Vice President's Conversation on the Future

Trend Research: Food Production, Safety, and Security

Descriptor Definition

The food and agriculture production supply chain is the largest industry in Ohio (LaFayette, 2013). At the same time, Ohio also ranks in the top 8 states in the US for household food insecurity (Coleman-Jensen, Gregory, & Singh, 2014). This descriptor paper focuses on trends related to the very complex and interconnected system of agriculture production, food handling and food access to meet changing patterns of consumer demand; ensuring quality, adequacy, affordability and safety of the food supply for a global population; and challenges and dynamics related to agriculture production practices.

Author Insights[1]: Descriptor Relevance

This is an extremely interconnected and complex topic. Food is one of the most fundamental human needs. As our American society has prospered and technology for food production has advanced, fewer people are required to produce the food needed to feed the world. Because of this, nearly 99 percent of the US population is not actively involved in production agriculture.

As world population continues to increase, a crucial mission for American agriculture is to lead the effort to feed the planet. It is often one of the main arguments for job security in encouraging young people to investigate careers related to agriculture. However, even in this present age when food production is adequate to feed the world population, there are segments of even Ohio's population that are considered to have very low food security. This global food system also presents challenges in traceability and safety as food travels from the field through the processing system to ultimately reach the consumer.

During this same time of global focus, a growing number of people in the US and Ohio are spending their time and money to understand where their food comes from and to support the local producers within the local foods movement. There is not just one picture of agriculture in the world or our country or within the state of Ohio. This paper strives to uncover some of the recent trends that may help us to think toward possible future scenarios and possibilities for this massive system of food production, safety and security.

Trend Information and Interpretation

Trends in Food Production: *Economic Impact*

Ohio's food and agriculture sector, in its larger context including the food processing industry, accounts for nearly 14 percent of the state's employment. Of the approximately 120,000 people employed by the agricultural sector, about 59,000 employees are in high-wage jobs. (Ohio Center of Excellence, 2009)

In 2012, a study using 2010 data found that the total food and agricultural cluster contributed 11.7 percent, or $105 billion, of Ohio's total economic output of $898.8 billion. The cluster includes the entire food and agricultural production and supply chain of production agriculture, agribusiness, forestry, processing, food service and wholesale/retail outlets. The agricultural cluster share of the gross domestic product of $477.7 billion was $51 billion, or almost 11 percent (LaFayette, 2013).

US and Ohio Agriculture Demographic Information

The United States Department of Agriculture (USDA) National Agricultural Statistics Service (NASS) conducts a US Census of Agriculture every 5 year to collect a wide range of data from those involved in production agriculture throughout the US. According to the most recent US Census of Agriculture (2014), there has been a flux in the number of farms in Ohio since 1992. Up until 2002, the number of farms had been steadily decreasing for decades (see Table 1). The definition of a farm for this census is "any place from which $1,000 of agricultural products were produced and sold, or normally would have been sold, during the Census year."

Agriculture Census Year	Number of Ohio Farms	Number of US Farms
1992	70,711	2.18 million
1997	68,591	2.22 million
2002	77,797	2.13 million
2007	75,861	2.20 million
2012	75,462	2.11 million

Table 1. Number of farms in Ohio and in the United States according to USDA Agriculture Census taken every five years from 1992-2012

Another factor to consider is how much of Ohio's land is being used for agriculture (see Table 2). Over the past 20 years the number of acres used for production agriculture has decreased by a total of 287,365 acres or 2 percent.

Agriculture Census Year	Acres of Ohio Farms
1992	14,247,969
1997	14,103,085
2002	14,583,435
2007	13,956,563
2012	13,960,604

Table 2. Number of acres of Ohio farms according to USDA Agriculture Census taken every five years from 1992-2012

Age continues to be one of the most notable demographic changes for the US farmer. In the US the average age of principal operators continues to increase every year. In 1992 the average age of the principal farmer was 53.3 years old. It increased each census year to 58.3 years old in 2012. In Ohio the average age in 2012 was slightly lower at 56.8 years old. Nationwide the number of beginning farmers – on their current operation less than 10 years – was down 20 percent from 2007 (USDA NASS, 2014).

Bifurcation of Agriculture

In 2012, US farms sold almost $395 billion in agricultural products. This was 33 percent more than agricultural sales in 2007 driven in large part by increased commodity pricing for corn and soybeans. The average sales per farm for the US were $187,000 in 2012. Averages only give part of the picture.

When analyzing the agricultural sales from operations, 4 percent of the operations sold $1 million or more. 75 percent of operations sold less than $50,000 per farm (USDA NASS, 2014).

In Ohio in 2012, the market value of agricultural products sold was over $10 billion, which was a 42 percent increase over 2007. The average sales per Ohio farm were $133,366. The average net cash farm income was $39,714 per farm. Just 6 percent of farms sold over $500,000 per operation and 72 percent of farms sold less than $50,000 per operation (USDA NASS, 2014).

The size of farms has also begun to further diverge. The average size of the Ohio farm has changed little over the past 20 years. In fact, the average number of acres is fewer now than 20 years ago (see Table 3).

Agriculture Census Year	Average Size of Ohio Farm (acres)
1992	201
1997	206
2002	187
2007	184
2012	185

Table 3. Number of acres of Ohio farms according to USDA Agriculture Census taken every five years from 1992-2012

In the US, about 55 percent of the total farmland is made up of farms that are 2,000 acres or more. This accounts for only 4 percent of the farms in the US. On the other extreme are farms less than 180 acres which make up only 9 percent of the total farmland, but account for 58 percent of US farms. Obviously some of this will vary simply because of geography as even median farm sizes in the western US will be much larger than those in New England for instance (USDA NASS, 2014).
In Ohio, only 17 percent of the farmland is made up of farms that are 2,000 acres or more, but this accounts for just 1 percent of Ohio's farms. In comparison the farms that are fewer than 180 acres in size make up 48 percent of the farmland and 91 percent of Ohio's farms (USDA NASS, 2014).

According to a 2008 Census by the USDA NASS, there were 14,540 organic farms in the US. Ohio had a total of 547 certified organic farms or operations that were exempted from certification. These census numbers do not include those farms that were not USDA certified or exempt, even if they might be following USDA's National Organic Program standards (USDA NASS, 2010).

Technology

Two of the most noteworthy trends in production agriculture in recent years include genetically engineered crops (often referred to as GMO – genetically modified organisms) and use of precision agriculture.

Martin-Retortillo and Pinilla (as cited in Kaloxylos, 2012) concluded that agricultural productivity per worker increased three fold between 1970 and the 2000s due to chemical fertilizers, biological innovations, harvesting and threshing machines and other mechanical technology. Before this time agricultural production doubled from 1870 to the 1920s per land area due to commercialization and more labor intensive production. The production increase from 1920-1970 increased by about 180 percent even though total inputs used in agriculture only increased by 20 percent (Kaloxylos, 2012).

According to the USDA Economic Research Service (2014) adoption of genetically engineered crops has steadily increased since they were first commercially available in 1996 (see Figure 1). The three main crops in the US that are genetically engineered are corn, soybeans and cotton. Two primary types of genetically engineered crops include those that are herbicide-tolerant and those that are insect-resistant. Most of the herbicide resistant crops have been developed to be glyphosate resistant, allowing glyphosate to be applied to the growing crops and kill weeds without significant damage to the crop. The insect-resistant crops contain a gene from a soil bacterium abbreviated as Bt (Bacillus thuringiensis) which produces a protein that is toxic to specific insects. When a variety of corn or cotton contains multiple traits, this is known as a “stacked” variety, and most varieties planted in the US are now stacked varieties (see Figure 2).

The adoption of genetically engineered crops in the US has been a relatively quick process and at this time makes up the vast majority of crops grown. In 2014 96 percent of cotton was genetically engineered cotton, 94 percent of soybeans were genetically engineered soybeans and 93 percent of corn acreage was genetically engineered corn.

In Ohio in 2014, 86 percent of corn acreage was genetically engineered corn. In 2000 only 9 percent of corn planted in Ohio was genetically engineered corn when nationwide about 25 percent of all corn acres were genetically engineered corn. Compared to the 12 other US states that produce the most corn in the US (states in the Midwest, Great Plains and Great Lakes areas) Ohio has the lowest percentage of genetically engineered corn.

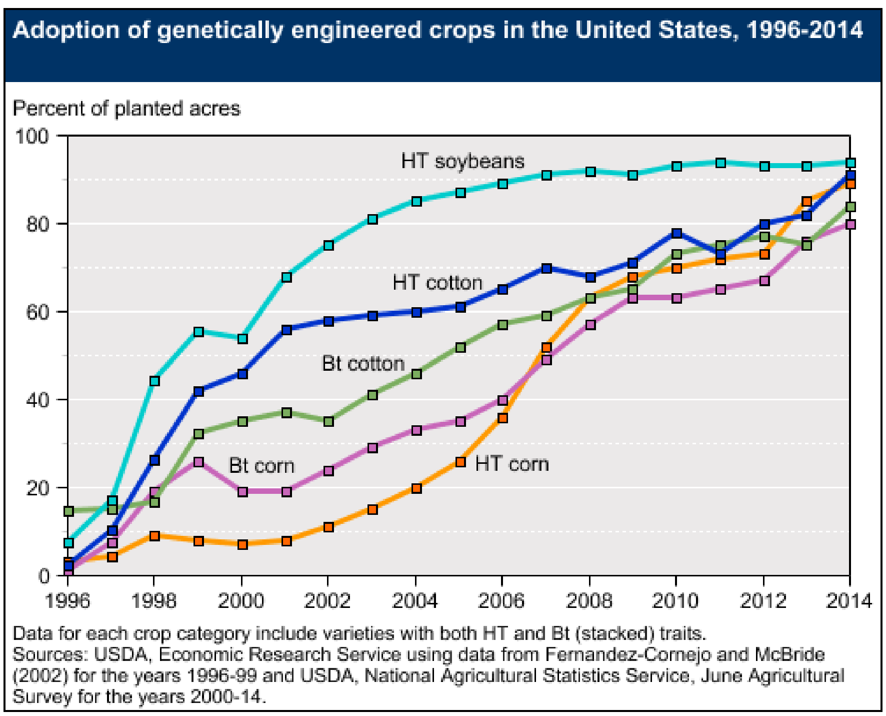


Figure 1

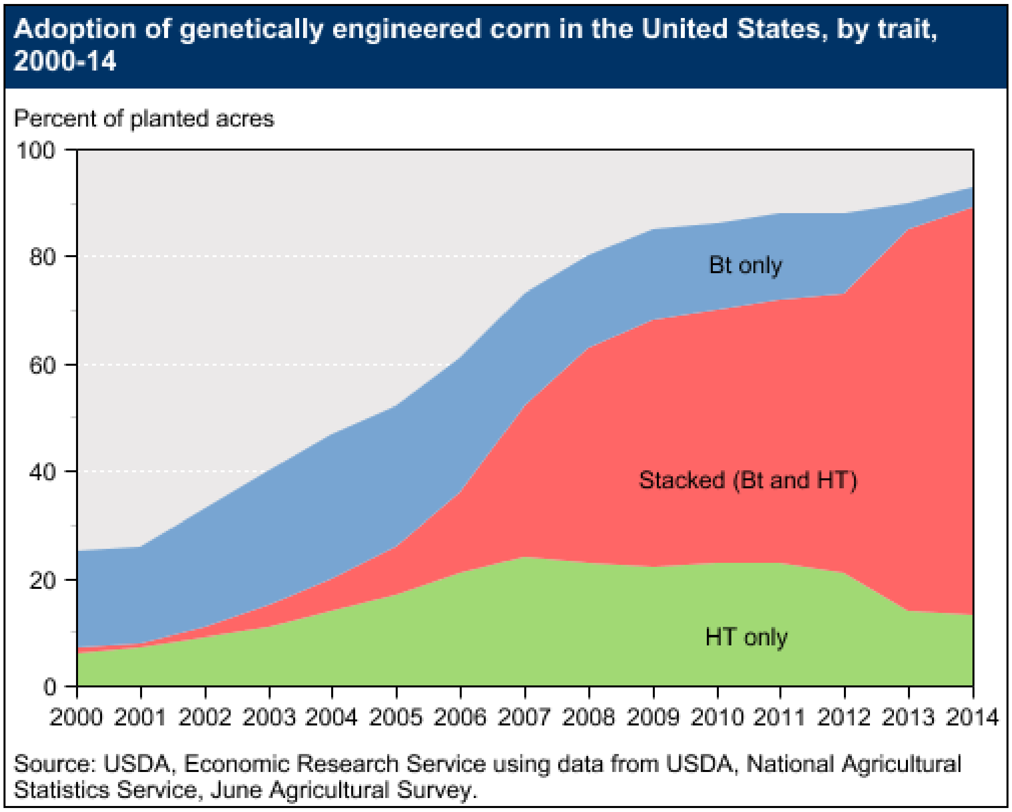


Figure 2.

Another technology that has had a significant effect on production agriculture is precision agriculture. Precision agriculture technologies include yield monitoring harvesters, tractor guidance systems, global positioning system (GPS) soil mapping, and variable rate input application (Ebel & Schimmelpfennig, 2012). The adoption of this collection of information technologies has not been as widely adopted as genetically engineered crops. Both of these new technologies became available to farmers at roughly the same time, with precision agriculture equipment commercially available in the early 1990s (Daberkow and McBride, 2003).

According to Schimmelpfennig & Ebel (2011) there is a three-step approach to the adoption of precision agriculture practices. The first is collecting yield data with a yield monitor followed by soil mapping. The final step is assimilation of this data to use variable-rate technology and adjust seeding rate, fertilizer rate, and pesticide rate to optimize yield and effectiveness.

In the Corn Belt, which includes Ohio, GPS mapping was used on 24 percent of corn in 2005 and 17 percent of soybeans in 2006. Variable-rate technologies were used on 16 percent of corn in 2005 and 12 percent of soybeans in 2006. Yield monitors were used on 40-45 percent of corn and soybeans acres in 2005-2006. Adopters of these technologies had higher yields for both corn and soybeans compared to those not using this technology (Schimmelpfennig & Ebel, 2011).

In addition to these uses of precision agriculture, there are also many applications for livestock management. Examples of this include the radiofrequency identification (RFID) tags used to identify dairy cattle with milking robots and computer-controlled self-feeders. There are several countries that require electronic identification of cattle, swine, sheep and goats to prevent spread of disease and improve food safety. This type of traceability is possible for all types of food in the food system to allow for tracking from the farm through distribution to the retailer and finally consumer (Gebbers & Adamchuk, 2010).

What others are saying about the trends in world food production

An article published in the Philosophical Transactions of the Royal Society in 2010 explored the drivers of the future global food system. They highlighted twenty-three articles written as part of a special project titled “Food security: feeding the world in 2050.” The authors were from a variety of disciplines and were challenged to explore the major drivers affecting the food system between 2010 and 2050.

They found several themes. A common theme in all the research suggests that advances in food production as well as availability can be accomplished with current technologies, especially if research occurs soon to plan for upcoming challenges. If food production must increase to feed a world population that is estimated to reach 9 billion by 2050, then it is important to understand what types of food will be desired by the consumers at that time. It is predicted that Europe’s population will decline, Africa’s will double and China will peak about 2030 and India’s population will exceed China’s starting in 2020. This has a direct impact on agriculture as different cultures eat different types of food. Historically as incomes increase the consumer demand for higher energy foods (meat as well as high fat and high sugar foods) increase as well. Higher energy foods also require more resources (Godfray et al., 2010).

For many years humans could increase land use for agricultural purposes in order to produce more food. However, in the past 50 years very little new land has been brought into production throughout the world. There is major concern from many groups of people over maintaining rather than reducing the biodiversity of the earth. One example of this is deforestation. As more trees are removed, it is predicted that the amount of greenhouse gas emissions will increase. It has been estimated that agriculture contributes about 20 percent of the greenhouse gas emissions as well as a majority of methane and nitrous oxide (Godfray et al., 2010).

As the food system has become a true global system over the last 50 years, food has become less expensive to transport and communications have improved. There is also a correlation between investment in agriculture (research and development, technology and extension) and growth in yields and other productivity measures. Since WWII, food production has kept pace with demand, largely because of scientific and technological innovation. Recently there has been a shift from public research to private research, as well as a decline in total investment in research. Brazil and China have become major investors in agricultural research and investment. If this trend of private research continues then this could lead to more restrictions on intellectual property which in turn could affect the availability of new technology to developing countries (Godfray et al., 2010).

Godfray et al. (2010) also presented one factor of importance for increasing food supply as a reduction in food waste. There is food waste at all steps throughout the food supply chain. In developed countries this waste has been greatly reduced early in the food chain to increase profits of those businesses involved. However, in developing countries there are still challenges in the early part of the chain with spoilage and spillage post-harvest and inadequate transport and storage. In industrialized countries most waste occurs near the end of the supply chain with consumers and the retail trade.

Author Insights: Food Production

No matter the size of the operation, a majority of producers desire sustainability. According to Sustainable Agriculture Research and Education (SARE) the definition of sustainability includes:

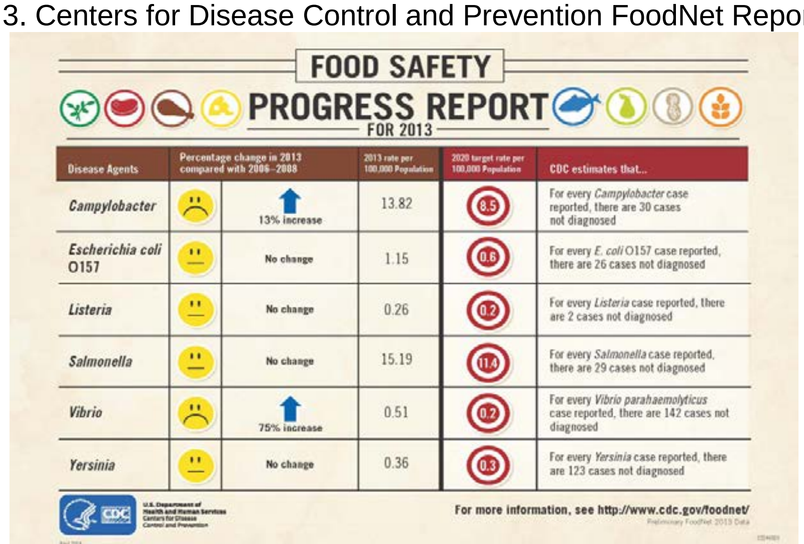
1. Profit over the long term
2. Stewardship of our nation’s land, air and water
3. Quality of life for farmers, ranchers and their communities

In Ohio, the trend of bifurcation in agriculture is not surprising. Ohio is unique in our location in the country where Appalachia meets the Midwest. There are also many interfaces of rural with urban. There is certainly not a one size fits all operation for Ohio. Successful producers will need to choose the best production methods that are sustainable in order for Ohio agriculture to continue to be a driving force in the Ohio economy. There are certainly opportunities for increased yield of traditional crops like corn and soybeans in Ohio through the use of genetically engineered crops and precision agriculture. But since 91 percent of Ohio farms are less than 180 acres, there may be opportunities for a majority of farmers to explore alternate specialty crops or less traditional options for marketing in order to increase profits. In Ohio, 58 percent of the principal operators of farms have a primary occupation other than agriculture, which is slightly higher than the US average at 52 percent. For producers with other sources of primary income, profit may not be the decisive reason for making management decisions on the farm.

Trends in Food Safety: *Foodborne Illness*

The Centers for Disease Control and Prevention (CDC) monitors 15 percent of the nation’s population to measure rates of foodborne illness and compare trends from year to year. The CDC 2013 FoodNet Report tracks incidence of illness associated with eight pathogens (see Figure 3). *Salmonella* rates remain about the same since 2006. *Campylobacter* infections have increased 13 percent since 2006 (often linked to contaminated chicken). *Vibrio* were at the highest levels in 2013 since tracking began in 1996 (often linked to eating raw shellfish). *E. coli* infections are about 30 percent lower than baseline year of 1996 (Crim et al., 2014)

Figure 3. Centers for Disease Control and Prevention FoodNet Report 2013



FOOD SAFETY PROGRESS REPORT FOR 2013

Disease Agents	Percentage change in 2013 compared with 2006–2008	2013 rate per 100,000 Population	2020 target rate per 100,000 Population	CDC estimates that...
Campylobacter	13% increase	13.82	8.5	For every *Campylobacter* case reported, there are 30 cases not diagnosed
Escherichia coli O157	No change	1.15	0.6	For every *E. coli* O157 case reported, there are 26 cases not diagnosed
Listeria	No change	0.26	0.2	For every *Listeria* case reported, there are 2 cases not diagnosed
Salmonella	No change	15.19	11.4	For every *Salmonella* case reported, there are 29 cases not diagnosed
Vibrio	75% increase	0.51	0.2	For every *Vibrio parahaemolyticus* case reported, there are 142 cases not diagnosed
Yersinia	No change	0.36	0.3	For every *Yersinia* case reported, there are 123 cases not diagnosed

For more information, see http://www.cdc.gov/foodnet/

In 2000 the USDA Economic Research Service (ERS) estimated that five major pathogens causing the majority of all foodborne illness resulted in a cost of illness of $6.9 billion per year. Cost of illness is an established practice that is used to estimate the economic burden of nonfatal illness. Comprehensive reports by other authors were published in 2010 and 2012 with much higher costs. The ERS analyzed these reports and when controlling for difference in methodology, the estimated foodborne illness costs reported in 2012 were $14.1 billion from the 2012 article by Hoffman, Batz and Morris and $16.3 billion from the 2012 article by Scharff (Hoffman & Anekwe, 2013).

Quested et al. (2010) state that “while consumers benefit by the product variety available to them, the complexity of the global food supply requires more international collaboration and harmonization of management efforts in order for existing and emerging risks to consumers to be dealt with adequately.”

Some key drivers identified by Quested et al. (2010) that will affect food consumption and the consequences for burden of disease include:

Food prices will remain at elevated levels if input costs such as energy continue to increase. If these food prices stay high, then one possible outcome is a decrease in consumption of more expensive foods that are resource and land intensive to produce (such as meat, milk and eggs). Climate change policy could lead to taxation being extended to all parts of food production. As populations continue to age in developed countries this could increase the number of cases or the severity of cases of foodborne illness as immune systems are not as effective at fighting disease as the body ages.

The most important factor in reducing food-borne disease as identified by Quested et al. (2010) is the “ability to first detect and investigate a food safety issue and then to develop effective control measures.” In order for these measures to come about, there will have to be investment in resources and infrastructure required to develop effective global surveillance of food-borne disease. It is crucial to develop risk management techniques to handle complex food safety issues and to effectively communicate and educate regionally and globally so that systems can be aligned. For developed countries it is a delicate balance to encourage trade with developing countries yet also ensure that food safety management systems are protecting all consumers.

The Food Safety Modernization Act

According to the US Food and Drug Administration (2014), “the FDA Food Safety Modernization Act (FSMA), the most sweeping reform of our food safety laws in more than 70 years, was signed into law by President Obama on January 4, 2011. It aims to ensure the U.S. food supply is safe by shifting the focus from responding to contamination to preventing it.”

One of the most notable attributes of the law is the attention to preventive control. FDA now has a legislative mandate to require comprehensive, prevention-based controls across the food supply. This applies not only to food produced domestically but also to imported foods. Now importers must verify that they comply with US food safety standards through accredited third party audits.

The proposed standards for produce safety have been widely discussed throughout the country. These standards have been developed for the production and handling of fresh produce. Special attention is given to fresh produce because it is responsible for more illnesses (46 percent) than any other food type. In fact, leafy vegetables were responsible for 22 percent of all foodborne illness, which is more than any other commodity. Illnesses associated with leafy vegetables were the second most frequent cause of hospitalizations (14 percent) and the fifth most frequent cause of death (6 percent) (Painter, 2013).

There are also preventive controls for human food that apply to facilities that manufacture, process, pack or hold human food. Again the focus is on the prevention of foodborne illness by identifying possible risks and hazards and developing a plan to monitor and address them.

Author Insights – Food Safety

The emphasis on food safety from farm to plate is imperative. Everyone who comes into contact with food has responsibility for keeping it uncontaminated by microorganisms that can cause foodborne illness. There are risks for contamination at any point in the food system chain from farm to distribution to retail to consumer. That is one reason that some consumers support local food production and prefer to buy direct from the producer. There are many other reasons as well, but a sense of inherent health and safety will sometimes create a halo effect on produce, meat or eggs that are marketed directly from the producer to the consumer.

The majority of produce sold in the US, however, is not direct from producer to consumer. Retail venue purchases, like grocery stores, represent almost 90 percent of all food for home consumption (Clark and Sharp, 2011). And trend information does not suggest that this will change. The U.S. imports approximately 15 percent of the food we consume each year. As an American society, especially since September 11, 2001, we value safety and security. The safety of our food clearly falls into this category. And for a society that is further and further removed from production agriculture, it can be challenging to establish realistic expectations of the inherent risks associated with agriculture.

As technology advances, there are many enhanced methods of testing for microorganisms that can cause foodborne illness. A challenge may be to keep consistent standards between domestic and imported foods, especially from countries with fewer resources to devote to elaborate food safety and quality systems.

It also should be mentioned that there is great concern from many American and Ohio producers about the new Food Safety Modernization Act. Though it includes exemptions for small operations, retail establishments have begun to mandate that exempt operations meet the same standards (i.e. third party audits) established for the non-exempt operations as part of their risk management strategies. There is a perception that the government requirements, though not even required for smaller operations, are still responsible for driving smaller operations out of business.

Trends in Food Security: *Prevalence of National and Ohio Food Insecurity*

According to Coleman-Jensen, Gregory, & Singh, (2014) food security is determined by US households and there are several definitions. A *food secure* household has access to enough food for an active, healthy lifestyle for all household members at all times. Households that are *food insecure* include those with low food security and very low food security. *Low food security* means that a household was uncertain of having enough food because of insufficient money or other resources. They did however obtain enough food to avoid substantially disrupting their eating patterns by eating less varied diets, participating in federal assistance programs or getting food from community food pantries. The final category is *very low food security*. This category is the most severe in the US and includes the food-insecure households in which normal eating patterns of one or more household members were disrupted and food intake was reduced because of sufficient money or other resources for food.

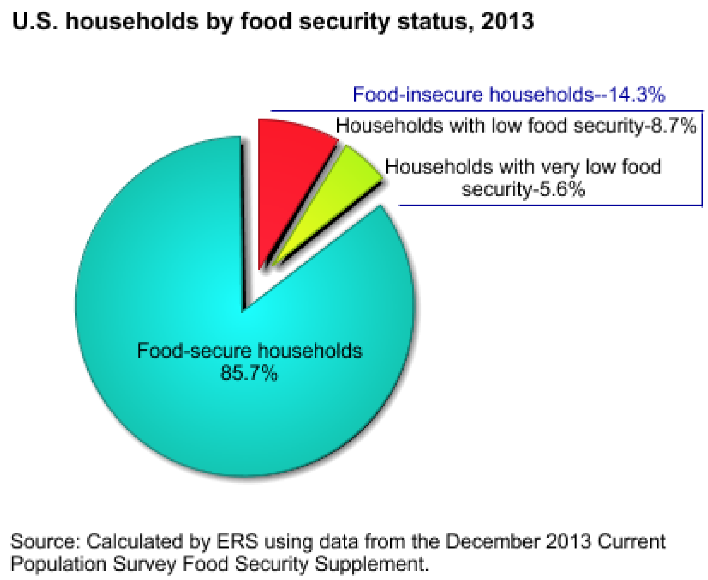


Figure 4.

In 2013 there were 49.1 million people (14.3 percent of households) living in the US in food-insecure households (see Figure 4). Approximately 765,000 children (or 1 percent of children in the US) live in households in which one or more children have experienced very low food security. The trend information for food insecurity and very low security shows that there was a jump in food insecurity in 2008 that has become the new "normal" since that time (see Figure 5) (Coleman-Jensen, et al., 2014).

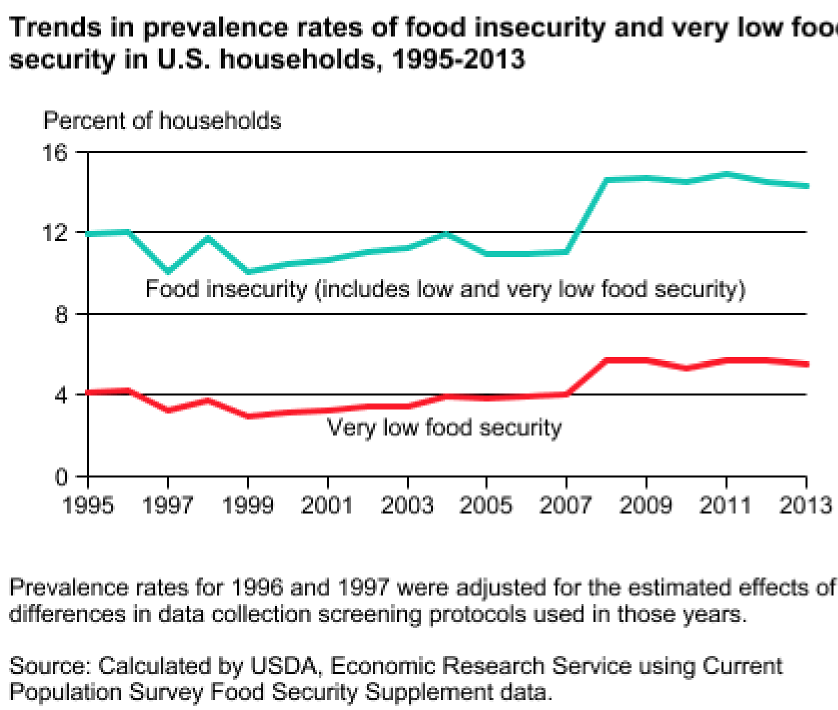
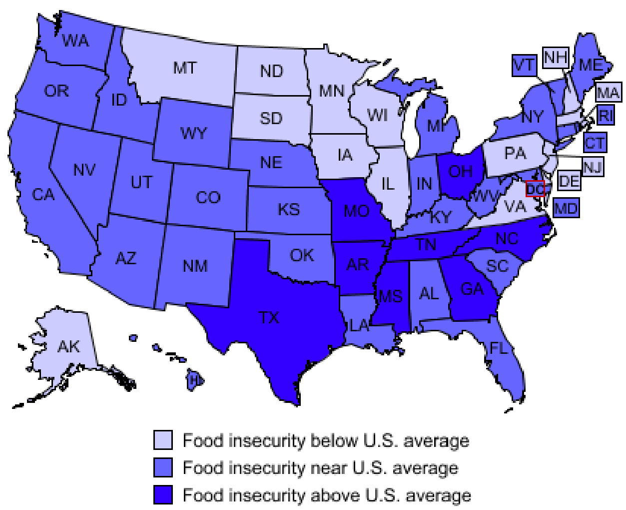


Figure 5.

Ohio is one of eight US states that is above the US average for number of households experiencing food insecurity (see Figure 6). The national average for 2011-2013 was 14.6 percent for food insecurity and 5.7 percent for very low food security. Ohio's average for 2011-2013 was 16.0 percent for food insecurity and 7.2 percent for very low food security. The majority of other states above the national average are located in the southern US (Coleman-Jensen, et al., 2014).

Prevalence of food insecurity, average 2011-13



Source: Calculated by ERS based on Current Population Survey Food Security Supplement data.

Figure 6.

Prevalence of Global Food Security

Worldwide, the Food and Agriculture Organization (FAO) of the United Nations (2014) estimates that about 805 million people, or 11.3 percent of the global population, were chronically undernourished in 2012-2014. Most of these people live in developing countries which would be 13.5 percent of that population. Over the last decade this has decreased by more than 100 million, and since 1990-92 it has decreased by 209 million people. Chronic undernourishment is measured in terms of dietary energy supply, which is a different measurement than food insecurity in the United States.

Effects of Food Insecurity

For a number of years there have been various ways to measure and characterize food security. In recent decades there has been a shift away from the concern of global and national food supply adequacy to food access for households and individuals. During the late 1970s and 1980s, studies began to highlight the importance of food access compared to purely food production. The FAO Committee on Food Security was one such entity that drew attention to the coexistence of widespread hunger and adequate food supply (LeBlanc, Kuhn, & Blaylock, 2005).

There is a relationship between poverty and food insecurity, but it is not always the same population. Cook and Frank (2008) found that the populations affected by both poverty and food insecurity do not always overlap. Not all people below the poverty line are food insecure. Likewise, food insecurity does affect households above the poverty line. In 2002 the Food and Agriculture Organization (FAO) estimated that reducing the number of undernourished people in the world between 2002 and 2015 would yield over $120 billion annually in increased income as a result of increasing the capacity of individuals to learn and earn (LeBlanc et al., 2005).

During 2007-2010 the entire world experienced various levels of food price increase and overall economic stress. Some regions and countries were more vulnerable to drastic increases in food than others. In many of these countries the consequences were more diverse and complex than simply a reduction in total dietary energy intake. When a greater percentage of income is required for food, then other basic needs may be forfeited that relate to health and education (Food and Agriculture Organization of the United Nations, 2014).

A main concern of food insecurity is its influence on health, nutrition and child development. Foods often most affordable are calorie-dense and nutrient deficient. So though a child or adult may not experience hunger, the foods they are eating are not providing the needed components to provide adequate nutrition in a balanced diet for good health and development. There are many resulting affects from poor adult nutrition including decreased parental energy for providing care to children, parental depression, and the subsequent effects on children raised in these environments (Cook and Frank, 2008).

Author Insights – Food Security

Globally the trend is very positive for food security. However, there are still millions of people, many of them children, who are suffering because of hunger or facing the side effects of poor health due to improper nutrition. There is enough food production from an agricultural and food system standpoint to feed the world currently. The issue is not food production; the issue is access to food. As we look to the future of feeding 9 billion people by 2050, we cannot only focus on agricultural production and think that is our only responsibility as part of the larger agricultural and food industry. We must examine methods for food access globally, nationally, and within Ohio.

Overall Summary of Trend Information

Advances in technology and especially information technology management are continuing to increase food production and reduce the waste within the system. This technology is also helping improve traceability from production to consumer as well as overall emphasis on prevention-based controls to improve food safety. There are still many people throughout the world who struggle to obtain adequate, nutritious food. However, global food security has increased greatly over the past few decades.

Author Insights – Alternative States for the Future

Looking out to the year 2035 the author proposes four possible outcomes related to these three focus areas. The probabilities are based on information included in this document and simply provide a starting point for conversations about the future.

A. Production agriculture continues to increase the amount of food that is available for consumption through continued improvement of technology and further innovation. Farmers can do this in a sustainable manner that does not increase the number of acres needed. Food safety systems continue to advance and preventive controls result in a similar low incidence or even fewer cases of foodborne illness. Efforts that have globally reduced the food insecurity continue to improve access to nutritious food to a growing population. Based on 2014 trend information, this outcome appears to be the most likely with an a priori probability of 0.40.

B. Production agriculture continues to increase the amount of food that is available for consumption through continued improvement of technology and further innovation. Farmers can do this in a sustainable manner that does not increase the number of acres needed. Food safety systems continue to advance and preventive controls result in a similar low incidence or even fewer cases of foodborne illness. However, focus is so much on production and safety that food security issues are neglected. The local trend of Ohio remaining one of the most food insecure states in the US remains. Based on 2014 trend information, this outcome appears to be the most likely with an a priori probability of 0.30.

C. Production agriculture continues to increase the amount of food that is available for consumption through continued improvement of technology and further innovation. Farmers can do this in a sustainable manner that does not increase the number of acres needed. Food safety systems are not able to handle the increase in production. There is little investment in research and development to advance technologies and preventive controls. Though government regulations exist, producers and food manufactures are not able to meet requirements. Cases of foodborne illness increase. Food security issues are also neglected. The local trend of Ohio remaining one of the most food insecure states in the US remains. Based on 2014 trend information, this outcome appears to be the most likely with an a priori probability of 0.20.

D. Production agriculture maintains the amount of food that is available for consumption, but this does not meet the demands of the growing global population. This could be the result of decreased public agricultural research or increased government regulations due to public opinion which decrease access to genetically modified crops or precision agriculture technology. Food safety systems are not able to handle the increase in production. There is little investment in research and development to advance technologies and preventive controls. Though government regulations exist, producers and food manufactures are not able to meet requirements. Cases of foodborne illness increase. Food security issues are also neglected. The local trend of Ohio remaining one of the most food insecure states in the US remains. Based on 2014 trend information, this outcome appears to be the most likely with an a priori probability of 0.10.

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[1] Along with the research-based data and statistics included in this document, is information provided by the research paper author(s). Although these author insights are not directly cited with research references, they reflect research, observation, logic, intuition, and well-considered expectations compiled by the author(s). The Author Insights sections of this paper are offered for discussion and to help provide a wider perspective for incorporating the descriptor data into the possible future trends. These conclusions are drawn by the author(s) using their knowledge of the scholarly references and their years of professional experience related to the descriptor, and are provided to help the reader more effectively envision the future impact and effects of the descriptor.