



# Expert Stakeholder Workshop for the USDA Technical Report on Global Climate Change, Food Security, and the U.S. Food System

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Reston, VA

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## Major Meeting Themes

**Climate change influences on the major pillars of food security.** Each of the four elements of food security (availability, access, utilization, and stability) is vulnerable to changes in climate. For example, reductions in production related to regional drought influence food availability at multiple scales. Changes in price influences the ability of certain populations to purchase food (access). Utilization may be affected when production zones shift, reducing the availability of preferred or culturally appropriate types of food within a region. Stability of the food supply may be highly uncertain given an increased incidence of extreme climatic events and their influence on production patterns.

**Data and analytical frameworks.** Much has been written regarding climate change's relationship to food security. However, that literature has been largely conceptual in nature, with few analytical frameworks available to examine the relationship quantitatively at geographic and temporal scales for application by programmatic professionals in the field working to reduce food insecurity. Connecting global food security frameworks to the climate vulnerability of the U.S. food system requires datasets with similar conceptual foundations. While improved data, models, and other types of information that allow scientists to project outcomes of changes in climate to agricultural production (availability) are needed, more is currently available in this area of food security than for its other elements – access, utilization, or stability. Limited analytical capacity currently exists relating climate change's relationship to food systems, more broadly, and to U.S. food systems specifically.

**International perspective.** U.S. agriculture and the U.S. food system are vulnerable to climate change effects in other parts of world. Changes in the frequency and intensity of droughts, floods, and other types of extreme weather globally will not only affect imports into the United States, but are also likely to influence exports through global food demand and pricing.

Questions of food security, therefore, are global in nature and cannot be understood at the national scale without factoring in global forces.

**Weather extremes.** Weather extremes, rather than a gradual change in temperature or precipitation, have posed the most recognizable challenges to the food system in recent years, and are likely to become even more important in the future. Climate variability is a source of both risk and opportunity for agricultural households, as they can take advantage of good weather years to improve food security during bad weather years. Weather extremes can also pose large-scale risk to society that can cascade across multiple economic sectors in unforeseen ways, causing food insecurity and hardship that can degrade development gains. Both the likelihood of extreme events and adaptation practices – be they biophysical or institutional – affect farmers and food insecure people.

## 1.0 Introduction

The United States Department of Agriculture (USDA), with help from the National Center for Atmospheric Research (NCAR), hosted a workshop on Climate Change and Global Food Security on June 25-27, 2013 in Reston, Virginia.<sup>1</sup> The workshop was held as part of the process of writing a USDA Technical Report on the effects of climate change on global food security, and how these changes might affect global and U.S. food systems. The workshop was designed to develop a baseline for understanding the issues, identify some of the threats and opportunities posed by climate change to global food security, and get expert input on the topical scope of the USDA technical report. The workshop included 29 participants with expertise across a range of disciplines. Participants represented federal, state, and local government, non-governmental organizations, industry, and academia. The two-day event fostered dialog among the authors and subject matter experts in climate change, food security, and related areas, with stakeholders providing input on their priorities and analytical needs. The report authors will use this feedback, factoring those interests and topics into the technical report to the degree both technically and practicably feasible.

This summary document provides a general overview of the climate change-food security intersection. In addition, it offers a synopsis of the presentations by workshop participants on food security, food systems, and climate change. As part of the meeting, participants were asked to share their expert opinions regarding the likely effects of changing climate on food security and systems regionally, nationally, and globally.

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<sup>1</sup> A list of attendees in Appendix A.

## 2.0 The Intersection of Climate Change, Global Food Security, and Food Systems

The 2006 United Nations Food and Agriculture Organization (FAO) defines food security<sup>2</sup> as having been achieved when all people at all times have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life, and is composed of four fundamental elements (see Box 1). Achieving global food security in the face of growing environmental and socio-economic change is amongst society's greatest challenges. The United Nations estimates that by 2050 the world will need to find a way to feed more than nine billion people – approximately two billion more than live on the planet today. Economic, social, biophysical, technological, and institutional drivers of current and future global food security, as well as the environmental constraints affecting each of these areas and the global food system, are all important, interdependent considerations.

### **Box 1. The Four Fundamental Elements of Food Security**

- Availability – the availability of sufficient quantities of food of appropriate quality, supplied through domestic production or imports (including food aid).
- Access – access by individuals to adequate resources for acquiring appropriate foods for a nutritious diet.
- Utilization – utilization of food through adequate diet, clean water, sanitation and health care to reach a state of nutritional wellbeing where all physiological needs are met.
- Stability – to be food secure, a population, household, or individual must have access to adequate food at all times. They should not risk losing access to food as a consequence of sudden shocks or cyclical events.

In a recently published USDA Technical Report<sup>3</sup> that assessed how climate change is affecting U.S. agriculture, increasing atmospheric carbon dioxide (CO<sub>2</sub>), rising temperatures, and altered precipitation patterns were found to have notable effects on the nation's agricultural productivity. The report authors found that increases in temperature, coupled with more variable precipitation, will reduce productivity of crops, with these effects outweighing any benefits of increasing CO<sub>2</sub>. Climate change, however, is an issue affecting not just U.S.

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<sup>2</sup> FAO Food Policy Brief, 2006. Food Security. AO's Agriculture and Development Economics Division (ESA) with support from the FAO Netherlands Partnership Programme (FNPP) and the EC-FAO Food Security Programme. [ftp://ftp.fao.org/es/ESA/policybriefs/pb\\_02.pdf](ftp://ftp.fao.org/es/ESA/policybriefs/pb_02.pdf)

<sup>3</sup> Walthall, C.L., J. Hatfield, P. Backlund, L. Lengnick, E. Marshall, M. Walsh, S. Adkins, M. Aillery, E.A. Ainsworth, C. Ammann, C.J. Anderson, I. Bartomeus, L.H. Baumgard, F. Booker, B. Bradley, D.M. Blumenthal, J. Bunce, K. Burkey, S.M. Dabney, J.A. Delgado, J. Dukes, A. Funk, K. Garrett, M. Glenn, D.A. Grantz, D. Goodrich, S. Hu, R.C. Izaurralde, R.A.C. Jones, S-H. Kim, A.D.B. Leaky, K. Lewers, T.L. Mader, A. McClung, J. Morgan, D.J. Muth, M. Nearing, D.M. Oosterhuis, D. Ort, C. Parmesan, W.T. Pettigrew, W. Polley, R. Rader, C. Rice, M. Rivington, E. Rosskopf, W.A. Salas, L.E. Sollenberger, R. Srygley, C. Stöckle, E.S. Takle, D. Timlin, J.W. White, R. Winfree, L. Wright-Morton, L.H. Ziska. 2012. Climate Change and Agriculture in the United States: Effects and Adaptation. USDA Technical Bulletin 1935. Washington, DC. 186 pages.

agricultural productivity and agro-ecosystems. It is altering agricultural and food production systems worldwide, and influences each of the four food-security elements beyond production considerations alone. These changes are having repercussions on global food security, and will continue to do so as the global climate continues to react to the effects of increasing atmospheric greenhouse gas concentrations.

### **Box 2. Global Effects of Climate Change**

Human influences will continue to alter Earth's climate throughout the 21<sup>st</sup> century. Current scientific understanding, supported by a large body of observational and modeling results, indicates that continued changes in atmospheric composition will result in further increases in global average temperature, changes in precipitation patterns, rising sea level, changes in weather extremes, and continued declines in snow cover, land ice, and sea ice extent, among other effects that will affect U.S. and global agricultural systems.

While climate change effects vary between regions, among annual and perennial crops, and across livestock types, all production systems will be affected to some degree by climate change. Temperature increases coupled with more variable precipitation will reduce crop productivity and increase stress on livestock production systems. Extreme climate conditions, including dry spells, sustained droughts, and heat waves will increasingly affect agricultural productivity and profitability. Climate change also exacerbates indirect biotic stresses on agricultural plants and animals. Changing pressures associated with weeds, diseases, and insect pests, together with potential changes in timing and coincidence of pollinator lifecycles, will affect growth and yields. When occurring in combination, climate change-driven effects may not simply be additive, but can also amplify the effects of other stresses on agroecosystems.

With ever tighter global linkages, events and crises affecting the global food system are increasingly influencing U.S. food systems. Various components of the global food system are vulnerable to weather extremes, which a changing climate is exacerbating. Extreme weather events can lead to disruptions within the food system. Further adding to food system pressures is the growing demand from emerging middle-income consumers who, with additional wealth, are changing consumption patterns. With more demands placed on global production systems and greater likelihood of extreme weather events, the probability of market volatility grows. When market volatility occurs in combination with other social or political disturbances, disruptions in global, national, and regional food systems may be exacerbated; this ultimately affects food security. While emerging middle-income nations and individuals on average can more easily withstand the effects of higher food costs, volatile markets and weather still have the capability of adversely affecting vulnerable populations.

### **Box 3. Food Systems**

Food systems encompass all of the activities related to food production, processing, distribution, preparation, and consumption. Each part of the food system's inputs and outputs helps determine individual, community, national, and international food security. In addition, food system function across the various scales contributes to environmental and other security concerns (e.g., income), with interactions between and within biogeophysical and human environments influencing the activities and outcomes of society at every level – regional, national, and international.

## **2.1 Technical Report Guiding Principles**

Certain guidelines had already been determined for the report prior to the Workshop. The report will identify some of the current issues and research on the effects of climate change on global food security, and how these outcomes might affect national and global food systems. Additionally, the technical report will use the present day state of the climate and food security as a baseline for developing projections of the trends and outcomes of climate change on food security that will occur in the near-term (i.e., the next 25 years) and over the longer term (i.e., 100 years). The report will not provide policy prescriptions; instead it will report on the current and possible future state of food security and global and U.S. food systems, factoring in the effects of climate change.

## **3.0 Background Information: Presentations on Climate Change and Food Security**

The workshop consisted of two types of presentations: Informational background regarding the nature of food security, the science of climate change, and what is currently known about the relationship between the two topics. The second type of presentations came from stakeholders, to discuss important analytical gaps for operational purposes. The following sections of this summary highlight each. The summaries describe the material presented and are the opinions of the presenters. Moreover, the priorities reported do not represent a mandate for the *Climate Change, Global Food Security, and the U.S. Food System* report.

### **3.1 Molly Brown: What is Food Security?**

Food security ties directly to the availability, access, utilization, and stability of a food supply. However, how each of these characteristics of food security manifests typically varies, depending on geographic scale. For instance, household food security may be most affected by income, whereas national food security is driven by a nation's ability to produce or import food, or weather extremes, while global food security is affected by large-scale land and water constraints, political stability across nations, global-scale weather extremes, etc. As a result, information requirements for analyzing issues that affect each level of food security also differ greatly. Scale- and context-relevant information are necessary for fully understanding how food supplies and security may be affected by changing climate.

Socio-economic factors are also relevant. Wealthy, middle income, and poor or agriculture-dependent populations will experience different vulnerabilities to extreme weather events, with household, regional, and national income notably affecting regional food security and food demand. Nations transitioning from agricultural to industrial and service economies, and

growing urban areas may be influenced differently by changes in climate. National priorities for balancing food security with greenhouse gas emissions from energy, development, and urbanization, versus energy conservation will also influence outcomes.

### 3.2 Stacey Rosen: Assessing Food Security

Models are important tools for assessing food security. The USDA Economic Research Service's (ERS) annual report, the *International Food Security Assessment (IFSA)*, describes factors affecting food consumption and gaps in the per capita nutrition target using the ERS IFSA model. IFSA provides current estimates and future projections of food availability and access in 76 countries in four world regions, including sub-Saharan Africa, Asia, Latin America and the Caribbean, and North Africa. IFSA relies on food security indicators to identify gaps in average nutritional targets (nutritional gap) and the food gap associated with unequal purchasing power or food access (distributional gap).

Analytical tools, such as IFSA, are essential for providing comparative metrics that answer the question, 'Which counties are prone to food insecurity?' However, like all analyses on food security, the approach is constrained by data availability and reliability.

### 3.3 Peter Backlund: Climate Change, its Effects on Agriculture, and Land-Use Considerations

Climate change is the significant and lasting change in the statistical distribution of weather patterns over periods ranging from weeks to decades or longer. It reflects changes in average weather conditions or in the distribution of weather around the average conditions (i.e., more or fewer extreme weather events). Current understanding of how increasing atmospheric greenhouse gases affect average temperature is far greater than understanding of precipitation changes, although shifts in temperature, precipitation, and water resources (among other effects) resulting from climate change are becoming more evident.

Climate change will have a number of effects on agriculture, including:

- **Direct effects** from changes in temperature, precipitation, and CO<sub>2</sub> concentrations. For example, with increasing average air temperatures, crop water demands will likely increase, as will stresses on livestock. In some regions, precipitation intensity will increase, affecting soil erosion, decreasing soil quality, and reducing young plant survival, among other issues. Also, incidence of weather extremes will increasingly affect agricultural systems, with higher incidence of hot nights, increasing incidence of extreme storms, and with changes in the maximum number of consecutive dry days and temperature extremes.
- **Indirect effects** include changes in weed, disease, and insect populations and distributions. For example, C<sub>3</sub> plants, which include most weeds, tend to respond well to increasing CO<sub>2</sub>. Increased populations and northward expansion of weeds are predicted, which will increase costs of managing pests and increase crop losses. Additionally, increasing drought incidence can disrupt the biotic resistance of native species, while fire will favor succession and survival of invasive species.

Among the topics to consider with regard to effects of climate change on agriculture are:

- Whether the rate of adaptation within the agroecosystem and food production systems will keep up with the rate of climate change, and how will these adaptive responses affect global food security?
- Will climate change reduce or expand agricultural lands? Where?
- How will regional climate change affect regional, national, and global food security? E.g., changes in temperature and precipitation may favor some regions and harm others.
- How will climate change affect marine ecosystems and marine ecosystem productivity regionally? Globally?
- How will climate change affect other aspects of food security and the food system beyond production (e.g., harvesting, processing, transportation)?
- How will the climate change over the next century?
- Can we increase capacity to adapt to climate? Is climate change mitigation possible while improving food security?

### **3.4 Molly Brown: Connecting Food Prices to Environmental Dynamics**

Food prices, whether rising, falling, or remaining stable, offer insights on urban food security. While climate change-driven events are certainly not the only effects that influence food prices, they affect global, national, and regional food price spikes, which, in turn, affect food security. Food price volatility and its links to environmental change provide insight on the effects of climate change on food security.

Food-price time series support diagnoses of the effects of local food production variability and global economic food price trends on food access in specific markets by enabling a quantification of the vulnerability of particular communities to large-scale changes in productive capacity due to effects of changing climate. Availability of food price information is on the rise: 956 data time series now span approximately 10 years and may be used operationally to understand food access across many different countries.

In regions or nations where few or no measures of trade are available – predominantly in food-insecure regions – satellite data may be used to estimate food production in economic models. Satellite images provide critical information on production and production variability by allowing analysis of spatially explicit anomalies resulting from weather variability. This information, when merged with food prices and other relevant economic model data, helps to improve understanding of food prices and how food markets are working.

### **3.5 Hector Maletta: The Geography and Related Driving Factors of Food Security**

Agriculture is not just a biophysical process, but an adaptive human activity interacting with nature. Potential impacts of climate change that do not consider adaptation are limited. Anticipating farmers' spontaneous and planned responses to climate change should be included in projecting future impacts.

Adaptation is a selective process at the population/ecological/farming-system level, not just at the level of individual farmers changing their individual ways. Long-term changes (e.g., climate) involve successive generations of farmers, farm restructuring, changes of ownership and management, etc. Replacement and selection of farmers and reorganization of production cannot be disregarded in adaptation studies. An evolutionary framework should be used to understand adaptation processes, because as livelihoods evolve, so do land tenure, farm management, farming practice, land use, crops, and farming systems.



Examples show rapid adaptation of farming to climate.

- **Andean farmers under a new climate:** In response to changing climate, highland smallholders have been moving to tropical lowlands. With this change, lowland agriculture has thrived, anticipated ecological hardship has not occurred, and environmental quality has been maintained.
- **Changing rainfall in the Argentine plains:** Isohyets have moved west in Argentina along recent decades. Agriculture rapidly adapted: grassland was cropped, productivity and exports increased, land tenure changed, new forms of farm management developed.

Humans have an extraordinary adaptive capacity. This is heightened among farmers, who universally adapt to their environment. Understanding how populations are adapting to changing climate and other processes may assist in understanding future response to climate change and the influence of farming adaptive capacity on regional, national, and global food security.

### 3.6 John Reilly: Pathways of Future Development

A major challenge for developing the 25- and 100-year future scenarios is that trade, which is important to food security and food system dynamics, is often poorly represented in current modeling frameworks and difficult to project into the future. How trade affects the world and how these effects are reflected globally are important considerations. Other environmental and resource issues, as well as competition for land, will be valuable to represent in scenarios. While climate change is certain, uncertainty exists about the specific responses of the Earth system to changing climate and how these changes will affect food security. Finally, uncertainties exist related to agriculture (e.g., yield growth, water availability, willingness to convert new land to crops, dietary changes, crop and livestock response to climate, and environment change). In addition, policies, economic growth and other trends factor into analytical approaches. Mitigation and adaptation activities also influence potential future food security outcomes.

### 3.7 Jean Buzby: Food Loss and Food Waste

Food loss (particularly the food waste component) is becoming an increasingly important topic both domestically and internationally. Food loss represents the edible amount of food, pre- and post-harvest, available for human consumption that is not consumed for any reason. Food loss includes cooking loss and natural shrinkage (for example, moisture loss from food), loss from mold, pests, inadequate climate control, and food waste. Food waste occurs when an edible item goes unconsumed, as in food that is discarded by retailers due to objectionable color or appearance, or plate waste by consumers. Food waste and loss are relevant for a variety of reasons:

- More food will be needed as the global population expands.
- Food loss means that negative externalities are created unnecessarily throughout the supply chain from the uneaten food's production (e.g., soil erosion) to disposal (e.g., landfilled food produces methane gas when decomposing anaerobically).
- Food loss represents a loss of money and other resources invested in the production and purchase of food.

Food waste, per capita, in the developed world exceeds that which occurs in developing nations. In Europe and North America annual, per capita waste is 95-115 kg/year, whereas in sub-

Saharan Africa and South/Southeast Asia waste accounts for 6-11 kg/year, according to a 2011 report by the Food and Agriculture Organization.<sup>4</sup> In developing countries, food waste occurs for a variety of reasons, including problems with storage, limited markets, and poor transportation infrastructure. Understanding the reasons for food loss and identifying methods to reduce waste and loss in developing and developed countries – e.g., improving storage and access to markets – will be useful to bring to light and factor in to the larger food security picture.

### **3.8 Bill Easterling: Food Aid and Climate Change**

Millions of the global poor are at risk of hunger under changing climate in the next 25 to 100 years. Understanding where the regions with the most need are will be important to making food aid decisions; food aid is the voluntary transfer of resources from one country to another. Regions of Africa are expected to experience the greatest need during the next century. Declining per capita production in sub-Saharan Africa will likely make regional trade an increasingly important means for ensuring adequate food provision, as well as a focus for international food aid.

For reasons of increased efficiency under changing climate conditions, U.S. decision makers may have to develop new ways of delivering aid. The U.S. tends to buy food from domestic producers, transporting these goods to recipient countries, which then distribute the food to target audiences. Only US\$0.40 on every dollar goes to food production, the rest covers shipping, administration, and other expenses. Additionally, when food prices are kept artificially low, poor countries have become significant food importers, resulting in a decrease in social welfare when subsidized prices are removed. Understanding the nuances of the effects of U.S. aid may benefit from being articulated.

In a world of constrained resources, climate change response priorities will need to be identified. Increasing incidence of extreme events, increased population numbers, and a reasonable reprogramming of assets will serve to increase the need for food aid. The humanitarian community seeks effective tools to transfer climate risk and to enable affordable social safety nets.

## **4.0 Case Studies and Stakeholder Perspectives**

Stakeholders offered the authors input and advice regarding useful outcomes for the *Global Climate Change, Food Security, and the U.S. Food System* report. Some of these perspectives are captured in the following sections. While the authors turned to stakeholders to gather expert input on identifying important topical areas, the opinions below are those of the presenters, and do not represent a mandate for the report.

### **4.1 Kathy Jacobs: White House Office of Science and Technology Policy**

Adverse effects due to climate change are expected to affect the U.S. and global agricultural sector over the next 100 years. While authors of the U.S. National Climate Assessment (Key Finding 8) suggest that over the next 25 years, the nation's agricultural sector should remain relatively resilient to changes in climate, U.S. food security and farm incomes also depend on

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<sup>4</sup> Gustavsson, J., et al., 2011. Global Food Losses and Food Waste: Extent, Causes, and Prevention. Food and Agriculture Organization (FAO) of the United Nations. [http://www.fao.org/ag/ags/ags-division/publications/publication/en/?dyna\\_fef%5Buid%5D=74045](http://www.fao.org/ag/ags/ags-division/publications/publication/en/?dyna_fef%5Buid%5D=74045)

how agricultural systems in other regions of the world adapt to climate changes. This USDA technical report may benefit many of its readers by looking at the implications of global food security on the U.S. economy and agricultural system and the ripple effects of these policies on national and global food security. While it seems likely that some U.S. citizens will have issues with food security in the future, many others in the world are much more vulnerable to this issue, which may make looking at regional food security issues in this report a valuable exercise. The report also might consider climate change as an added stress in an already complicated situation, using a risk management framing. Food security is at the intersection of economics, transportation, technology, energy, institutions, etc. When intersecting with the climate issue,, opportunities arise to either increase resilience or cause catastrophic failure, with cascading effects running through multiple systems. Already, much work has occurred in many relevant areas of food security and food systems, such as the effects of climate change on developing nations' food security and drought so, where possible, exploration of new and emerging areas of research on food security would be of broad benefit.

#### **4.2 Ana Rios: Inter-American Development Bank**

The Inter-American Development Bank (IDB) serves Latin America and Caribbean (LAC) economies spending one out of every four dollars on climate change and adaptation in the agricultural, land use, and forestry sectors in these regions. Recent work of the IDB has been to measure the effects of climate change, noting related adaptation measures. In a recent report, the IDB notes that the effect of climate change on the agriculture sector is only measured by loss in net exports of wheat, soybean, maize, and rice. The report estimates \$26-44 billion in climate change-related losses occurring by 2050 if climate change remains unaddressed. Additionally, glacier retreat (\$22 billion) and coral bleaching (\$8 billion) contribute to the total economic damage of \$100 billion for the regions served by the IDB. However, costs of adaptation are estimated to be no more than \$25 billion, with many of these adaptive measures benefitting regional food security.

Most research on climate change effects in the regions served by the IDB has focused on the consequences of ambient air temperatures; however for small and vulnerable countries like the Dominican Republic and those in Central America, more detailed information on the regional effects of climate change would be beneficial. For instance, understanding the interactions between higher temperatures and changes in rainfall, or potential changes in soil temperature, which affects plant germination and growth, would be useful information for IDB's constituents. Rios also pointed to the benefits of performing analyses examining the connections between food security effects, poverty, and children. Many of these areas might be of interest to other stakeholders if explored in greater detail in the USDA technical report.

#### **4.3 Brian Peniston: Food Security in Nepal**

Half of the world's biodiversity hot spots are located in the world's mountainous regions. These areas are often also home to indigenous people who are particularly vulnerable to climate change and food insecurity. Nepal offers an example of both, and is a low-ranking nation on human development indices, with an estimated 50% of the nation's 27 million inhabitants experiencing malnutrition. Eighty-five percent of the population works as agricultural producers, under generally challenging food production conditions in a geography marked by steep slopes, degraded soils, and extreme weather.

Among its other efforts, the UN World Food Programme has a protracted relief and recovery program in the poor northwestern region of Nepal. Using a food-for-work approach, food is provided in exchange for unskilled labor that supports and enhances community farming and climate resilience in a variety of ways, such as paving of trails with stone, changing water flows in vulnerable streams, and improving community forest resources. This aid program provides a ‘triple win’ of using food to feed hungry people, creating employment in an underemployed area, and creating community assets. However, the program has some limitations because people are limited to small projects, and while this aid program addresses the nation’s immediate, chronic hunger, significant risk exists of creating aid dependency. Additionally, an inherent contradiction exists in that by giving people food for not producing food, it may become harder to use community projects to produce food. The USDA assessment might explore the effects of food security on the agriculturally dependent to provide more information on what these populations might expect in future.

#### **4.4 Mike Budde: An Overview of the Famine Early Warning Systems Network (FEWS NET)**

The Famine Early Warning Systems Network (FEWS NET) is a USAID-funded activity that collaborates with international, regional, and national partners to provide timely and rigorous early warning and vulnerability information on emerging and evolving food security issues. FEWS NET uses a suite of communications and decision support products to help decision makers mitigate food insecurity. These products include monthly food security updates for 25 countries, regular food security outlooks and alerts, as well as briefings and support to contingency and response planning efforts. More in-depth studies in areas such as livelihoods and markets provide additional information to support analysis as well as program and policy development. FEWS NET teams recently began assessing effects of global and regional climate change, identifying locations with greatest needs and times when outcomes will have greatest effect on livelihoods and seek to inform where adaptation is needed. Metrics for validation of the utility of FEWS NET tools and capabilities are desirable to support anecdotal stories of improvements to understanding of global and regional food security, particularly in areas lacking on-the-ground FEWS NET members.

#### **4.5 Martha Schlicher: Industry Perspective on the Effects of Climate Change on Agriculture**

Advances in agricultural productivity have gone global; with advances previously realized in the United States now being achieved at a faster rate outside of the United States. These advances are due to the application of genomics across both breeding and biotechnology, as well as information sharing and favorable regulatory regimes that are pushing yield advances, attributable to all sources, forward. Increased productivity has resulted in the U.S. global supply mattering less in the global marketplace.

Despite these advances, under changing climate, industry experts recognize the importance of continuing to challenge the technology frontier to mitigate volatile weather conditions. While breeding programs, in general, provide for great flexibility in offering hybrids adapted to various production zones, continued recognition and emphasis of these changes will be required to maintain this flexibility of the germplasm pool. Biotechnology provides an additional tool in this tool kit with opportunities for greater stress tolerances adaptable across all geographies. Producers readily adapt new offerings that mitigate risk and continue to adopt risk mitigation

practices in their own operations. A favorable regulatory environment is critical to risk mitigation.

Growers and the industry are united in looking for opportunities to help provide systems solutions to meeting a growing public need for food, feed, and fuel while ensuring that environmental concerns are addressed. These divergent needs provide unique opportunities for agriculture to provide unified solutions. Agriculture also needs to expand its vista beyond conventional row-crop production and recognize that increased insect pressures in areas outside of row crops (i.e., forest areas) could detrimentally impact temperatures and thus row crops. We must holistically address these challenges for the greater public good.

#### **4.6 Christopher Delgado: A World Bank Perspective on Agriculture and Resilience Under Changing Climate**

The World Bank's core business is improving the life of people while addressing poverty, with interest in agricultural development primarily as it applies to dealing with poverty, hunger, and nutrition issues. These issues are interrelated, with three quarters of the world's truly poor (incomes of less than \$1.25 a day in 2005 dollars) living in rural areas and deriving a large share of their livelihoods from agriculture – typically in areas where land and water resources are degrading. In the past, a small group of nations helped the global poor directly during food and financial crises, however, these nations are less able to do this now. Many more decision makers around the world are presently involved in the conversation related to food. Decision makers understand that intensification on current cropland will have to provide the additional production required, but more fresh water on the order of 150 km<sup>3</sup> will be needed, and more emphasis on many other traditional means of boosting production. Without climate change, the world might just muddle on food through by 2050, despite population increases of up to two billion people. Unfortunately muddling through is not going to be a feasible strategy.

Climate warming is expected to lower cereal yields by about 5% per degree Celsius change, and will, if following business as usual, turn what might have at best have been a 50% increase in aggregate food production by 2050 into a 20% decrease, with disastrous consequences. Already, developing countries are focusing on adapting to climate change – mitigation is typically a much lesser focus. Adaptation increases farm productivity, increases incomes, and addresses climate adaptation and mitigation.

The World Bank is taking a landscape approach in helping nations deal with climate change. But much more needs to be done and much sooner. Donor nations and others need to focus on and communicate what is needed and what is deemed important. Public dialogue is needed to understand what regional resilience and mitigation looks like, whether these actions may achieve the desired end goals, how global interests are interlinked, and options for getting the job done with shared costs and benefits.

#### **4.7 Kimberly Pfeifer: Oxfam's Perspective on Climate Change and Global Food Security**

In the context of a changing climate, increases in the number and severity of extreme weather events across the U.S. landscape and globally will likely increase the need for emergency responses. Even with global efforts in place to reduce the numbers of poor and hungry in the world, climate change and the related outcomes will hit the hungry and impoverished particularly hard.

Oxfam is a humanitarian relief and international development agency with an overarching goal of ending poverty and injustice. From the USDA's technical report, Oxfam hopes to better understand the agency's thinking on and approaches to dealing with food security and climate resilience. In addition, the organization hopes to improve understanding of how climate change might affect food-price volatility, including if and how price spikes might be avoided, and who will likely win and lose in the market volatility resulting from changing climate.

Oxfam supports development of a broader set of tools to address food insecurity, and would be interested in seeing some of these issues taken up in the report. The organization also has interest in learning more about the effects of climate change on agricultural production in low-income countries, along with the plausibility of policy shifts in dealing with climate change-related crises. In addition, Oxfam sees benefit in the report covering how climate change will affect issues of nutrition, diet, and dietary behavior, globally and regionally, as well as providing some insights on the cascading effects of climate change on U.S. agricultural and food systems on the global market. Other questions of interest include understanding how nations might deal within the linked global food systems in the face of disaster, including addressing the trade-offs for increasing global linkages within the system and the implications of decisions to exit the global food system, particularly as a consequence of inadequate presence or access to risk management strategies.

#### **4.8 Diana Liverman: National Climate Assessment and Development Advisory Committee Perspective (NCADAC)**

Diana Liverman, a NCADAC member, noted that the 2013 U.S. National Climate Assessment (NCA) considered food security, however the report did not cover the topic within the context of the connections between regional, national, and global food systems. Inherently global in nature, regional-, national-, and global-scale food system interactions and operations are affected by what goes on in the rest of the world. The NCA's readers would benefit from content that includes this international perspective on the function of food system, food security, and the effects of climate change. Moreover, some of the world's biggest companies rely on global supply chains for their profitability; if other parts of the world suffer, it will affect U.S. exports, U.S. profits, and the nation's ability to do business. Connections between food insecure people and global and national supply chains, retail, and the corporate "bottom line" will affect decisions made both within the global and U.S. food industries, and by decision makers worldwide. Moreover, from a consumer point of view, the international food system affects local markets, with global food price increases causing related costs to rise in key consumer products. As a result, the international food system context provides a critical perspective that helps producers, decision makers, and consumers better understand future trends within the U.S. food system, as well as the effects of global-scale food security on the nation.

#### **4.9 Bob Watson: The Role of the Assessment and Food Security Issues**

Global food security is central to environmentally sustainable development. Food production must be economically, environmentally, and socially sustainable, but if global decision makers sacrifice current production for sustainability, the world will have more food insecure people instead of fewer. To achieve both sustainable development and food security will require identifying how to maximize the value of relevant ecosystem services, with some studies suggesting that a radical redesign of the global food system will be needed to achieve the desired ends.

Watson warns that just looking at agriculture and climate change is not enough. There is a need to think through natural climate variability and post-harvest loss.

Addressing hunger might be achieved with current technologies, with advanced biotech possibly used to address future productivity requirements – especially given the growing numbers of the global population whose incomes are rising. Future technologies might increasingly emphasize agro-ecological practices (e.g., no/low till, integrated pest management, and integrated natural resource management), coupled with decreased post-harvest losses and food waste. Advanced biotechnologies may be needed to address future demands for increased productivity and emerging issues such as climate change and new plant and animal pests, but the risks and benefits must be fully understood. Additionally, global agriculture could contribute less to climate change if farmers were paid to maintain and enhance ecosystem services.

In the next 20-50 years, a vibrant agricultural sector will be needed to feed the world, stimulate growth, and ensure equal access to food. Climate change that will occur through the 2030s is inevitable due to inertia in the climate system. With climate change mitigation, currently projected changes may be significantly reduced beyond that time. To respond to climate change, a need exists to integrate agriculture, economics, environment, and social sustainability into policies, practices, and technologies. The USDA report may benefit from incorporation of some or all of these considerations.

## **5.0 Scope: Climate Change, Global Food Security, and the U.S. Food System Report**

To study some of the effects of climate change on global food security, and to better understand the cascading consequences of climate change and global food security on food systems, the USDA has tasked a team of authors from the Federal service, universities, and the international community to write a technical report. The report will begin by looking at areas of intersection between global food security and climate change. In addition to investigating the worldwide effects of climate change and food security, the report will consider the influence that these effects have on global and U.S. food systems; food systems include food production, transportation, storage, processing, etc. (see Box 3), as well as provision of food aid, and wholesale and retail trade.

The USDA technical report will explore how climate and food security interconnect globally, including economic feedbacks. Building from these initial explorations of cause, effect, and possible repercussions, the authors hope to generate scenarios that provide a sense of how these effects will play out over time in a changing climate.

Scenario development will consider the effects of future climate change and socio-economic development to help assess future food security 25 and 100 years in the future. Challenges abound in developing realistic scenarios. Considerations include the degree to which current technological conditions apply into the future, how scenarios include estimates of future climate change adaptation strategies and technologies such as different agricultural management techniques or new economic tools, and projections of future economic conditions.

This information will then be used to assess what these outcomes will mean for the global food system. With an understanding of how global food systems change under scenarios of changing climate and the related effects on global food security, the focus will return to U.S. food systems. The initial global viewpoint on food security and food systems will be essential given the degree to which international food system dynamics influence U.S. food systems, with effects ranging from costs of food and related products, to transportation and production logistics, to changes in demand.

Based on discussion at the workshop, the technical report is now anticipated to have four developmental sections. The first will explore current connections between global food security and climate change and the many ways in which the two areas intersect. Socioeconomic scenarios will be developed and discussed in the second section, providing analysis and tools to anticipate possible changes in food security outcomes due to climate change occurring in the next 25 and 100 years. The third section will analyze consequences for global food systems of the changes projected in the scenarios, and the final section will consider on the consequences for U.S. food systems.



## Appendix A: Workshop Attendees

Peter Backlund  
Director of NCAR External Relations  
and the Integrated Science Program  
NCAR

Molly Brown  
Research Scientist  
NASA

Michael Budde  
Geographer  
USGS

Jean Buzby  
Chief of the Diet, Safety, and Health  
Economics Branch  
USDA Economic Research Service

Jared Creason  
Office of Air and Radiation/Office of  
Atmospheric Programs  
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Greg Degen  
Advisor, Global Climate Change  
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Christopher Delgado  
Economics and Policy Adviser  
Agriculture and Environmental Services  
Department  
The World Bank

Bill Easterling  
Dean of the College of Earth and  
Mineral Sciences  
The Pennsylvania State University

Rob Flynn

Development Consultant  
School of Media and Public  
Affairs/Center for Innovative Media  
The George Washington University

John Furlow  
Climate Change Specialist  
USAID

Jerry Glover  
Senior Sustainable Agricultural Systems  
Advisor  
USAID

Bill Hohenstein  
Director  
USDA Climate Change Program Office

Kathy Jacobs  
Assistant Director for Climate  
Adaptation and Assessment  
OSTP, Energy and Environment Division

Jenna Jadin  
AAAS Fellow/Advisor  
USDA Office of the Chief Scientist

Rick Leach  
CEO  
World Food Programme USA

Diana Liverman  
Co-Director, Institute of the  
Environment, University of Arizona and  
Visiting Professor and Senior Research  
Fellow in the Environmental Change  
Institute, Oxford University

Hector Maletta  
Professor at the Graduate School of  
Social Sciences  
Universidad de Buenos Aires

Anthony Murray  
Economist  
USDA Economic Research Service

Moffatt Ngugi  
Program Analyst for Climate Change in  
Agriculture  
USAID/USDA-Foreign Agricultural  
Service

Brian Peniston  
Director, Himalaya Program  
The Mountain Institute

Kimberly Pfeifer  
Head of Research  
Oxfam America

John Reilly  
Senior Lecturer and Co-Director of the  
Joint Program on the Science and  
Policy of Global Change at the Center  
for Environmental Policy Research  
MIT Sloan School of Management

Ana Rios Galves  
IDB Climate Change Senior Associate  
Inter-American Development Bank

Stacey Rosen  
Agricultural Economist  
USDA Economic Research Service

Martha Schlicher  
Bioenergy Technology Lead  
Monsanto Company

Claudia Tebaldi  
Senior Scientist, Climate Statistics  
Climate Central

Prasad Thenkabail  
Research Geographer

USGS

Margaret Walsh  
Ecologist  
USDA Climate Change Program Office

Robert Watson  
Chief Scientific Advisor, UK Department  
for Environment, Food and Rural  
Affairs, Professor of Environmental  
Sciences, University of East Anglia, and  
Director of Strategic Development,  
Tyndall Centre for Climate Change