agent against one or more components of the food or agriculture sectors, with the goal of causing mortality and morbidity, generating fear, inducing economic losses, or undermining sector stability and confidence in government.”⁹⁰

“Some experts have estimated that up to 10,000 veterinarians and over 100,000 other emergency responders would be needed to respond to an outbreak of foot-and-mouth disease like that which occurred in the United Kingdom (UK) in 2001.”⁹¹ The implications of an agroterrorist attack require a whole of government approach to ensure the resilience of the agribusiness industry to provide food security for those who depend on it. The current level of federal planning and preparedness, even with major successes since 2001, is still not adequate to prevent large-scale devastation of the U.S. agribusiness sectors against a well orchestrated terrorist bio-attack. Despite the many strategies currently in use to mitigate or prevent a terrorist attack, the risk cannot be completely eliminated.

Counter-agroterrorism resources are underrepresented and under-resourced throughout the federal government interagency. The U.S. has observed multiple devastating animal disease outbreaks in other countries, none of which were proven deliberate. The threat continues for deliberate attacks from terrorists. Al Qaeda leadership has voiced and demonstrated their desire to harm this nation, and documents found in caves in Afghanistan manifest their view that agroterrorism is one of the most viable options. A timely federal response can make a difference, provided the policy decisions, training, and resources to do so.

Foot-and-mouth disease (FMD) is extremely contagious and affects cloven-hoofed animals. The UK was devastated by an accidental introduction of FMD in 2001 and 2007. An accidental release from the UK’s government laboratory created the 2007 outbreak. The 2001 outbreak was traced to imported animal feed that was contaminated with the virus and distributed to only three

farms. The virus then spread via wind to herds of nearby sheep and subsequently all over England through sales and continued windborne contamination, even contaminating vehicles and persons. The 2001 outbreak is estimated to have cost the UK approximately \$20 billion US in lost revenue and 7,800 jobs in agriculture and almost 200,000 in other sectors. Several farmers committed suicide over their personal losses. The outbreak lasted over seven months and resulted in euthanizing almost ten million animals.⁹²

To prevent this type of devastation, the U.S. improved measures in both coordination of disease response and by strengthening the authority of the Secretary of the United States Department of Agriculture (USDA).⁹³ Nevertheless, several areas still need improvement. The USDA Animal and Plant Health Inspection Service (APHIS) is authorized to serve as the lead agency during an animal or plant emergency, but APHIS lacks resources necessary to handle a catastrophic outbreak. Structures and agreements under the Economy Act and the Stafford Act allow interagency assistance to APHIS during a crisis. However, the requirements for support and the methods of requesting support differ, and little interagency planning differentiates between the two. For example, the Department of Defense (DoD) has agreed to assist in an animal health emergency by signing a Memorandum of Agreement (MOA) with APHIS under the Economy Act, and DoD is listed as a supporting agency under the National Response Framework Emergency Support Function #11 under the Stafford Act. Yet aside from the U.S. Army Veterinary Corps, little planning exists to cover support under the Economy Act, and very few DoD planners are aware the MOA exists.

USDA must launch its specific requirements into the federal budgeting and planning priorities and provide these to interagency partners so that they too can budget and create priorities for this type of event. More food and agricultural inspectors are required overseas to prevent disease introduction in the first place. More federal agency veterinarians are needed, as most are projected to retire in the next two years.⁹⁴ The National Level Exercise Program must include scenarios on catastrophic agricultural sector disease outbreaks in order to train strategic leaders about the complexities of these events. Federal government plans and policies for all aspects of animal disease emergency response require development. Every pathogen is different and living organisms are complex. Therefore, Federal Emergency Managers, knowledgeable about all aspects of domestic emergency management, as well as biotechnology, epidemiology, and agriculture, are needed to advise at the strategic level throughout a disease outbreak or attack. A strategic communications and education program is required now to prevent the mental distress that such an event can cause in a uninformed public.

Many individuals work to keep our nation's food supplies safe. However, federal leadership cannot discount or ignore the threat that exists in the form a deliberate attack using pathogens against our agricultural sectors: economic hardship, loss of food security, psychological impacts, and use of resources for disposal and decontamination operations. The constant changes and challenges of globalization require that improvements continue in federal level counter-agroterrorism planning and preparedness. Current efforts are inadequate to prevent large scale devastation of U.S. agribusiness sectors from agroterrorism attacks or unintentional outbreaks.

Essay 2: Food Aid

Food is strength, and food is peace, and food is freedom, and food is a helping hand to people around the world whose good will and friendship we want.

-John F. Kennedy

U.S. food assistance programs have been adopted in order to promote a variety of domestic and international objectives. In addition to preventing deaths from starvation, food assistance programs support U.S. industry while at the same time promoting U.S. geostrategic interests. The U.S. currently spends nearly three billion dollars annually assisting tens of millions of people worldwide.⁹⁵ Without a comprehensive strategy, the infusion of food aid may disrupt rather than promote long-term stability. Despite this large annual expenditure of funds and occasional adverse results, U.S. food assistance and development programs support America's national security strategy. Thus, targeted assistance in coordination with other governments and nongovernmental organizations should be sustained as a part of a comprehensive foreign policy strategy.

Initially established in 1954 to help stabilize U.S. crop prices and to support the Cold War strategy, recent food assistance has been guided by other national considerations. The latest U.S. food assistance report identifies five objectives for these programs. The programs are designed to (1) combat world hunger and its causes; (2) promote broad equitable and sustainable development; (3) expand international trade; (4) foster and encourage private development and demonstrate partnerships; and (5) prevent conflicts.⁹⁶ With the exception of Haiti, the top ten countries receiving food aid are located in south Asia and sub-Saharan Africa.⁹⁷ These countries combined received over \$1.7 billion of U.S. food assistance.⁹⁸

Although recent events necessitating consequence management have shifted U.S. resources to emergency assistance, targeted food development assistance must remain the primary focus. In order to create lasting solutions, development assistance programs should be initiated and sustained within high-risk populations in order to establish resilient and sustainable agricultural systems. USAID has recently acknowledged that demands have outstripped their capacity to provide universal assistance. They recently changed their policy to focus their programs on the top 20 priority countries.⁹⁹ In order to optimize limited resources, USAID is undertaking assistance programs in these priority countries in conjunction with other partner countries and nongovernmental organizations.

Numerous food security initiatives are designed to create sustainable agriculture for the purposes of creating stable societies. Diverse programs are tackling traditional problems, such as soil conservation and crop selection, as well as implementing more progressive programs that improve gender equality and female empowerment in order to address underlying causes of agricultural instability. Emerging research is recognizing the profound role that women play in agricultural recovery and sustainment in distressed societies. If successful, these multi-faceted programs will catalyze agricultural systems that will contribute to stability and reduce the need for emergency foreign food assistance. Continued emphasis and investment in targeted development programs designed to establish sustainable agricultural systems are essential for domestic and global stability.

Food assistance programs must be carefully administered in order to limit unintended consequences that may harm the overall prospects for long-term stability of food insecure

countries. Although the Bellmon amendment to Public Law 480 requires examination of potential impacts on the local market to which food aid is delivered, accurately predicting outcomes from a specific food assistance program is difficult.¹⁰⁰ Consequently, within the global food assistance community, views diverge regarding the best method to effectively and efficiently provide food assistance in order to minimize potential negative impacts.

At its inception, emergency food assistance exclusively comprised agricultural products grown by U.S. farmers, packaged by U.S. processors, and shipped by U.S. flagged carriers. This construct, often referred to as the “iron triangle,” is grounded in a variety of U.S. statutes and remains relatively unchanged almost 60 years after the program’s establishment. Arguably the most rigid and enduring requirement in the iron triangle is the shipping requirement. The requirements are contained in the Cargo Preference Act of 1954, designed to assist U.S. flag carriers. This act requires 75 percent of the gross tonnage of all U.S.-funded food aid to be transported on U.S. flagged vessels.¹⁰¹

Advocates for retaining the current requirement to rely primarily on U.S. agricultural products remain strong. They acknowledge that costs are higher but argue that quality and reliability are superior. Unlike some local or regional procurements, spoilage or delivery of substandard products rarely occurs with food originating in the U.S. Furthermore, if problems arise with locally procured products, the absence of an effective commercial code prevents enforcement of any contractual remedy. Proponents argue that higher costs are justified, because food aid recipients reliably receive a better product; and U.S. farmers and corporations benefit financially while simultaneously advancing U.S. goodwill.

Conversely, several individuals, including many within U.S. assistance agencies, advocate that methods should expand to include options such as local purchases of food assistance or monetization rather than direct supply from the U.S. First, by using commodities grown in the U.S., delivery is slowed to affected areas in emergency situations. A World Food Program (WFP) study of ten countries in sub-Saharan Africa from 2004 to 2008 highlighted that U.S. food donations required on average 147 days to be delivered vice 41 days using local and regional sources.¹⁰² This delay can result in additional loss of life. Second, transportation from the U.S. to hunger-struck countries and regions is costly. The Government Accountability Office (GAO) compared the WFP’s local procurement of agricultural products for sub-Saharan Africa from 2001 to 2008 to USAID’s purchase and shipment of similar U.S. products and calculated an approximate 34 percent cost savings.¹⁰³ If transportation costs are reduced by purchasing commodities locally, the amount of food aid can be increased to assist more people. These observations were acknowledged in the 2008 Farm Act, which authorized local purchase of \$60 million worth of agriculture products over a five-year period as emergency food assistance.¹⁰⁴ Still, transfer of agricultural practices to improve crop production in less developed countries is prohibited if those crops have the potential to compete with U.S. exports.¹⁰⁵

Many of the world’s hungry live in rural areas and depend on the consumption and sale of natural products for both their subsistence and livelihood. Local producers in distressed countries cannot compete with direct food aid from the U.S. Direct food assistance distorts local market prices. If the distortion is prolonged or severe, it may force local producers out of farming. In addition, providing direct commodities tends to create dependence. This dependence stifles individual and community-led development that would provide long-term stability in the most food insecure regions. This destabilization may lead to migration, as populations that can no longer sustain themselves through agriculture abandon rural areas and

migrate to urban centers in search of food and other forms of security. This migration not only creates additional stress in already overcrowded urban centers but further reduces the number of workers available to develop a sustainable agricultural system that will ensure continuous food production for future generations. These potential consequences require thorough consideration in order to avert exacerbating food insecurity.

As human populations swell unevenly and incomes rise, food production and distribution must adjust. To improve food security the OECD proposed initiatives to reduce food waste in less developed countries by improving handling, storage, transportation, and marketing infrastructure.¹⁰⁶ Moreover, the U.S. should diffuse sustainable agricultural and environmental practices to help less developed countries meet their own needs.

U.S. food assistance programs have provided enormous assistance for millions of people worldwide during the past 56 years. Program failures may result in escalating instability throughout many regions that could ultimately precipitate intervention by the U.S. and others within the international community. In order to enable these countries' food security, continuation of targeted and balanced food assistance programs remains in our national interest. The U.S. should carefully implement food aid programs in order to maximize their benefit to affected populations throughout distressed regions. Working with international partners, the U.S. should dedicate scarce resources to targeted long-term food security strategies with the goal of creating stable, self-sustaining societies.

Essay 3: Water, Water Everywhere...

While food production escalates, pollution and growing consumption diminish the world's supply of fresh water. Because agriculture depends on water and accounts for roughly seventy-one percent of freshwater consumption in the world, aggressive action must be taken to manage this valuable resource. This endeavor to manage the world's water supply will require the combined efforts of all sectors of the agribusiness industry as well as effective government support and policy. Without a coordinated approach, water availability will become the limiting factor in meeting the world's food demands.

With three-quarters of the world covered by water, how can there be a shortage? To start, 97 percent of the world's water is salt water, contained in the oceans and seas, and another two percent is frozen in the world's glaciers, which are melting into the oceans.¹⁰⁷ We are left with one percent—about 2.81 million trillion gallons—to sustain all life on Earth.¹⁰⁸ That one percent, the same one percent that dinosaurs drank, is in high demand. We use it to drink, grow crops, manufacture goods, supply energy, and cool power plants. By far though, the largest user of the world's freshwater supply is agriculture. On average 71 percent of freshwater supplies are used to grow food.¹⁰⁹ Some areas have an abundance of water, while others other areas suffer from severe scarcity. In some dry areas, including parts of the U.S., almost 90 percent of freshwater goes to agriculture, while in other more fortunate areas, less than 50 percent goes to agriculture.¹¹⁰ Expanding populations will continue to pressure both the food supply and the environment by both demand and stress.

Increased Demand

Over the past fifty years, the world's population has doubled, and as a result water available per person has declined by fifty percent.¹¹¹ While the human population is projected to increase

by 25 percent, the food required to feed that population will double from the current rate of consumption due to increased economic prosperity, placing additional stresses on the world's freshwater supply.¹¹² On average growing one calorie of food requires one liter of water, while a healthy diet consists of approximately 3,000 calories per day—requiring 3,000 liters of water to produce.¹¹³ As countries increase wealth and people rise from poverty, diets change shifting toward higher meat consumption. This can raise the water requirement for a day's food supply by a factor of five to up to 15,000 liters per day.¹¹⁴

While much water falls to the earth as rainfall—about 100,000 cubic kilometers a year—its distribution is highly uneven.¹¹⁵ It is estimated that 24 percent of the world's renewable water resources fall in Canada every year while other regions of the world receive zero rainfall most years.¹¹⁶ Compounding the issue of distribution and use is the uneven distribution of rain in the time domain. Some areas such as India and Bangladesh can receive 90 percent of their annual rainfall in a few storms during the monsoon or rainy season.¹¹⁷ Climate change will only exacerbate distribution issues as rain patterns change, snow caps melt at different times, and water appears in places once dry or disappears from places once wet. The challenge then is to get the right amount of water to the crops both when and where it is needed.

Freshwater and irrigation are critical to agriculture. While overall, only 16 percent of U.S. cropland is irrigated, those acres that are irrigated account for almost 50 percent of crop value in the country.¹¹⁸ This is even more extreme in Western states where overall 30 percent of cropland is irrigated, with some farms in the region irrigating over 80 percent of harvested land.¹¹⁹

Delivering the Water to the Crops

The two primary sources of water for irrigation are surface water and ground water. Surface water, which accounts for about 60 percent of irrigation, is water diverted from rivers, streams, and lakes by either gravity or pumping.¹²⁰ Ground water which accounts for the other 40 percent is pumped from wells drilled into underground aquifers—essentially drilling or mining for water.¹²¹ The method used is dictated by the water sources in the region. Drawing water out of subterranean aquifers can become problematic if withdrawals exceed the natural recharge rate. Globally, anywhere from 15 to 35 percent of water withdrawals on average are unsustainable as withdrawals exceed natural replenishment.¹²² In some parts of India the groundwater overdraft rate is over 50 percent.¹²³ Water tables in areas of Mexico, China, India, and North Africa are declining by as much as one meter per year.¹²⁴ This issue is particularly evident throughout the U.S. High Plains states of South Dakota, Nebraska, Kansas, Oklahoma, and Texas. These states lie above the Ogallala Aquifer and rely on the aquifer for a significant majority of irrigation water.¹²⁵ Irrigation transformed this region from the Dust Bowl of the 1930s into the Breadbasket of today at a significant price. Because the rate of withdrawal has exceeded the rate of replenishment, aquifer water levels have fallen by up to 150 feet.¹²⁶ This may result in land sinkage, increased salinity, and greater energy requirements to pump vanishing water to the surface. Alternatively, surface water is easier to obtain if a source is readily available, but this source has disadvantages as well. Diverting surface water can reduce flow to rivers and streams, drain lakes, and harm wildlife habitats and wetlands.¹²⁷

In either case, when moving water from the source to the farm, “conveyance losses” result from seepage and evaporation from reservoirs and canals.¹²⁸ In some cases conveyance losses may be significant—up to 40 percent—particularly when the water is transported in old and

unlined or permeable canals.¹²⁹ While costly, losses can be significantly reduced by building new concrete or plastic-lined delivery channels.

The use of water in cropland irrigation is categorized as either consumptive—water unavailable for reuse in the basin from which it was extracted due to evaporation, plant transpiration, incorporation into the plant biomass, or contamination due to fertilizers or salts—or non-consumptive—water returned to the basin from which it was withdrawn through return flow and available for later reuse.¹³⁰ However, consumptive water loss is not necessarily wasted. Consumptive use is beneficial if it contributes to crop production through crop evapotranspiration—water returned to the atmosphere through the plant—or by leaching salts away from the root zone.¹³¹ Non-beneficial use does not contribute to crop production and is wasted water.

Once water is withdrawn and transported to the farm, a number of methods enable delivery to croplands. Flood irrigation, the original method, is simply allowing water to flow by gravity through a field, typically through small channels or furrows through the rows of crops. While simple and inexpensive, flood irrigation is considered the least efficient method, because it loses the greatest amount of water to non-beneficial uses—primarily runoff and evaporation.¹³²

A more efficient method of irrigation is a sprinkler system that delivers water to crops through a pressurized pipe system and then through nozzles or rotating sprinkler heads.¹³³ A sprinkler system can significantly reduce the volume of water applied and provide a more uniform application, thereby reducing losses to evaporation and runoff.¹³⁴ Among sprinkler systems, efficiency varies. Traveling sprinklers, which are suited for irregular sized or shaped fields and are readily moved from one field to another, tend to have the poorest efficiency.¹³⁵ Various types of center pivot sprinkler systems, including a low-energy precision application sprinkler that has drop tubes to apply the water only a few inches from the ground, conserve both water and energy and typically are more efficient than flood irrigation due to less runoff and evaporative losses.¹³⁶

Two of the most efficient of all delivery methods are the drip system and the micro-irrigation system. Drip systems provide a slow application of low-pressure water through plastic tubing buried near the plant's root zone, while micro-irrigation systems provide water through a small sprinkler attached to a stake near the ground.¹³⁷ Drip systems allow for precise application of water and fertilizer, minimizing non-consumptive losses and reducing water and fertilizer requirements while increasing crop yield and quality.¹³⁸ Because of their efficiency, drip irrigation systems can pay for themselves, increasing irrigation efficiency by up to 90 percent.¹³⁹ Improved irrigation systems that target root zones and do not broadcast water should be mandated now in an effort to halt the unsustainable extraction of ground water from aquifers.

On the Downstream Side

As described, runoff can be a major issue, particularly when flood irrigation techniques are used. As irrigation water or rainwater leaves the fields, it carries with it residual elements—sediment, fertilizers, pesticides, pathogens, and salts.¹⁴⁰ Water quality assessments indicate that agriculture is the leading source of impairment in the nation's rivers, lakes, and estuaries.¹⁴¹ Nitrates and phosphorus from fertilizer, fecal coliform bacteria from animal waste applied to fields, pesticides, suspended sediments, and effluent from Concentrated Animal Feeding Operations (CAFOs) produce significant environmental impacts on water supplies and significantly impact their suitability for agricultural, recreational, and domestic uses.¹⁴² High

levels of nitrogen loading from fertilizers that runoff into the Mississippi River have created a nitrogen-rich zone in the Northern Gulf of Mexico leading to algae blooms and the creation of “dead zones” where oxygen levels are so depleted that aquatic life cannot be sustained.¹⁴³ Similar issues occur off the East Coast and in the Chesapeake Bay.

Possibly the greatest impact on agriculture may be the issue of salinity. Salts are naturally occurring in the soil and are also deposited through irrigation and rainfall. As water evaporates, salts are concentrated, reducing crop productivity and yields by up to 25 percent.¹⁴⁴ This effect can be compounded downstream as salts are carried through runoff to water supplies that are used for further irrigation. Downstream concentration of salts reduces crop yields and sometimes damages soil so much that crops can no longer be grown.¹⁴⁵

Another threat to downstream waters is animal waste. While the application of animal wastes as fertilizer can provide soil nutrients and increase crop yields, sustained long term use or overuse results in nitrogen and phosphorus buildup in soil which later runs off into water supplies.¹⁴⁶ This contamination is an acute consequence of CAFOs where waste is released to the environment. The manner in which wastewater is applied to crops contributes to the potential for release of elements into the environment. Spray irrigation results in the emission of ammonia and other volatile organic compounds to the atmosphere, leaves nutrients on or near the surface where they are more susceptible to runoff, and requires the use of more water, which increases the opportunity for nutrients to leach below the root zone.¹⁴⁷ The Agricultural Research Service tested the effects of subsurface drip irrigation on nutrient release and found that not only does yield increase but that less water is required as less is lost in the process to evapotranspiration.¹⁴⁸ The benefits of this approach are twofold as waste water can be applied as irrigation in place of both fertilizer and clean ground or surface water while simultaneously reducing nutrient runoff.¹⁴⁹

Competition for Water

Population growth and shift to urban areas¹⁵⁰ will place an increased demand on water resources, potentially diverting water that would be used for irrigation and food production to cities for consumption. Stiff competition for water is already being seen in California where farmers are increasingly struggling to get much needed water for their crops. In California, 100,000 high-tech jobs require about 250 millions gallons of water a year, while that same amount of water dedicated to agriculture will sustain only ten jobs.¹⁵¹

A complicating factor in the overall competition for water is the price of water. In some areas, water is used for little or no charge. One may only have to pay for the energy costs to run a pump. In other regions, water can be quite expensive. In some parts of California, water may compose up to thirty percent of a farm’s total costs.¹⁵² This significantly impacts decisions about what crops to plant and whether to plant at all. It can also provide impetus to install more efficient methods of irrigation. Government subsidies for growing water-intensive crops in areas that require significant irrigation discourage better water management.¹⁵³

Energy versus Food

As fuel consumption and costs increase and the quest for renewable energy sources grows, biofuels play a greater role in global energy strategies. Through subsidies the government incentivizes farmers to grow biofuel crops. Aside from the issue of whether food resources should be used to power vehicles, another major impact of biofuel production is surfacing.

Globally, about two percent of all irrigation water goes to producing crops specifically for biofuel.¹⁵⁴ Some studies estimate that the amount of water it takes to produce a liter of liquid biofuel is the same amount of water it takes on average to produce food for one person for one day.¹⁵⁵ This water use is regionally dependent. In some world areas such as Brazil, where rainfall is plentiful and irrigation is minimal, essentially no irrigation water is used for biofuel production. In other regions such as the U.S. where more irrigation is used in biofuel crops, the figures are higher.¹⁵⁶ Within the U.S. consumption of irrigation water for biofuel varies from seven gallons of water per gallon of biofuel in Iowa and Indiana to 320 gallons of water per gallon of biofuel in North and South Dakota, Nebraska, and Kansas.¹⁵⁷ This is particularly troubling for the Northern Plains region, which draws from the shrinking Ogallala Aquifer for much of its irrigation needs.

Putting Technology to Work

Given competing and increasing demands on the static supply of water, measures must be taken to protect our water supply. The USDA Agricultural Research Service is placing great effort into water conservation research and technologies. These technologies will play an increasing role in the smart application of water including the use of satellite data, computer models, and remote sensing.¹⁵⁸ By monitoring crop and field conditions, farmers will be able to determine daily water needs on specific field sections and can then adjust irrigation levels precisely with drip or sprinkler irrigation systems.¹⁵⁹ This more precise and efficient use of water minimizes waste, waterlogging, salinity buildup, and runoff issues.

Where rainfall is plentiful and drainage and runoff are problems, new studies are being conducted in capturing toxins coming off the fields and preventing them from entering the downstream water supplies. By developing riparian zones—native grass and vegetation buffers alongside fields and around drainage ditches—chemical runoff can be reduced by up to 90 percent.¹⁶⁰ Other promising methods to protect downstream waters from toxic runoff include various filtration systems or “socks” filled with compost or other industrial byproduct filtering materials placed in waterways to intercept toxins from the fields.¹⁶¹ Conservation tillage—growing crops with little or no tillage or plowing¹⁶²—allows more plant residue to remain in the fields thereby increasing the biomass and organic content of the soil as well as its productivity and water retention capabilities.¹⁶³ The use of conservation tillage can reduce soil erosion and runoff contamination by up to 90 percent.¹⁶⁴

Downstream

Competing demands and environmental stresses on our water systems from both agricultural and industrial use ensure no easy answers. Action must be taken to preserve this life sustaining resource. The agriculture industry, consumers, and governments must work together to provide solutions and set priorities. Only by practicing good farming and irrigation techniques, by taking advantage of technological advances in agriculture and water management, and by accurately pricing water as a commodity to drive efficient behavior will we be able effect the change needed to ensure our water supply of the future is adequate. Nine billion people will be depending on our ability to manage this precious resource.

CONCLUSION

“An army marches on its stomach.”

-Napoleon Bonaparte

Food security is critical to maintaining the health and leadership of the U.S. As a critical resource of national security, food needs to be secure. U.S. agribusiness in the 21st century faces multiple challenges. Concentration within the industry has been growing over the last several decades, representing both benefits and challenges. Agribusiness must produce and distribute food to feed a growing domestic population that is becoming more urbanized and providing a smaller rural labor force. This population is forecasted to demand more protein requiring even more feedstocks. At the same time the industry must confront the issues of increasing biofuels requirements and environmental sustainability. The severe environmental threat of conventional and industrial agriculture is well documented.

Despite growing global competition, rising input costs, resource allocation pressures, and climate change, agribusiness is robust and one of few U.S. industries that is a net exporter. High efficiencies and productivity found within this industry combined with government support enable U.S. farms and firms to achieve trade surpluses but at great cost to our natural resources. At the same time, they overproduce some commodities while failing to meet domestic demand for locally grown, organic products. As we move into the future, U.S. agribusiness policy must confront a slew of complex problems of sustainability for the nation and its own industry. To maintain U.S. preeminence in both industry and world standing, we must implement sustainable agribusiness practices and infrastructure. Agribusiness policy must be part of a coherent solution in the larger national strategy. Successful resolution will keep U.S. agribusiness as a source of national power, security, and pride.

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End Notes

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