How will Climate Change Affect Agriculture?

Agriculture and climate change are inextricably linked—crop yield, biodiversity, and water use, as well as soil health are directly affected by a changing climate.

Climate change, which is largely a result of burning fossil fuels, is already affecting the Earth's temperature, precipitation, and hydrological cycles. Continued changes in the frequency and intensity of precipitation, heat waves, and other extreme events are likely, all which will impact agricultural production. Furthermore, compounded climate factors can decrease plant productivity, resulting in price increases for many important agricultural crops.

Impacts of Climate Change

Hydrologic: The hydrologic cycle now includes more frequent and intense droughts and floods in many agricultural regions. These events can damage and at times even destroy crops.

Heat: Over the next 30-50 years, average temperatures will likely increase by at least 1.0 °C. Anticipated regionally-dependent changes include increase number of heat waves and warm nights, a decreasing number of frost days, and a longer growing season in temperate zones.

CO_2: Over the next 30-50 years, CO_2 concentrations will increase to about 450 parts per million by volume (ppmv). The CO_2 response is expected to be higher on C_3 species (wheat, rice, and soybeans), which account for more than 95% of world's species than on C_4 species (corn and sorghum). C_3 weeds have responded well to elevated CO_2 levels, symbolizing the potential for increase weed pressure and reduced crop yields.

Crop Biodiversity: The distribution of wild crop relatives, an increasingly important genetic resource for the breeding of crops, will be severely affected leading to fragmentation of the distribution and even extinction.

Economic Consequences: Price will rise for the most important agricultural crops–rice, wheat, maize, and soybeans. This, in turn, leads to higher feed and therefore meat prices. As a result, climate change will reduce the growth in meat consumption slightly and cause a more substantial fall in cereals consumption, leading to greater food insecurity.

How Do We Predict Climate Change Impacts?

Climate models have been developed that consider social and economic factors (population and carbon emissions). By combining these factors with an understanding of global and regional climate science, experts have developed **climate scenarios** that express the potential for different behaviors to impact climate patterns. **Climate scenarios** have the ability to inform our choices about the likely impacts of temperature, precipitation, and seasonality on food production. They also allow us to guide agricultural sectors on the best methods to adapt to various climate consequences by evaluating impacts and identifying tradeoffs.

What are the Agricultural Impacts and Tradeoffs?

- The net effect of climate change on world agriculture is likely to be negative. Although some regions and crops will benefit, most will not.
- While increases in atmospheric CO_2 are projected to stimulate growth and improve water use efficiency in some crop species, climate impacts, particularly heat waves, droughts and flooding, will likely dampen yield potential.
- Indirect climate impacts include increased competition from weeds, expansion of pathogens and insect pest ranges and seasons, and other alterations in crop agroecosystems.

How Can Agriculture Adapt?

Adaptation strategies are short and long-term changes to human activities that respond to the effects of changes in climate. In agriculture, adaptation will require cost-effective investments in water infrastructure, emergency preparation for and response to extreme weather events, development of resilient crop varieties that tolerate temperature and precipitation stresses, and new or improved land use and management practices.

Tools for Adaptation

- Crop breeding for development of new climate tolerant crop varieties is a key tool for adapting agriculture to a changing climate. History and current breeding experience indicate that natural biodiversity within crops has allowed for plant adaptation to different conditions, providing clear evidence that plant breeding has great potential to aide in the adaptation of crops to climate change.
- Cropping system development is another tool that can help agriculture adapt. For example the use of crop mixtures that have several crops growing at one time can help systems exhibit greater durability during periods of high water or heat stress.

C_3 and C_4 carbon fixation are biochemical mechanisms in plants that fix CO_2 to make carbohydrates through photosynthesis.

- C_3 plants take CO_2 directly from the air during carbohydrate production whereas C_4 plants first concentrate CO_2 and produce malate, an organic compound, inside the plant, which then enters the photosynthesis cycle. Thus, C_4 plants will respond less to increased CO_2 levels.

Cropping systems determine how crops are grown, by determining the arrangement of crops in time and space and the way in which they are planted (density), fertilized, irrigated, weeded, and harvested.

What Are Our Research and Development Needs?

- Development of drought-resistant crops that have been tested for strong yields when subjected to periods of extended water shortage.
- Improvements in plant nitrogen and water use efficiency and development of cost-efficient nitrogen uptake delivery systems and low-cost, high efficiency irrigation techniques
- Development of global testing sites and data collection and dissemination efforts, using standard data protocols, to assess the performance of existing and new genetic material and management systems in today's range of agroclimatic conditions
- Continuous field testing to track climate change, breeding for resistance to new diseases and pests and to address changes in pollinator distribution have been identified as avenues to confront adaptation of crops in the face of climate change.
- Development of assessment tools that incorporate the biophysical constraints that affect agricultural productivity and include climate and socioeconomic scenarios, including improved characterization of policy and program environments and options.

Biographies of Speakers

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Dr. Gepts is an agronomy and range science professor with an extensive international research and teaching program focused on the evolution of crops under cultivation which are important to human diets around the world. A widely published researcher and co-author of a background chapter evaluating the effects of transgenic maize on maize diversity in Mexico for the NAFTA Commission on Environmental Cooperation, Dr. Gepts' is an elected fellow of the American Association of the Advancement of Science and the American Society of Agronomy.

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Dr. Izaurralde is also an adjunct professor in the departments of Geography and the Natural Resource Sciences and Landscape Architecture. Dr. Izaurralde is a soil scientist with more than 30 years of research experience in agronomy, soil science, and ecosystem modeling.

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Dr. Nelson is an agricultural economist with over 30 years of professional and research experience in the areas of agriculture, policy analysis, land use and climate change. As co-leader of IFPRI's global change program, he is responsible for developing IFPRI's research in climate change modeling and spatially explicit assessments of potential adaptation and mitigation programs and policies.

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Dr. Rosenzweig has organized and led large-scale interdisciplinary regional, national, and international studies of climate change impacts and adaptation. She is a co-chair of the New York City Panel on Climate Change and co-led the Metropolitan East Coast Regional Assessment of the U.S. National Assessment of the Potential Consequences of Climate Variability and Change.

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