Global Partnership on Climate Change

The American Society of Agricultural and Biological Engineers (ASABE) has a long history of providing resources to help its member engineers solve problems in food, agriculture, natural resources, and the environment. In 2012, the ASABE implemented an initiative toward achieving its global vision, recognizing the need to connect its members and partner societies to address emerging challenges as a global community:

"ASABE will be among the global leaders that provide engineering and technological solutions toward creating a sustainable world with abundant food, water, and energy, and a healthy environment."

In spring 2015, ASABE published "Global Partnerships for Global Solutions: An Agricultural and Biological Engineering Global Initiative," which identified six goals related to the challenges of food security, energy security, and water security in the context of sustainability and climate change. To explore these issues further, ASABE is hosting a series of Global Initiative Conferences in locations around the world. This paper reports on the first of those conferences, which focused on climate change.

The Challenge

Climate change is a global concern, as evidenced by the annual conferences held by the United Nations Framework Convention of Climate Change (UNFCCC), particularly the 1997 conference that established the Kyoto Protocol.

In December 2009, the Copenhagen Accord was drafted by the U.S., China, India, Brazil, and South Africa. The Copenhagen Accord recognized that climate change is one of the greatest challenges of the present day and that actions must be taken. The draft Accord was debated by all the participating countries but did not pass unanimously. Many countries and non-governmental organizations initially opposed the agreement; however, 141 countries signed the Copenhagen Accord by January 2010.

The 2015 Paris Conference, sponsored by the United Nations and referred to as COP21, achieved a legally binding agreement to keep global warming below 2°C. Following the COP21 agreement, climate change demanded a global effort in biological and agricultural engineering to guarantee economically and environmentally sustainable agro-ecosystems while meeting the needs for food, water, and energy of future generations.

These actions indicate a growing global concern about the challenge of climate change. How we respond to this challenge is one of the most pressing questions of our time. Current research indicates that two complementary approaches must be applied: adaptation and mitigation. The 2009 report from the U.S. National Agricultural Biotechnology Council (NABC) indicates that agriculture produces about 10% of global greenhouse gas (GHG) emissions (CO_2, CH_4, N_2O, etc.) and states that agricultural production systems must mitigate their GHG emissions while adapting to the stresses of climate change. The report identifies multiple adaptation strategies and emphasizes the importance of education (bringing climate change to classrooms and informing the public), climate modeling with increased resolution and reduced uncertainty, soil science as a basis for plant breeding (in addition to a sink for carbon), and economics and policy, with the intent that scientists must educate policymakers and the public about climate change and its impact on food production.

The 2014 U.S. National Climate Assessment report recognizes that the effects of human-induced climate change are being felt throughout the U.S. Greater climatic extremes are being manifested through increased droughts, floods, heat waves, wildfires, and forests that are under assault from invasive, heat-loving insects. These extreme events are already affecting our ecosystems (including agricultural, urban/suburban, aquatic, wetlands, forests, coastal, etc.), while glacial melting, sea level rise, and saltwater intrusion in coastal areas are stressing our water resources.

ASABE's Response: The ASABE 1st Climate Change Symposium

As a first step in responding to this challenge, ASABE organized the "ASABE 1st Climate Change Symposium: Adaptation and Mitigation," which was held on 3-5 May 2015 in Chicago, Illinois. The symposium was organized around the following topics:

- Adaptation strategies.
- Mitigation strategies.
- Ecosystem health and ecosystem services.
- Agro-ecosystem sustainability (economic, environmental, and human health).
- Climate change modeling and interfacing climate models with agro-ecosystem models.
- Uncertainty and complexity.
- Water resources policy.

Recognizing the need for partnerships to address the challenges of climate change, ASABE reached out across disciplines and national boundaries to bring together a diverse group of professionals from a range of organizations, including the USDA National Institute of Food and Agriculture, the National Oceanic and Atmospheric Administration, the U.S. Geological Survey, Land Grant and other universities, as well as representatives from other countries and regions, including Canada, South America, Asia, and Europe. Presentations by agricultural and biological engineers, hydrologists, soil scientists, atmospheric scientists, plant biologists, animal scientists, and others referred to the alarming stress that climate change is imposing on production systems, water resources, and ecosystems. The presenters provided research results on modeling and monitoring strategies for adapting to climate change and methods and technologies for mitigating GHG emissions. The conference proceedings, consisting of 122 extended abstracts, are available from ASABE (see "Further Reading"). Highlights of presentations for each topic area are included in the following sections.

Adaptation strategies

The presentations reiterated that we are already experiencing changes in climate, as evidenced by longer summers, more severe storms, species migrations, uneven spatial and temporal distributions of precipitation, and melting of glaciers and ice caps. These changes are affecting the availability of natural resources. For example, rising water tables in coastal areas take land out of production, reduce access to clean water for domestic use, and affect the quality of water by exacerbating flooding and pollution. Adaptation strategies, informed by research and education, must be developed to sustain agriculture without further harm to our ecosystems. Adaptation strategies described at the conference included:

- Incorporating non-stationary climate information, producer awareness, and economics for sustainable crop production into management decisions.
- Employing satellite, unmanned aircraft, and modeling tools to collect climate information (precipitation, temperature, drought periods, etc.) that affect crop production.
- Mist cooling over the crop canopy to cope with increased climate induced drought.
- Modeling approaches to evaluate BMP efficiencies in reducing pollutant discharges under diverse and changing climate conditions.
- Using biochar for both adaptation and mitigation. Sustainable biochar systems can be carbon negative by transforming carbon from farm or other biomass waste into stable carbon, which can remain sequestered in soils for the long-term. In addition, surface modification of biochar with nanoparticles and other physical treatments can increase soil water storage and the sorption of noxious chemicals in the soil and reduce water pollution.

- Combining controlled drainage and modeling to find ways to adapt to climate change induced hydroperiods. Compared to overdrainage, controlled drainage limits GHG emissions and can serve to mitigate rising temperatures.
- Developing alternate beef cattle feeding plans to adapt to decreasing productivity associated with the effect of global warming on pasture capacity.

Mitigation strategies

Symposium participants showed that mitigation strategies must include more than mitigating GHG emissions. To sustain agro-ecosystem services (such as food and fiber production) in a changing climate, mitigation strategies in the form of best management practices (BMPs) must be implemented to ensure efficient use of all our natural resources (soil, water, and air). Research, education, management, and policy must emphasize mitigating the effects of climate change, as well as adapting to those effects, through efficient water use and environmentally sustainable crop and animal production systems. Recommendations for mitigation strategies discussed during the symposium included:

- Develop relationships between soil organic matter and bioenergy production, offering a balanced approach between biomass production and its impact on soil organic matter.
- Assist dairy farmers to install digesters to capture and use methane and reduce greenhouse gas emissions.
- Develop mitigation practices to adjust to an imbalance in carbon fluxes between grassland soils and the atmosphere due to increases in atmospheric carbon dioxide associated with climate change.

Ecosystem health and ecosystem services

Despite the immense societal benefits that agriculture provides, there is clear evidence that agriculture is also associated with local and regional decreases in ecosystem health. For example, most models of climate change predict an increase in flooding in the mid-Atlantic region of the U.S. Hydrology is essential to the function and extent of wetlands; thus, changes in hydrologic conditions will affect the ability of wetlands to provide ecosystem services that are important to: (1) agricultural prosperity, such as crop production; (2) long-term environmental sustainability, such as reduction of sediment and pollutants; (3) mitigation of climate impacts, such as carbon sequestration; and (4) regulation of pestiferous insects, such as disease-carrying mosquitoes. Understanding the relationships among climate variables, wetland nutrient filtering and hydrology, and biotic communities, including vegetation, stream macroinvertebrates, and waterfowl, can help us assess the impacts of climate change on fragile ecosystems. Recommendations for improving our understanding of ecosystem health and services examined by participants included:

- Link groundwater withdrawals to available water resources, ecosystem health, and ecosystem services under climate change conditions.
- Quantify the impacts of management policies that have led to environmental degradation and poverty, and assess their linkages to current climate change and future projections.

Agro-ecosystem sustainability (economic, environmental, and human health)

Sustainability generally refers to the ability of a system to maintain a balance of processes or conditions. In ecology, sustainability is the ability of an ecosystem to maintain ecological processes, functions, biodiversity, and productivity into the future. Sustainability loses its dictionary meaning when confronted by poverty, inequality, global warming, food insecurity, water scarcity, and the lack of ecosystem health and human health in many parts of the world. According to a 2002 report by the United Nations' Development Program, more than one billion people lack access to clean water and proper sanitation. Maintaining ecosystem sustainability in a changing climate requires economic and environmental strategies that also guarantee the sustainability of our production systems, for both ecological health and human health. Recommendations for improving agro-ecosystem sustainability included:

- Develop a systems approach for integrating climate forecasts with sustainable crop production.
- Use total factor productivity (TFP), a measure of aggregated output produced per unit of aggregate input. Climate change makes TFP vulnerable and affects the production economy.
- Adapt sowing dates to temperature and soil moisture changes under different climate scenarios.
- Use seasonal-scaled forecasting to make informed decisions about farming operations.
- Evaluate farm emissions using the Integrated Farm Systems Model (IFSM).
- Use seasonal agro-climate forecasts and crop models as long-term decision tools (www.agclimate.org).

Climate change modeling and interfacing climate models with agro-ecosystem models

Climate models are generally large-scale models (regional or continental scale) and therefore are often very coarse. On the other hand, hydrologic and water quality models are typically applied to agro-ecosystems that range from field scale to watershed scale, while crop models are typically applied at point scale to field scale. Interfacing these different modeling scales is necessary to forecast the impact of climate change on agro-ecosystems at the farm scale as well as the global scale. Model-based results and recommendations for improving agro-ecosystem sustainability included:

- Use climate and landscape models to quantify the impact of climate change on hydrologic processes.
- Use crop models (such as DSSAT, etc.) and agro-hydrological models (such as SWAT-CUP) to identify critical source areas (CSAs) under future high emissions, thus planning for effective BMPs to alleviate high runoff, sediment, and phosphorus discharges.
- Consider that elevated levels of carbon dioxide in the atmosphere may result in increased grain yields due to climate change.
- Consider that increased temperatures may increase photosynthesis, thus increasing crop water uptake that balances out the increased precipitation amounts in terms of water budget. Increased temperatures may also create more diseases for crops, animals, and humans.

Uncertainty and complexity

The relationships among weather, climate, crop yields, and natural resources, as well as between yield and income, are complex. Climate scientists, agronomists, economists, and others must work collaboratively to explore how a changing climate may influence agricultural and natural ecosystems and, subsequently, agricultural profitability and livelihood. Projections from oversimplified models that fail to consider the complexity and uncertainty of these integrated systems can undermine adaptation and mitigation strategies. For example, in 2013, the Agricultural Modeling Intercomparison and Improvement Project (AgMIP) reported that the uncertainty introduced in future projections of wheat yield by the choice of yield model was as large or larger than the uncertainty introduced by an ensemble of climate projections. Sessions presented by the AgMIP group in ASABE’s 1st Climate Symposium discussed such uncertainties as part of their presentations. Researchers must evaluate the assumptions behind their models and the uncertainty surrounding all model components, rather than just the uncertainty of the climate information.

Water resources policy

According to a 2011 Overseas Development Institute report, “water will be the primary medium through which the climate change impacts will be felt.” Water scarcity in many parts of the world, unsanitary conditions due to limited freshwater resources, yield loss in agro-ecosystems due to water shortages, and the shrinking lakes and aquifers around the world are all testament to a growing water crisis that poses a significant challenge to humanity that will likely exacerbate in the near future. Therefore, policies regarding water resources and water conservation must be established at regional, national, and global levels. A collective message from the keynote speakers at ASABE’s 1st Climate Change Symposium in

2015 addressed this alarming threat to our water resources and called for the development of strategies to adapt to it.

The Path Forward

ASABE's 1st Climate Change Symposium reinforced the understanding that multi-disciplinary and multi-institutional collaborations are needed to meet the national and global challenges related to climate change. In short, the symposium's findings are as follows:

- We are facing existential problems related to climate change, as we are challenged to satisfy basic human needs while enhancing environmental quality and sustaining economic vitality for an increasing world population.
- We must deal with tremendous uncertainty, including the uncertainty of our predictions and assumptions; therefore, we must use a systems approach to identify the sources of uncertainty, rigorously verify our results, and rely on our proven strengths.
- Agricultural and biological engineers have the ability to improve lives by responding to this challenge. Our work will benefit the world, and it would do so even without the impetus of climate change. The reality of climate change makes our work essential.

Our consensus is that a global partnership must be formed to extend our knowledge, share our experience, and form a united strategy for adapting to climate change and mitigating its effects. The 1st Climate Change Symposium is an example of that effort, as ASABE successfully brought together scientists, engineers, and other experts from a variety of backgrounds and regions. Similar multi-disciplinary efforts and improved communication will lead to workable solutions and an informed society. This symposium led to a collection of papers that are available to the scientific community on a global level. In addition, it brought together agency leaders, such as the director of the USDA National Institute of Food and Agriculture (NIFA) and the national director of USDA Climate Hubs, with engineers and scientists for a meaningful discussion on the vital topic of climate change adaptation and mitigation, especially as related to agro-ecosystems.

ASABE is committed to leading this global engagement, and including partners from other engineering societies and professional organizations from around the globe, to address the challenges of climate change.

Further Reading

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