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Industry Study

Final Report
Agribusiness

The Dwight D. Eisenhower School for National Security and Resource Strategy
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ABSTRACT: Our nation's food security lies in the strength and sustainment of the Agribusiness Industry. Famine and hunger contribute to political instability within and between sovereign borders and negatively impact global world order. The United States should beware of exogenous events and focus on maintaining the strength of the industry by: 1) responding to water scarcity and the threats that may accompany the growing value of water, 2) addressing the ability to maintain a reliable labor force for farming, 3) developing adaptive strategies that address the effects of climate change and 4) ensuring the domestic population is protected from food insecurity.

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Places Visited

Domestic:
American Farm Bureau Federation, Washington, DC
United States Department of Agriculture, Washington, DC
Clagett Farm, Upper Marlboro, MD
Miller Farms, Clinton, MD
USDA Agricultural Outlook Forum, Crystal City, VA
United States Agency for International Development, Washington, DC
Central Intelligence Agency, Washington, DC
Smithfield Foods, Smithfield, VA
Syngenta Inc., Durham, NC
North Carolina State University, Raleigh, NC
United States Senate, Washington, DC
Scoma's Restaurant, San Francisco, CA
Climate Corporation, San Francisco, CA
Monsanto, San Francisco, CA
Wine Institute, San Francisco, CA
Revolution Foods, Oakland, CA
California Institute for Water Resources, Oakland, CA
Tanimura & Antle, Salinas, CA
Christopher Ranch, Gilroy, CA
Ocean Mist Farms, Castroville, CA
Harris Ranch, Coalinga, CA
Woolf Farming and Processing, Coalinga, CA
Driscoll's Berries, Inc., Oxnard, CA

International:
U.S. Embassy, Mexico City, Mexico
USDA Foreign Agricultural Service, Mexico City, Mexico
International Maize and Wheat Improvement Center (CIMMYT), Texcoco, Mexico
Wal-Mart Stores, Inc., Mexico City, Mexico
White & Case, Mexico City, Mexico
Grupo Bimbo, Santa Fe, Mexico
Cargill Inc., Santa Fe, Mexico
Parque Cientifico y Tecnologico, Merida, Mexico
Proteinol, Port of Progreso, Mexico
USDA Foreign Agricultural Service, San Jose, Costa Rica
Tropical Agricultural Research and Higher Education Center (CATIE), Turrialba, Costa Rica
Inter-American Institute for Cooperation on Agriculture (IICA), San Jose, Costa Rica
Starbucks Corporation, Alajuela, Costa Rica
Café Britt, Heredia, Costa Rica

Introduction

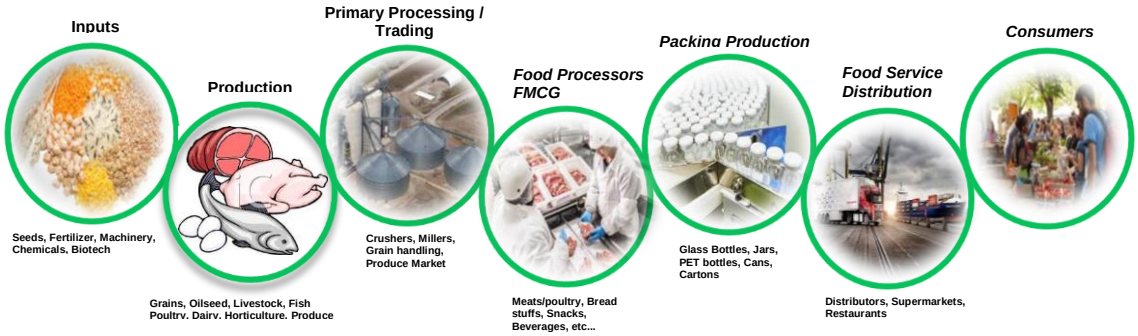
Food insecurity threatens global peace and creates social unrest. Recently, national security analysts have attributed the Arab Spring and the Egyptian uprising directly to food security crises.[1] Today's regional crises are projected to be exacerbated in the near future as conservative estimates predict the global population will increase by over 30% by the year 2050.[2] Compounding this growth are the impacts of climate change on key enablers of agribusiness.

The United States agribusiness industry contributes to the domestic economy by providing food, fiber, medicine, and biofuel to address global demand. While China relies heavily on U.S. exports to sustain their population, the U.S. enjoys food sovereignty and exports food products as well as feed for livestock. Over the next few decades, as the global population swells and the climate changes, the U.S. will continue to shape the industry by leveraging the strength of innovation as demonstrated in sustainable agriculture, free trade agreements, and ongoing efforts to increase production and nutrition while reducing waste.

This paper provides an assessment of the industry's financial vitality, its productivity and fiscal outlook, and the challenges that should be addressed to ensure the industry's success. It also offers policy recommendations to ensure America's continued food security and independence. Although the issue of trade is not addressed independently, it is interwoven throughout the study topics. In the first quarter of 2017, every agribusiness expert and stakeholder that was interviewed identified international trade as a major concern. The industry was particularly wary of our country's strained relationship with Mexico and its potential negative impact on the North American Free Trade Agreement (NAFTA). Once it became clear that President Trump's intent was to renegotiate NAFTA rather than repeal it, the concern gave way to sincere optimism. The agricultural trade surplus that this nation has enjoyed since 1960 is likely to continue through the foreseeable future and the policy recommendations included in this study are intended to ensure the continuation of this national success.

Agribusiness Defined

"Agribusiness" in its simplest form is the intersection of agriculture (farming) and the business management practices focused on achieving efficient functioning of the entire system of food production. In the 1950s, agriculturists and American economists expanded this concept, redefining agribusiness as "the sum total of all operations involved in the production, processing, and distribution of food and fiber on a farm."[3]

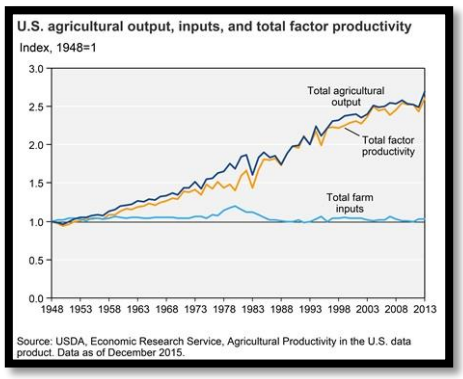


Today, the root definition of the words 'agribusiness' (farming and business) is the umbrella term used for many different facets that defines an industry engaged in crop production and farm operations; the manufacturing and distribution of farm equipment and supplies; and the processing, storage, and distribution of farm commodities.[4] For the purposes of this study, the definition of 'agribusiness' is adopted from several sources encompassing the broadest interpretation of the agribusiness value-chain directly or indirectly involved in the process of food production defined as "the entire collection of activities and supporting institutions that are involved in the world's complex food and fiber system."

While the agribusiness value-chain encompasses a wide range of activities, this paper is focused primarily on crop and livestock production and the challenges directly related to U.S. national security, economic policy, and agriculture policy. This focus involves the work of such U.S. Federal Agencies as the Departments of Agriculture (USDA), Health and Human Services, Energy, Commerce, Interior, Transportation, Defense (DOD), State, the U.S. Trade Representative, and the U.S. Agency for International Development (USAID).

Current Conditions

In 2014, agriculture and related industries generated nearly one trillion dollars, representing 5.7% of the U.S. gross domestic product (GDP).[5] The U.S. has the third highest total agricultural output in the world (after China and India)[6] and has the seventh highest agriculture value added per worker in the world.[7] As of 2012, there are approximately 2.1 million farms in the U.S., a decline from the peak in 1935 which witnessed 7 million farms.[8] Since 1945, the total number of cultivated acres in the U.S. has decreased slightly, while total output has risen 169%.[9] U.S. average corn yields increased from 37 bushels per acre in 1951 to 168 bushels per acre in 2015, an average gain of more than two bushels per year.[10] This surge is largely attributed to the widespread availability and use of excess military nitrogen after World War II, as well as increased mechanization and improvements in pesticides and plant genetics.



Of each dollar spent on food, 32.7 cents go to foodservice companies, 15.3 cents to food processors, 12.9 cents to retail trade, and 10.4 cents to farm production.[11] Gross cash farm income rose steadily from around $300 billion in 2000 to $470 billion in 2014 before regressing to $399 billion in 2016 (constant year dollars) due to lower commodity prices.[12] Meanwhile net farm income has dropped from $113 billion in 2011 to $68 billion in 2016 owing to higher production expenses.[13] Meanwhile, total employment in agribusiness has declined slightly over the last decade from 7.3 million workers in 2007 to 7.2 million in 2016.[14]

Agribusiness is in the mature stage of the industry life cycle, characterized by revenue growth (1.5%) similar to the rate of growth in gross

domestic product (2.1%) and an increase in consolidation.[15] So, although the number of farms have decreased since 1935, the average size of the remaining farms has nearly tripled from 155 acres to 430 acres per farm.[16] Also, while 97% of farms are still family-owned, there has been a trend toward corporatization of farms, contract farming, and vertical integration.[17] Contract farming transfers the bulk of the industry's risk to corporations who purchase the farms and in return provide farmers guaranteed base salaries and performance bonuses based on the yield achieved in any given year. Vertical integration is evident in Smithfield Foods, who began as a meat processing and packaging company in the 1930s, expanded into hog production in the 1990s and now has its own distribution networks and markets directly to retail stores – even applying store brand labels in its own processing plant.[18]

The agribusiness industry has a particularly low level of concentration with the top four companies accounting for less than 10.0% of industry revenue.[19] Most farm commodities are sold in a perfectly competitive market characterized by the inability of firms to affect price (a horizontal demand curve); multiple buyers and sellers; identical products; perfect information; and low barriers to entry. Despite the low formal barriers to entry, economies of scale favor large-scale farms as farmers need access to large quantities of capital to acquire land and the most efficient technology and techniques, such as genetically modified seeds and precision analytics equipment. Foodservice companies typically operate in a monopolistic competition structure characterized by many buyers and sellers; similar but not identical product; small but real barriers to entry, such as licenses; and a downward sloping demand curve.

In contrast, the agrochemical industry tends to be oligopolistic with only a few large sellers; high barriers to entry; and a differentiated product. Although there are approximately 20 pesticide manufacturers, the five largest (Syngenta AG, The Dow Chemical Company, Monsanto Co., Bayer AG, and E.I. du Pont de Nemours and Company) account for 82.7% of total market share.[20] The Herfindahl-Hirschman Index for this segment is currently between 1650 and 1750,[21] which indicates a moderate to high level of market concentration according to the US Department of Justice.[22] Assuming the successful execution of the planned merger of Dow Chemical with E.I. du Pont in June 2017,[23] and the proposed merger of Monsanto and Bayer AG,[24] the industry will become even more oligopolistic with three large manufacturers accounting for 82.7% of the market. Although oligopolies do not result in the most efficient allocation of scarce societal resources, this is likely the optimal structure for the US pesticides market. Consumers may pay a price greater than marginal cost, and the product may not be produced at the minimum average cost, but consumers benefit from being able to purchase a differentiated product that best meets their unique needs. Furthermore, only a handful of established firms have the necessary capital for the research and development (R&D) and production of agrochemicals.

Just as the market structure varies by industry segment, so does Porter's five forces. This analysis focuses on row crop farmers. The bargaining power of suppliers is high due to elevated concentration of seed and agrochemical companies (e.g. Monsanto, Syngenta) and a general shortage of farm labor. However, farmers can mitigate the bargaining power of labor by substituting mechanization. Buyers of row crops include grain merchants, livestock producers and the energy sector. Because row crops are traded as fungible commodities at a market price, there is relative balance in bargaining power between buyers and row crop producers. Rivalry among farmers is moderated by the horizontal demand curve of perfect market competition. In essence,

farmers are competing against nature to maximize their individual yields. The threat of new entrants is low due to a relatively fixed amount of cultivated land coupled with a high capital cost for farmland and machinery. The threat of substitutes is also low since science has not eliminated the need for humans to consume calories. While diet preferences may change, farmers can adjust each year through their planting choices. Even as a growing middle class consumes more animal protein, row crop farmers provide the bulk of animal feed requirements.

Overall, the agribusiness industry is financially stable as the market leaders have adopted business strategies to create value at an acceptable level of risk. The following financial and strategic overview focuses on four key firms across the agribusiness industry: Syngenta (a high-tech provider of seeds and agrochemicals), Bunge (a global trader in agricultural commodities), McCormick (a leading manufacturer of spices, herbs, and flavorings), and Kraft-Heinz (a food and beverage conglomerate).

Syngenta's average return on investment (ROI) over the past five years is 12.5%, exceeding the S&P 500 average of 10.9% over the same period.[25] Syngenta enjoys a better long term debt to equity ratio than its largest competitors, but twice as high as the S&P 500.[26] This is largely due to the significant capital investment required to develop and market new genetic seed traits and agrochemicals. Syngenta reduced its number of employees by 3.4% over the past three years in order to reduce cost in an increasingly competitive market, especially in consideration of the decline in commodity prices. Syngenta seeks to differentiate itself through state-of-the-art research and development and by providing integrated solutions to its growers. The company is also employing needs-based positioning by targeting crop market segments and then striving to meet most or all the needs of the growers of those crops. Syngenta competes globally to take advantage of economies of scale and maximize return on R&D investments.

Over the past three years, Bunge's net profit has increased from $306 million to $791 million, despite an overall decrease in revenue from $61.3 billion to $43.5 billion.[27] As a global trader in commodities rather than a producer, this company has been able to successfully weather the downturn in commodity prices that reduced total revenue. Bunge has done so by reducing its workforce by 5.7% to 33,000.[28] Their strategy is to increase market share in the grain and oilseed value chains by capitalizing on key sourcing, logistics, processing and risk management competencies. This strategy is closely aligned with population economic growth trends such as a desire for healthy, less processed foods; food security; supply chain visibility; and sustainability.

McCormick's five-year average ROI of 12.3% exceeds the S&P 500, while net profit increased by 7.3% to $472 million over the past two years.[29] McCormick's long term debt to equity ratio of 64.8 is higher than the industry average of 30.8, which causes some concern although their current ratio is 1.0 which is an acceptable level of short-term liquidity.[30] McCormick's strategy is based on long term relationships with key suppliers, economies of scale, brand recognition, and well established distribution networks. McCormick resource "long-view" has kept raw materials flowing without interruptions at minimal price increases through hedging strategies and warehousing of key spices.

Kraft's merger with Heinz was driven by a desire to expand its domestic and global market share while leveraging newly acquired capital from Heinz. Kraft-Heinz revenue has remained

stable around $18 billion over the past three years, but net profit declined more than $1 billion to $634 million over the same period to the one-time merger costs.[31] Their strategy is to lower manufacturing costs through better use of the combined facilities and saturate markets with price competitive products. They are also evolving their products to include healthier food options to take advantage of growing demand in this segment.

Foreign competition in agriculture is robust. The U.S. had a $20 billion agricultural trade surplus in 2016 with exports totaling $135 billion and imports at $115 billion.[32] The primary U.S. surplus exports are in bulk commodities such as corn, wheat, and soybeans, while the primary deficits come from the import of consumer-oriented products, particularly from the European Union, and as such do not represent an indication of food insecurity. U.S. depends on foreign trade for products such as coffee, pineapple, and bananas which cannot be grown in the continental U.S. climates. Additionally, the U.S. is dependent on imports in order to ensure year-round availability of seasonal crops such as strawberries, lettuce, and broccoli. These specialty crops are harvested in California starting in mid-spring through summer, while winter production shifts to warmer climates in Mexico. U.S. agriculture has benefitted greatly from the multiple free trade agreements (FTA) negotiated since the early 1990s starting with the North American FTA (NAFTA) in 1994. Overall in countries with FTAs, U.S. food and farm product exports increased by more than 145% during 2004-2014 from $24 billion to $59 billion.

Outlook

The agribusiness industry directly sustains our country's national security and is a pivotal contributor to global security. In terms of domestic consumption, the focus continues to shift from evaluating progress through calorie counts to measuring it in terms of nutritional value, which has a positive impact on our nation's ability to develop a productive labor force. Our gains internationally can be measured in terms of vibrant exports, especially in the core commodities of soybean and corn. Continued growth in crop and animal production underscores this stability and is essential to providing the food needed both for the US as well as for the projected 9.7 billion people in 2050.[33] This can only be achieved by managing risks, the most formidable of which are labor, access to water, climate change, and food security.

Labor issues center on the shortage of human capital and the inefficiencies of immigration policies. These factors drive up the cost of food and commodities and may impact the country's ability to maintain its global competitive edge. The intensifying challenge of changing climate patterns and extreme weather events such as droughts, floods, and extended periods of extreme temperatures[34], not to mention the ongoing threat of pests and crop and animal diseases, also pose major challenges and have necessitated R&D investments by both public and private sectors in new food production practices.[35] Exacerbating climate challenge is continued stress on ecosystems, marine environments, fisheries, and the land, water, and natural resource base upon which productive agriculture relies. In addition, water resources defy convenient political borders, which precipitates complex interstate negotiations and collaboration.[36] While all of these are serious impediments, policy changes will allow the U.S. to address domestic needs and take advantage of growth around the globe. Food security can only hope to be achieved by directly addressing these impediments, which are expected to have an even greater impact on the industry in the coming decades.

With regard to the short-term outlook, the industry will continue with a steady rebound from the economic crisis nearly a decade ago due to population growth and increased demand for biofuels. U.S. export markets will continue to grow, especially in meat markets due to the rising demand for animal protein among middle-class consumers in an increasingly urbanized world. According to IBISWorld, "export values are forecast to grow at an annualized rate of 1.8% over the next five-year period to reach $156b in 2021."[37] Changes in the U.S. include a tighter supply chain that will circumvent the wholesaler as well as more vertical integration among multinational corporations. At the production level, increased mechanization and bio-technological advances will allow large farms to increase production and efficiency. As such, both multi-national companies and large farms are expected to consolidate and gain greater leverage over output and pricing in the value chain. Opportunities for U.S. agriculture growth exist with strengthening links between rural producers and the growing numbers of urban consumers through the development of input and output markets and related infrastructure.[38]

The long-term outlook is heavily influenced by exponential population growth that is not expected to taper off until 2100. The addition of over two billion consumers in the next thirty years will place ever-growing demands on agricultural producers.[39] Population gains in politically volatile developing countries along with economic growth and the expansion of their middle class are important factors for the projected growth in global food demand as well as the specter of crises if food security is not maintained.[40] These same countries are experiencing rising per capita incomes, increased urbanization, upgraded infrastructures, better access to modern food markets, and emerging diets with healthier preferences.[41]

Projections indicate the world economy will roughly double in size by 2042, growing at an annual average rate of around 2.6% between 2016 and 2050.[42] We expect this growth to be driven largely by emerging markets and developing countries, with the E7[43] economies growing at an annual average rate of almost 3.5% over the next 34 years, compared to just 1.6% for the advanced or G7[44] economies.[45] The shift in global economic power will migrate from established advanced economies, especially those in Europe, towards emerging economies in Asia and elsewhere.[46] Ultimately, the E7 could comprise almost 50% of world GDP by 2050, while the G7's share could decline to just over 20%.[47] The U.S. is expected to lead developed countries, averaging just over 2.1% annual growth, while developed countries as a group are expected to experience an average of 1.8% annual growth through 2026.[48]

An improved outlook for global agriculture and U.S. trade is a reflection of income growth in developing countries and a strong U.S. dollar in the near term, with steady world economic growth and continued global demand for biofuel and feedstocks in the longer-term.[49] Those factors combine to support long-term increases in consumption, trade, and prices of agricultural products. Global trade competition will continue to be strong and the higher valued U.S. dollar will somewhat constrain growth in US agricultural exports[50] although the U.S. will remain competitive.[51]

Examining water scarcity, the OECD's 2012 Global Environmental Outlook's Baseline Scenario[52] predicts increasing strains on freshwater availability through 2050, with the projected population growth expected to be in areas with severe water stress, especially in North and South Africa and South and Central Asia.[53] Another report predicts the world could face a 40% global

water deficit by 2030 under a business-as-usual scenario.[54] Specifically, agriculture accounts for roughly 70% of total freshwater withdrawals globally and for over 90% in the majority of least developed countries.[55] Without improved efficiency, agricultural water consumption is expected to increase by about 20% globally by 2050.[56] Today, approximately 38% of irrigated areas depend on groundwater worldwide which contributed to a ten-fold increase of groundwater abstraction for agricultural irrigation over the last 50 years.[57] Additionally the increase in water demand from the ensuing rise in manufacturing, electricity and domestic use will generate further stress on water resources and could impact water allocation for agriculture irrigation.[58]

Economic growth in developing countries is especially important because food consumption and feed use are particularly responsive to income growth in those countries, with predicted transitions from traditional staple foods to increasingly diversified diets.[59] Large numbers of once-poor consumers are spending higher incomes on more varied and higher value foods,[60] including more expensive animal proteins. Urbanization and modern food retailers will continue to expand over the next 20 years exposing these same consumers to new types of food, and improved infrastructure as retail chains increase food options to more consumers.[61] Taken together, these factors continue to stimulate world demand for grains, oilseeds, and livestock products.[62] By leveraging advanced technology, adopting plant based innovations and long-term farming adaptation practices, contending with human capital shortages, and continuing to have access to international markets without radical changes in trade policies, US agribusiness is well-positioned to maintain its preeminent agribusiness position to meet the increased global demand.

Numerous political and social factors will continue to impact the industry's health, both in the short and long term. Food safety issues, economic and social inequities, and food price volatility are seen as persistent disrupters of global food systems and global food security.[63] Outbreaks of civil unrest and violent conflict have deprived millions of reliable access to food and challenged physical security and social cohesion.[64] Adopting the goal of increased resilience in agriculture and food systems is a clear next step for food security efforts.[65]

Challenges

The agribusiness industry is facing several near- and long-term challenges. While many agriculture issues are local or regional in nature, labor shortfalls, water scarcity, the impacts of climate change, and food security, are challenges not only for the U.S., but also the world writ large. This section will primarily detail the elements of those challenges as they relate to U.S. national security.

Food Security

Food security is 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."[66] A comparable definition is "access by all people at all times to enough food for an active, healthy life."[67] In essence, it is availability (ample supply), access (economic and physical), and utilization (nutritional value). The lack of food security remains a challenge as the world's population is projected to increase to 9.7 billion by the year 2050. As a result, the global demand for food is projected to increase 33% concurrently. While globalization has significantly increased the world's GDP over the last 30 years, today approximately 800 million

people have not achieved food security. Of the 800 million people, approximately 15 million are in the United States.[68]

Of the several issues associated with achieving food security, poverty and distribution are significant factors. Currently, global food production exceeds population requirements yet food is not distributed evenly for various political and logistical reasons. However, even if food was distributed evenly, as we approach 2050, increased production will require an increase in arable land coupled with innovation and technological advances. The world's arable land is not proportionate with its population. For example, Asia, and the Middle East/North Africa have larger populations with less arable land. Unfortunately, increasing the amount of arable land would mainly result through increased deforestation.[69] The last major factor effecting food security is the economically driven practice of growing more commodity crops (corn, wheat, soy) instead of more nutritious food. The increase in demand for corn and soy for biofuels may disincentivize growers from producing more nutritious food which in turn could further decrease the amount of land used for food production.[70] Finally, climate change, labor, and water scarcity are also major challenges that are interrelated and greatly impact food security.

Labor

According to the Farm Labor Survey conducted by the USDA National Agricultural Statistics Service (NASS), an average of 1.1 million hired farmworkers are employed on U.S. farms, many of which are in the fruit and vegetable sector.[71] The USDA Economic Research Service (ERS) estimates that approximately 50% of all hired farmworkers, and over 61% of those hired in the fruit and vegetable sector, are not legally authorized to work in the United States.[72] This dependence on both authorized and unauthorized immigrant labor makes the agriculture industry particularly vulnerable to the uncertainties that continue to surround U.S. immigration policy. Furthermore, the H-2A Temporary Agricultural Worker Program, as currently executed, does not provide the efficiency nor the flexibility to mitigate US labor shortfalls through the employment of foreign workers. The agriculture labor shortfalls in the US has the potential to increase food prices, negatively impact the GDP, and further complicate immigration policy.

Despite the national debate concerning the impacts of immigrant labor on U.S. jobs, anecdotal evidence offered by growers around the country suggests that many Americans are simply not willing to perform arduous farm labor, despite wages that are often well above state and federal minimums. The grueling nature of many jobs in agriculture, particularly the hand-labor intensive fruits and vegetables sector, is driving potential employees to other less-demanding sectors and industries (such as construction, landscaping, and hospitality). The uncertainty of the labor force is driving the industry to explore the viability of automation in virtually every aspect of planting, harvesting, and packaging, even for the most fragile fruit and vegetable crops. However certain jobs, particularly within the livestock sector, simply demand human labor; cannot be automated; and are unfortunately but intentionally excluded from the H2A program.

Water Scarcity

Global agriculture accounts for approximately 70% of the world's annual fresh water use.[73] Competition for water resources in much of the world continues to grow as a result of increasing populations, urbanization, agriculture requirements, environmental considerations, and the impacts of climate change. In many regions, utilization rates are significantly outpacing steady-

state water availability. Consequently, several aquifers around the world, from the Upper Ganges Basin area of India to southern Spain and Italy to the central and western regions of the United States, could be depleted in the next 40-50 years as a result of ground water pumping.[74] The impacts of depleted aquifers will be catastrophic for more than just the agriculture industry. Many consider the competition for water between India and Pakistan, for example, to be a potential catalyst for expanded conflict while its scarcity and high value may make it a target of agroterrorism. Within the U.S., the expectation of geographically isolated droughts and floods, limited ground water availability, and confusing legislation are driving investments in efficient irrigation systems, drought and flood tolerant crop technologies, and support for advocacy groups.

Climate Change

Climate change is defined as a long-term change in the earth's climate, especially with regard to persistent changes in the average atmospheric temperature.[75] While some purport that climate change is anthropogenic, others believe it is part of the earth's natural cycle, and yet others believe that climate change is a combination of both anthropogenic and natural causation. Despite these disagreements, there is generally universal acceptance that climate change is indeed occurring and action must be taken to ensure food security. The frequency of extreme weather events associated with the dynamic climate has steadily increased from the 1950s until the 1980s where the number of disasters per year averaged around over 150, peaking at around 200. In the 1990s, the number of events ranged from 250 to 350 per year and since 2000, over 350.[76] In addition to the hundreds of thousands of lives lost, the cost to the global economy also continued to grow in proportion to the frequency of these events. In 2012, damage to infrastructure, housing, facilities, crops, and loss of revenue was almost $400 million.[77]

The impact of increasing temperatures and weather extremes on agriculture cannot be understated. "The frequency of rainfall events greater than 2 inches is increasing, leading to longer dry periods between rain events. Crop yields are likely affected by these changes to some extent already…"[78] Temperature increases have a dual effect as cooler parts of the country are predicted to become more viable for food and feed crops currently found in warmer climates while the farm lands in the southern, warmer regions will eventually yield fewer crops as a result of heat stress, severe weather and an expected increase in crop pests and disease.

Government Goals and Role

"Proper" Goals and Role of the Government

To understand the goals and role of the government relative to the agribusiness industry, it is important to ask which ideological position is needed as a foundation for argument. On the political far right, Libertarians and possibly some Traditional Conservatives might argue the industry has no connection to national security, and thus the only governments involved should be state or local governments. On the far left, Socialists, Communists, and possibly some Progressives might argue agriculture business should be all or partially federal government owned and that the protection of agricultural industry revenue is a national security issue. In addition, there are middle ground ideological positions, which include Neo-Conservatives, Fiscal Conservatives, Social Conservatives, and Liberals.

The dominant ideologies in a given political environment discern if industries such as agriculture are directly connected to national security. Those same ideologies define the role of the federal government. Given the current political environment, this seminar recommends policy alternatives based on the acceptance of agribusiness' connection to national security. The seminar believes politically feasible policy alternatives in today's environment are characterized by a federal government decidedly engaged in growing the GDP, demonstrating a philosophy of Economic Liberalism, and conducting federal level leadership with respect to trade while also maintaining membership in the World Trade Organization.

What policy issues are involved?

The intent of this Agribusiness Seminar is to recommend politically feasible policy alternatives. Recommendations may not reflect individual student personal ideologies as the interest is to recommend legislation with the greatest potential to pass Congress. Given the current political environment; this seminar recommends alternatives targeting Social Conservatives in the middle, and limiting their appeal beyond Traditional Conservatives on the right and very few Progressives on the left. In addition to recommending persistent attention be placed on the possibility of exogenous events, the following policy topics are not only also recommended but considered politically feasible as well:

1. Labor Reform: Garner efficiencies via a thorough review of the H2A program administered by DHS, and re-invest those efficiencies in such a way as to produce a less cumbersome more productive program. Measures of effective reform should demonstrate cost savings for farmers.
2. Research investment: Identify the most promising seed technologies to improve food security, increase nutrition, and increase trade opportunities.
3. Empower State Infrastructure Investment Programs: Efforts to improve infrastructure should first consider local and state-level efforts to those shovel-ready projects synchronized well with federal infrastructure improvement priorities. Those States which prioritize in conjunction with federal infrastructure priorities should be considered for receipt of additional science and technology educational funds.

Black Swans: Water Scarcity, Cyber Attacks, and Agroterrorism

Introduction

Water and food are essential for life sustaining systems including the entire agribusiness value chain. It seems water only gains public attention during droughts, when issues emerge across social media,[79] or when addressed by Congress or the United Nations. Additionally, food chain safety only becomes a public concern when a problem is discovered. Norm Groot, executive director of the Monterey County Farm Bureau said it best, "While [terrorism] is not a high priority – water [shortage] has eclipsed everything else – there is a constant concern about contamination of well heads. There are so many possible points where someone could insert something into the food chain. It's not a very difficult thing to do."[80] This essay highlights the links and impacts of

water scarcity, cyber-attacks, and agroterrorism threatening the agribusiness industry and how the United States (U.S.) can leverage advancements in innovative cyber security solutions to improve the security of associated systems essential to the agribusiness value chain, ensuring safe, reliable, and assured food production to maintain our national security.

Global Realities

Global demand for food is increasing as both populations and prosperity grows. Demands from developing countries for agricultural products are forecasted to increase at an average rate of 2% until 2030.[81] Global food demand is also affected by a shift in diets, which is occurring in developing countries as a result of increased prosperity, urbanization, and changing food preferences. Compounding this issue is that the same populations are also consuming more livestock, fruit, and vegetables, compared to fewer grains than in the past. Specifically, meat consumption in developing countries is projected to increase by 44% per capita by 2030.[82]

Food production and agriculture are the largest consumers of water, requiring 100 times more than personal needs.[83] Up to 70% of water obtained from rivers and groundwater goes into irrigation, about 10% is used in domestic applications and 20% for industry.[84] Further, irrigated agriculture, which accounts for the largest share of the U.S. consumptive water use,[85] makes a significant contribution to the value of U.S. agricultural production. In 2013, USDA reported that irrigated agriculture applied 91.2 million acre-feet[86] of water nationally, with over four-fifths occurring in the West.[87] As such, agriculture accounts for approximately 80-90% of U.S. consumptive water use.[88] The latest global average figures from the Water Footprint Network[89] state the amount of water required to produce one pound of: beef[90] is 1,800 gallons; lamb is 1,250 gallons; pork is 576 gallons; and chicken is 468 gallons of water.[91] As population and prosperity grow around the world, the amount of water available to produce food remains the same.

Water scarcity emerges from a combination of hydrological variability and high human use impacting all facets of agribusiness. While the risks of monthly water shortages are most severe in South Asia and Northern China, some significant risks of seasonal water scarcity appear on all continents.[92] Between 2011 and 2050, the world population is expected to increase from 7.0 billion to 9.7 billion[93] and food demand will rise by 60% in the same period.[94] Furthermore, it is projected that populations living in urban areas will almost double, from 3.6 billion in 2011 to 6.3 billion in 2050. The OECD's 2012 Global Environmental Outlook's Baseline Scenario[95] projects increasing strains on freshwater availability through 2050, with an additional 2.3 billion people expected to be living in areas with severe water stress.[96] As an example, a strategic concern facing the U.S. is the ongoing border disputes between China and India. These neighbors have growing strategic interests driving border disputes with military and diplomatic implications. However, China is also faced with water scarcity issues with huge population and sustained industrial growth required for a Peaceful Rise.[97] Accelerating urbanization and the exponentially growing middle-class demand for better food exacerbates water scarcity. The absence of formal water sharing mechanisms between China and India with the backdrop of rising nationalistic sentiments and socioeconomic divisions could escalate into extreme instability and even nuclear war as access to water directly impinges survival.

Challenges

As terrorists or adversaries' cyber capabilities are advancing, more and more malicious attacks are being detected at critical water infrastructure facilities, according to 2011-13 data collected by the Repository for Industrial Security Incidents (RISI), an organization devoted to tracking cyber-crime. RISI indicates cyber incidents experienced by the water and wastewater industry have increased by 60%.[98] While none were catastrophic, a recently completed Department of Defense-Defense Science Board Task Force on Cyber Deterrence stated, "the cyber threat to U.S. critical infrastructure is outpacing efforts to reduce vulnerabilities, so that for the next decade at least the U.S. must lean significantly on deterrence to address the cyber threat posed by the most capable U.S. adversaries.[99] As such, public interest in cyber defense and protection has grown due to increasing cyber-attacks and costly cyber intrusions. However, it is essential to understand cyber-attacks on the U.S. to date are not from "high end" threats that could be conducted by U.S. adversaries today; let alone the much more daunting threats of cyber-attacks the U.S. will face in coming years as adversary capabilities continue to grow rapidly.[100]

The latest infrastructure cyber vulnerabilities are in Supervisory Control and Data Acquisition (SCADA) networks as well as Industrial Control Systems (ICS). This is a national challenge because these systems are used to control infrastructure processes (water treatment, wastewater treatment, water distribution), facility-based processes, or industrial processes (power generation at a dam).[101] SCADA networks regulate centralized systems that control and monitor entire sites, or complex systems spread out over large areas. Since the networked SCADA systems and their protocols can now be accessed via the Internet, it makes them attractive for cyber-attacks and terrorism. Destruction of SCADA systems would have incalculable consequences therefore cyber security is not a nicety, but a necessity. Currently, the major threat can be categorized into two groups. The first includes unauthorized access to software, be it human access or intentionally induced changes, virus infections, or other problems affecting the control host machine.[102] The second involves the rising threat of Wi-Fi infiltration to networks hosting SCADA devices.[103] The reality is SCADA systems were not designed with imbedded security, despite being effective and efficient. Regrettably, as cyber threats increase, these devices are not equipped to support typical security features that most computing systems require and cannot support network monitoring to intercept or preempt malicious activities.

Agroterrorism is a term used to describe malicious criminal attacks against crops or mankind using viral, bacterial, fungal, or insect-borne agents.[104] Agroterrorism includes animal attacks using infectious pathogens like anthrax, viral avian influenza, foot and mouth disease, and other viruses. A recent National Institute of Justice research study concluded agro-terrorists would fall into the following four categories: international terrorists; economic opportunists; domestic terrorists (including unbalanced individuals and disgruntled employees); and militant animal rights groups. Malicious actions would escalate fear and uncertainty in our food security while economic losses would likely skyrocket given agroterrorism's reach to vast populations.

Additionally, biological warfare has been around for centuries and could be employed by terror groups, lone wolves, interest groups, political, and religious groups to create large-scale panic, death, and destruction. An advantageous target is the Harris Ranch in California, one of the largest beef feedlots in the U.S. The feedlot covers 800 acres and has the capacity to produce

250,000 head of cattle per year. The introduction of a biological pathogen at this location would have rippling effects across the agribusiness bottom-line and degrade food safety trust. Animal production losses would total $130 million dollars in addition to the exponential supply chain losses, the cost of animal destruction, and the overall environmental impact. This ripple effect would likely halt U.S. beef production and impact trade similar to the mad cow outbreak in 2003.

Recommendations

The U.S. government must make a concerted effort to ensure farmers are trained in biosecurity and mandate every head of cattle or crop be tested by USDA or contracted inspectors at entry port facilities before introducing product into the market. Efforts to increase biosecurity are key food security enhancements for the farmer, for the consumer, and will help mitigate the introduction of diseases to livestock and crops as well as minimize losses for farmers. USDA currently contributes less than .02% of their budget to R&D, however they should increase their R&D investment into crop and livestock surveillance efforts to enhance security. Additionally, USDA should allocate more funding to Agriculture Research Services for rapid biosecurity testing research. Recent testing advances have become available, allowing farmers to test livestock on the spot and receive instantaneous results of deadly pathogens presence.

Policy initiatives are needed to improve the cyber security of ICS and SCADA[105] systems controlling water resources that are now inseparable from the Internet. While efficiency and cost are paramount, cyber security expenses must be factored to protect customers, especially those in agribusiness. First, a cross-departmental initiative between Department of Homeland Security and the Environmental Protection Agency to establish an independent Cyber Infrastructure Security Program for top-tier random red teaming and annual certifications on all water facilities (dams, reservoirs, aqueducts). Finally, diplomatically, the U.S. could assist China, India, and Pakistan in completing a water-sharing framework to avoid a nuclear water war in the Asia-Pacific region.

This essay highlighted the links and impacts of water scarcity, cyber attacks, and agroterrorism threatening the agribusiness industry and how the U.S. can leverage advancements in innovative cyber security solutions to improve the security of associated control systems essential to the agribusiness value chain, ensuring safe, reliable, and assured food production to maintain our national security. Agribusiness is intrinsically tied to national security, as our ability to maintain food security and guaranteed food access is essential. Additionally, water scarcity is central to China and India, two key strategic counter-balances in the Pacific as well as the greater region as large parts of their populations are agriculture reliant. There are no guarantees that solutions to these threats won't reveal new vulnerabilities, but with increased investment in R&D and cyber security innovations coupled with improved agroterrorism policies and technology innovations, the groundwork is laid for the next great leap in securing agriculture's water systems, which is critical to establishing resiliency in agribusiness writ large.

Col William Rondeau, Lt Col Derrick Floyd, and Air Commodore Haider Ali Shah

Agriculture Labor Mitigation Strategies

The United States (U.S.) possesses one of the largest, most diverse, and most productive agriculture industries in the world. The economic benefits, and associated food security guaranteed by the U.S. agriculture industry, are significant sources of national power. However, as detailed in the 'challenges' section of this academic product, immediate and projected labor shortages are stressing several sectors across the industry, particularly fruits and vegetables. In order to successfully mitigate the US agriculture industry's labor shortfalls, the government and private sector must collaborate to reform the H-2A Temporary Agricultural Worker Program, as well as invest in labor-saving technologies where possible.

According to the Farm Labor Survey conducted by the National Agricultural Statistics Service, an average of 1.1 million hired farmworkers are employed on U.S. farms.[106] Since the late 2000s, an average of 71 percent of crop workers are foreign born, with 67 percent of those laborers being from Mexico. [107] The United States Department of Agriculture (USDA) Economic Research Service estimates that 50 percent of all hired farmworkers, and over 61 percent of those in the fruits and vegetables sector, are not legally authorized to work in the United States.[108] This dependence on both authorized and unauthorized labor makes the industry vulnerable to the uncertainties that surround US immigration policy and other reform initiatives.

From 2009 to 2014, more Mexicans migrated from the United States to Mexico, than vice versa.[109] The range of reasons reported by numerous sources include an improved Mexican economy, fewer employment opportunities in the U.S., increased U.S. border security, and uncertainty over U.S. immigration policy, among others.[110] Given the disproportionate percentage of Mexican nationals who make up the industry's labor force, this migration trend is directly impacting the production capacity of farmers in all sectors. Additionally, the grueling nature of many of the hand-labor jobs in the agriculture industry is driving potential employees to other industries such as hospitality, construction, and landscaping - even when the pay for agriculture work is more. Higher wages, bonuses, better living arrangements, improved tools, and ergonomic improvements such as elevated plant beds are some of the ways in which growers are attempting to attract quality labor. But these efforts are doubtful to mitigate long-term shortages.

The majority of planting, harvesting, and packaging of certain crops, particularly in the fruits and vegetables sector, still require the skilled hand, trained eye, and physical judgement of human laborers. Despite increased automation, an estimated 25 percent of vegetable acreage and up to 45 percent of fruit acreage in the US are dependent on hand-labor harvesting.[111] Given the reluctance of many US citizens to perform such work in the current economy, the primary method for growers to expand its authorized labor force, without major accommodations to attract and retain older workers, is through the H-2A Temporary Agricultural Worker Program.

The H-2A program's bureaucracy, and its resultant impacts on employers, are impediments to the industry. Managed in part by three federal agencies (Department of Labor, Department of State, and the Department of Homeland Security), the H-2A program is viewed by growers as being both costly and inflexible. Despite the industry's labor requirements, on average, fewer than 100,000 agriculture laborers are sourced annually through the H-2A program.[112] Several factors

prove problematic for growers. First, planting and harvest timelines are naturally influenced by weather. Weather variations make it difficult for growers to accurately predict labor requirement timelines to the level of precision demanded by the program. H-2A laborers are frequently early or late to need depending on the season's weather. Secondly, when timelines do change, growers have limited flexibility in repurposing laborers to other tasks, crops, or to other growers who are able to use the labor at that time. Such limitations are rooted in security concerns and worker protections, but adjustments are necessary in order to make H-2A an effective, efficient, and flexible program. Lastly, while the formal H-2A fees charged by the aforementioned agencies are relatively modest, many operations estimate the time costs associated with the process is several thousand dollars per worker each year.

Realizing that H-2A reform is likely to be a protracted effort and substantive reform is not guaranteed, many growers are turning to technology. Brian Antle of the California-based Tanimura & Antle captured the essence of the situation when he said, "We are all losing opportunities to sell quality products because (they are) picked late or we are too short staffed to meet our goals. If we cannot get more people, we must find machines."[113] Not surprisingly, companies throughout several agriculture sectors are actively evaluating various aspects of their production chains (i.e. planting, harvesting, and packaging) to find areas in which automation can decrease labor requirements while simultaneously increasing productivity.

Automation is becoming more ubiquitous in the agriculture industry. Row crop producers are generally familiar with the incorporation of drones, precision irrigation and fertilization, and advanced harvesters in operations. However, in recent years, the industry has also made significant advances in automation and robotics in traditionally hand-labor crops. There are now lettuce planting machines which are 1,250% more efficient than traditional hand-planting[114]; romaine harvesters that are 800% more efficient than hand-labor[115]; and even robotic strawberry pickers under development. But automation comes with its own challenges in technology maturation which make it difficult to harvest particular crops and require large capital investments. These challenges contribute to growers' reluctance to purchase today's innovation when technology is advancing so rapidly. Particularly important to note, the expanded incorporation of advanced agriculture equipment will eventually create higher paying jobs for agriculture machine manufacturers, operators, and repair technicians.

The following three policy recommendations will help mitigate labor shortfalls going forward:

1. Reform H-2A. Adjust the program to allow workers to complete myriad agriculture tasks under the same visa in order to hedge against weather-related timeline deviations and other impacts. The reform should include the ability for workers to move across state lines for multiple production locations as well as allow them to work on multiple crops depending on yields. Finally, the program should be reformed to allow for multi-trip visas to support multiple growing seasons.
2. Expand support for agriculture education and development programs at the local and state levels, such as 4-H and Future Farmers of America, to ensure US agriculture's future.
3. Increase government investment in research and development (R&D) of advanced agriculture technologies by increasing funding for USDA's Small Business Innovation Research program, and by issuing targeted grants to land grant universities. Provide tax incentives for private entities to invest in automation R&D and procurement. Both of these

approaches will reduce the industry's long-term dependence on labor while increasing its resilience and sustainability.

American agriculture has achieved unprecedented levels of productivity in recent years. The food security and economic benefits provided by the industry are clearly sources of national strength. In order to retain these advantages, the United States must ensure sufficient labor availability through such measures H-2A visa reform, and make necessary investments in the research and development of advanced agriculture automation technologies.

LtCol Chuck Dudik and Ms. Rita C. Dixon

Climate Change – Balancing Mitigation with Adaptation

Climate poses the largest risk to agribusiness. Although the debate continues whether climate change should be blamed on anthropogenic or natural causation, the fact that food security is dependent on climate necessitates action to decrease its negative effects on global food security and our domestic economy, yet, "there is no single global recommended formula for climate change adaptation."[116] While empirical evidence demonstrates that sea and ocean temperatures are climbing, massive glaciers are separating and surface temperatures are rising, the science of the data has given way to political posturing.[117] Rather than continue to debate the causation of what is universally accepted as inevitable climate change, the U.S. government should develop a bipartisan and flexible strategic plan that balances the mitigation strategies of sustainability introduced by the previous administration with new emphasis on adaptive planning in order to ensure the agribusiness industry's viability in the emergent climate.

A clear understanding and bipartisan acceptance of what the future geography of domestic agribusiness will look like is key to developing a sound strategy. The federal government must develop a single predictive model that depicts the emerging agricultural centers as we transition towards a new climate. This model will assist both the government and businesses in making key strategic and enduring decisions for maintaining a viable industry. In considering the predictive model, the government should focus on developing an infrastructure to meet the needs of the new environment and in looking to where the new breadbasket may shift to ensure a proactive network is well established to incentivize early investment and appropriate planning by agribusiness stakeholders and shareholders.

A bipartisan strategy with a sound adaptation framework should provide the basis for budget decisions while at the same time provide farmers, investors, and consumers a sense of stability and a roadmap for success. This structure will facilitate agribusiness' ability to achieve resilience and adapt to the changing climate with minimal negative effect on commerce and global food security.[118] President Obama's administration developed a climate change strategy that was largely focused on mitigation and the belief that anthropogenic behavior was contributing to climatic effects. The "Climate Action Plan" focused on actions to reduce carbon pollution, increase energy efficiency, (and) expand renewable and other low-carbon energy sources…" but

also included an adaptive call to "strengthen resilience to extreme weather and other climate impacts."[119] By removing the debate of anthropogenic versus natural causation, President Trump's administration has an opportunity to leverage the mitigation efforts with adaption.

Agribusiness can adapt if properly enabled and incentivized through well-informed government policies and industry planning. The previous administration provided USDA with the funding and mandate to develop and educate farmers on the economic benefits of sustainable farming.[120] Globally, farmers have reported that by altering their operational models for emphasis on sustainability they have benefitted from increased production, lower costs and higher profit margins after initial capital investments. An added side-effect was the diversification of farms in the biofuels market which also contributes to farmers' fiscal health. These benefits will continue to contribute to the industry's well-being through the long term, but alone, are not enough to ensure viability in the far future based on predictive models that depict significant shifts in the geography of the global breadbasket. Just as the previous administration incentivized farmers to make mitigative business decisions, providing them with the information and tools necessary to also develop adaptive business plans will preserve the industry's health. A robust bipartisan predictive model depicting the landscape of our country's future breadbasket against the backdrop of the current geography should be the foundation for both government and industry adaptive plans. This will minimize the ill-effects of the predicted environment.

"America's breadbasket isn't where it used to be. The epicenter of agricultural production has moved north and west over the past half-century, and that trend will likely continue at an accelerated pace due to global warming…"[121] Although our national infrastructure reflects the flow of goods and communities from the 1930's,[122] current scientific predictions show the U.S. breadbasket shifting northward into Canada and the climate in Illinois reflecting what is today typically found in East Texas.[123] With bipartisan acceptance of a national model for agriculture, both federal and state policymakers will be better able to make informed, enduring decisions that will not only alleviate stress on agribusiness but also develop opportunities and incentives to take advantage of the changing climate. "Farmers in heavily affected regions may reallocate their land to other purposes, while farmers in less-affected regions may intensify planting."[124] Globally, "smallholders are particularly at risk from climate change impacts. The implementation of appropriate climate change strategies that take smallholder needs into consideration can improve their livelihoods by increasing productivity and resilience to climate impacts." [125] Or, if the costs associated with adapting prove to be too costly, the U.S. may witness the final end of small farm participation in our economy but a formidable expansion of larger farms and co-ops.

The U.S. Government's strategic investments in infrastructure can lay the groundwork for the geographically shifting agribusiness while promoting more adaptive business models by key growers. Today's agribusiness relies primarily on road, followed by rail, then water. "America's rural transportation system provides the first and last link in the supply chain from farm to market."[126] As the crops move further from the Mississippi River, there will be added strain and reliance on an already aged road network and overburdened rail system.[127] This means added costs and diminished profits for growers.[128] By informing infrastructure investments with predictive models, the administration can set the foundation for agribusiness' successful migration toward more fertile and climate-friendly regions while helping to manage costs from farm to consumer. Understanding that existing rails may need to be augmented to satisfy the new geography and

roads and bridges fortified to withstand the increased weight of grain and corn, state and federal investments can be more aptly applied.

As our nation pivots from mitigation policies meant to slow or reverse the adverse effects of climate change, we have an opportunity to transition toward adaptation planning and marry the two approaches into a more comprehensive strategy. A culture of adaptation in agribusiness can help secure our ability to live in harmony with the negative effects of climate change and turn those effects into new opportunities. The government should develop a geographic focused predictive model to inform budget decisions in infrastructure and business investments so that the agribusiness supply chain can be preconditioned for success.

COL Patricia K. Wright, COL Steven Yamashita, and Ms. Linda Otero

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Food Security: Assuring Production and Nutrition in a Changing Climate

Although food security is often taken for granted by much of the US population; we may be at increased risk of food insecurity in the future. According to the USDA, climate change has the potential to significantly increase and exacerbate food insecurity worldwide affecting all dimensions of food security and nutrition.[129] Water is essential for food security, and remains the largest threat to both crop quality and crop yields. Climatic conditions affect food production, processing, access, utilization, and nutrition. The dynamic nature of climatic events has increased the risks of floods and drought in unpredictable patterns on arable land which threatens global food security. To be successful at addressing these risks, the US must invest dollars in the most promising seed technologies to address the adverse effects of climate change, and to safeguard the health and wellbeing of our population.

Recommendations:

The USDA's 2017 Agricultural Research Service (ARS) budget funds 700 research projects at over 90 laboratories, however it's unclear how many of these research projects are focused on plant breeding innovation (PBI) technology.[130] During the semester, three organizations [Syngenta, Driscolls, and the Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT)], mentioned this technology as the future of seed technology. PBI focuses on changing the traits of plant varieties of the same species in order to enhance desired characteristics or reduce them.[131] USDA should assess to what extent this technology is being researched, and determine if its researchers and laboratories can improve seed varieties to address the threats to the industry. This is important because the threats of droughts, floods, pests, and diseases provide the impetus to invest in seed technology to counter the specter of crop loss and achieve high yielding crops. Effective investments in seed research technology can potentially improve food security, increase nutrition, support sustainable agriculture, and increase our GDP.

Two technological approaches pursued to date to improve seed performance include hybrid technology and genetically modified organisms (GMO).[132] When USDA's research

budget was reduced in the 1980s, corporations like Monsanto filled the void by conducting private research on GMOs. This corporate investment contributed to consumers' distrust even though several agencies like the American Medical Association and the Food and Drug Administration have concluded that genetically modified foods are safe to eat.[133] During the seminar's domestic and international visits several companies expressed their customers' reluctance to purchase GMO products as well[134]. In addition to this concern, the use of GMOs has prevented a more positive trade balance with the European Union.

Based on this information, USDA should continue its research on hybrid breeding technology, and assess if PBI investments can improve food security and nutrition in the near term. The goal of the PBI technology is to maximize the plants positive genetic traits to support higher production and cultivation while reducing vulnerabilities to pests, diseases, and drought. Using the PBI technology, seeds can be naturally adapted to meet the challenges posed by climate change and other threats. Focusing on plant breeding innovations and on hybrid breeding will improve the nutritional value of the U.S. food supply as well. In 2015, 42.2 million Americans lived in food insecure households, including 29.1 million adults and 13.1 million children. [135] These numbers will likely worsen as the US focuses on feeding an estimated nine billion people by 2050. Current success in achieving higher nutritional quality yields while simultaneously reducing environmental impacts of conventional farming will continue to rely on biotechnology and innovation. At the same time, food security in the future will undoubtedly rely on greater production efficiencies and methods that do not rely on GMO technology. One of the surest ways to decrease hunger rates is to increase access to the most nutritious food produced.

There are economic and environmental benefits associated with plant breeding innovation. The European Union, which is one of our largest agricultural trading partners, have been working with PBI since before 2000, and have seen considerable economic and environmental benefits, according to a study published by the European Seed Association in 2016. Within the EU, plant breeding contributes to approximately 74% of total productivity of major crops cultivated with an increase of 1.24% per year in yields. Plant breeding has increased the agricultural supply level of grains by 47 million tons and oilseeds by 7 million tons. Since 2000, the generic crop improvement has added 14 billion Euros to the EU's GDP, and contributed to the avoidance of approximately 3.4 billion tons of CO2 emissions and used an estimated 55 million cubic meters less water in Europe over the last 15 years.[136] Therefore since the EU has embraced PBI versus GMOs this would be a great opportunity for the US to invest in this technology. It will increase yields, feed more people, increase the U.S. commitment to fighting climate change, and improve the economic prosperity of the nation's agricultural sector and the nation through increased exports.

Additionally, future PBI research should be performed by scientists that work for the USDA, and by various land grant Universities in the United States when possible to ensure that the U.S. Government owns the intellectual property. When this is difficult due to budgetary constraints, public/private partnerships should be pursued with corporations. Both approaches will ensure that the U.S. Government retains an ownership interest in the technology. If the PBI technology is developed using taxpayer dollars, the U.S. government can share the technology to our allies, partners, and fragile states who are facing the climate change threat. This would aid their agriculture industry and reinforce strong relationships. For example, in 2012, 77% of

Mexico's water usage was consumed by the agriculture sector.[137] This high percentage demonstrates agricultures high dependence on water, and the threat that drought poses to the agriculture industry. Overall, by sharing our technology, we are using employing it as an instrument of peace to improve food security on a worldwide scale.

Mr. *Donald W. Baker, Jr., COL Patricia K. Wright, and COL Stephen Kavanaugh*

Conclusion

The U.S. agribusiness industry provides our nation with both food security and food sovereignty while contributing to our national GDP. In order to maintain the health and strength of this vital industry, the U.S. government must make key strategic policy decisions today so that the effects of a booming global population and climate change will not threaten our economy or sustenance. As nations experience food insecurity and water shortages, the likelihood of civil unrest increases, potentially affecting our own vital interests. The U.S. must be capable of effectively predicting, mitigating and adapting to the changing climate while ensuring the sector has access to ample and healthy labor.

In developing near-term strategies to maintain our agricultural independence, the U.S. should focus on improving the quantity and quality of yields through technology and labor while preparing for exacerbated global water scarcity. Additionally, before climate change wreaks disastrous and irreversible effects on the industry, strategies should be put in place to not just mitigate the volatile and dynamic climate but also assist the country in adapting to those changes. Bipartisan acceptance of predictive models should aid in the decision-making process and provide a foundation for enduring investments in R&D and infrastructure planning.

Attention also needs to be placed on exogenous events that can disrupt or cripple the agriculture industry. Agroterrorism, international conflicts arising from water scarcity, and cyber-attacks against our enabling infrastructure should be considered in developing budgets and policies. Stakeholders ranging from federal and state governments to private entities and civic groups must overcome the risks of stove-piping, intransigence, and complacency in order to maintain a well-coordinated and focused approach to the essential Agribusiness Industry, one of the DHS's sixteen critical infrastructure sectors.

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