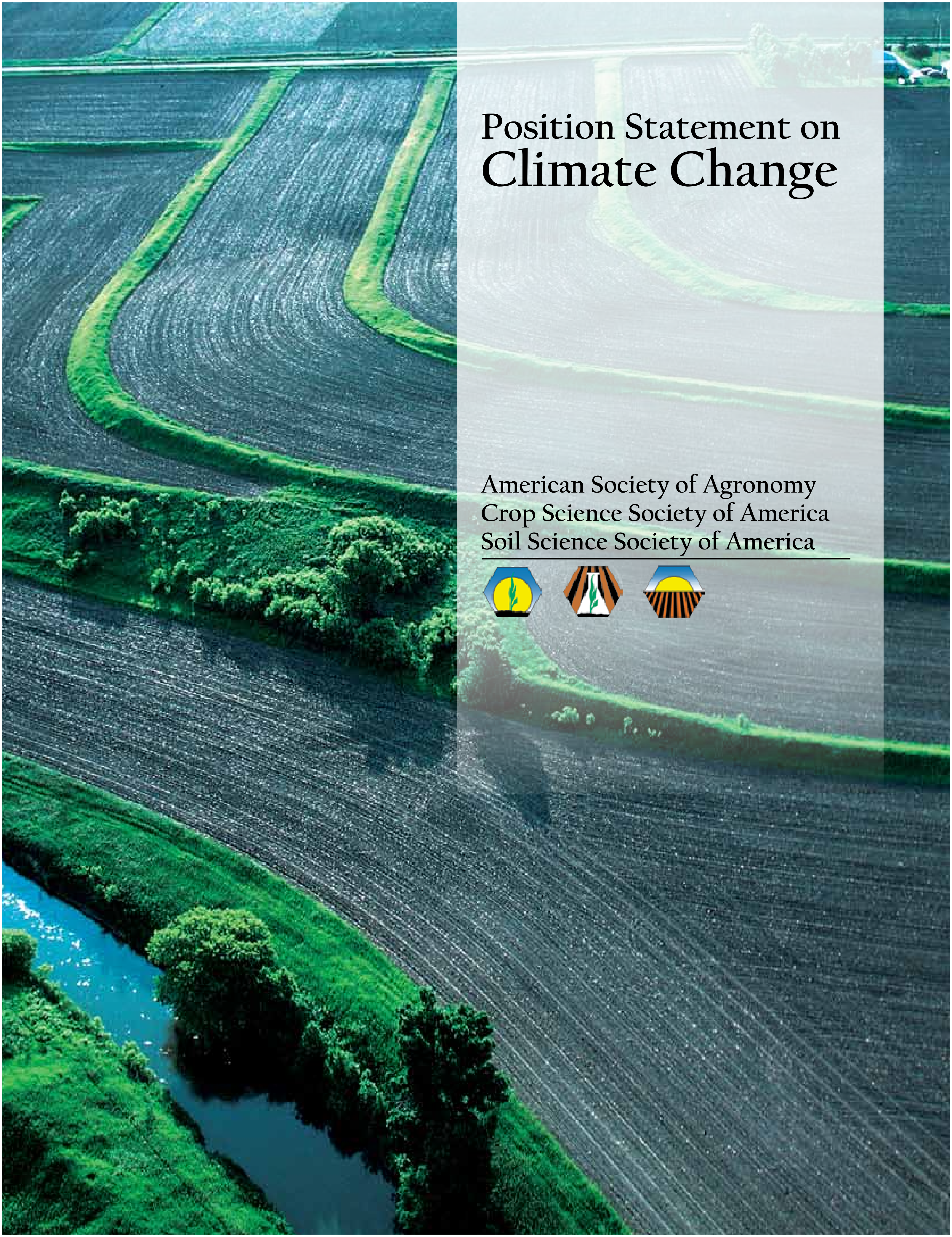

Position Statement on Climate Change

American Society of Agronomy
Crop Science Society of America
Soil Science Society of America

American Society of Agronomy | Crop Science Society of America | Soil Science Society of America

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The American Society of Agronomy (ASA) is an international scientific society, founded in 1907, with 8,000+ members who work to advance the disciplines and practices of agronomy by supporting professional growth. ASA members include scientists, graduate and undergraduate students, and practitioners who are experts in land management, agroclimatology, education and extension, environmental quality, international agronomy, and integrated systems.

The Crop Science Society of America (CSSA), founded in 1955, is an international scientific society comprised of 6,000+ members with its headquarters in Madison, WI. Members advance the discipline of crop science by acquiring and disseminating information about crop breeding and genetics; crop physiology; crop ecology, management, and quality; seed physiology, production, and technology; turfgrass science; forage and grazinglands; genomics, molecular genetics, and biotechnology; and biomedical and enhanced plants.

The Soil Science Society of America (SSSA) is a progressive, international scientific society that fosters the transfer of knowledge and practices to sustain global soils. Based in Madison, WI, and founded in 1936, SSSA is the professional home for 6,000+ members dedicated to advancing the field of soil science, providing information about soils in relation to crop production, environmental quality, ecosystem sustainability, bioremediation, waste management, recycling, and wise land use.

Citation: Climate Change Position Statement Working Group. 2011. Position Statement on Climate Change. Working Group Rep. ASA, CSSA, and SSSA, Madison, WI, May 11, 2011.

Preamble

The American Society of Agronomy (ASA), Crop Science Society of America (CSSA), and Soil Science Society of America (SSSA) have developed the following position statement on climate change based on a review of current scientific knowledge and understanding. Because the potential changes in climate are significant for the practice of agriculture and land management, ASA, CSSA, and SSSA issue this statement to describe the state of the science and facilitate ongoing discussion, decision-making, and research. The statement expresses the findings of a panel of scientists with national and international expertise in climate processes and impacts, mitigation strategies, and adaptation methods for natural and managed ecosystems.[1]

1 This statement will be updated periodically as new evidence and understanding of climate change evolves. For more information on ASA, CSSA, and SSSA activities and policies visit the society websites (www.agronomy.org, www.crops.org, and www.soils.org).

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I. Introduction

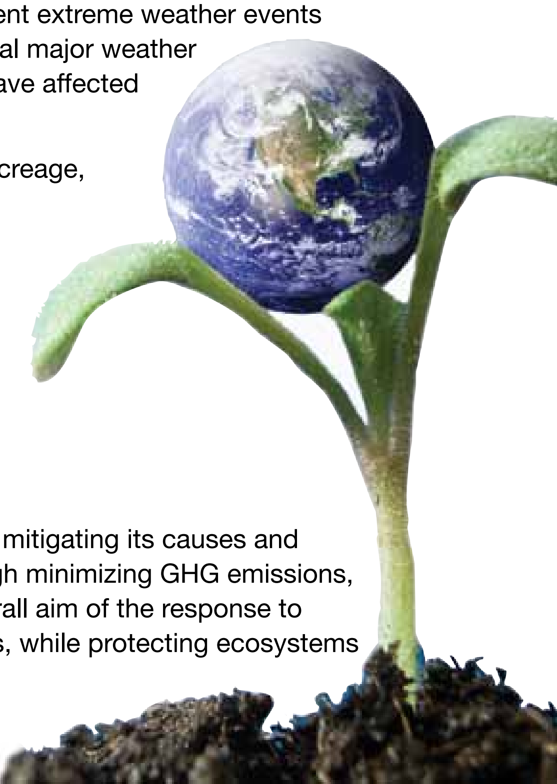
A comprehensive body of scientific evidence indicates beyond reasonable doubt that global climate change is now occurring and that its manifestations threaten the stability of societies as well as natural and managed ecosystems. Increases in ambient temperatures and changes in related processes are directly linked to rising anthropogenic greenhouse gas (GHG) concentrations in the atmosphere. The potential related impacts of climate change on the ability of agricultural systems, which include soil and water resources, to provide food, feed, fiber, and fuel, and maintenance of ecosystem services (e.g., water supply and habitat for crop landraces, wild relatives, and pollinators) as well as the integrity of the environment, are major concerns.

Around the world and in the United States (US), agriculture—which is comprised of field, vegetable, and tree crops, as well as livestock production—constitutes a major land use which influences global ecosystems. Globally, crop production occupies approximately 1.8 Billion (B) hectares out of a total terrestrial land surface of about 13.5 B hectares. In addition, animal production utilizes grasslands, rangelands, and savannas, which altogether cover about a quarter of the Earth's land. Even in 2010, agriculture remains the most basic and common human occupation on the planet and a major contributor to human well-being.

Changes in climate are already affecting the sustainability of agricultural systems and disrupting production. While climate is the average weather conditions in given locations over multiple decades, weather consists of the hourly and day-to-day variations in temperature, precipitation, and other variables. In many places around the world, increased incidence of extreme events such as heatwaves, droughts, and floods have been documented.

Although no singular event can be attributed to climate change, collectively recent extreme weather events have had a significant impact on agricultural production. There have been several major weather events in Iowa, the Northern Great Plains, Europe, Australia, and Ukraine that have affected agriculture, for example:

- The 2008 floods in Iowa which affected nearly 10% of corn and soybean acreage, causing over $1 B in losses to crops, livestock, property, and income;
- back-to-back 100-year floods in the Northern Great Plains during 2009 and 2010;
- extreme heatwaves during the summer of 2003 in Europe;
- recent multi-year droughts in Australia that peaked in 2007;
- the 2010 failure of the Ukrainian grain crop;
- and devastating drought in Niger during the summer of 2010.



Agriculture has an important role to play in responding to climate change, both mitigating its causes and adapting to its unavoidable impacts. Agriculture contributes to mitigation through minimizing GHG emissions, sequestering atmospheric carbon, and sustainably producing biofuels. The overall aim of the response to climate change is to ensure food security and other essential human enterprises, while protecting ecosystems and their vital services.

The agricultural sector faces a significant challenge: to increase global production for the purpose of providing food security for 9 billion people by the middle of the 21st century, while also protecting the environment and enhancing function of global ecosystems. Rising and more volatile food prices are also threatening food security. This challenge is further compounded by factors of climate change that now require mitigation and reduction of agricultural GHG emissions, sequestration of carbon in soils, and aversion of factors that limit agricultural production. Therefore, agricultural practices must be developed and applied to mitigate climate change and adapt cropping systems to the portending changes, so as to ensure adequate production of food, feed, fiber, and bioenergy, as well as protection of natural resources.

The American Society of Agronomy (ASA), Crop Science Society of America (CSSA), and Soil Science Society of America (SSSA) are dedicated to seeking ways to mitigate climate change to the extent possible, and to adapt the practices of agriculture and other land uses to the climate manifestations that cannot be prevented.

Climate Effects on Crops

- **Higher temperatures and heatwaves** affect the growth and development of crops, influencing potential yields. A critical variable is the numbers of days a crop is exposed to temperatures exceeding specific thresholds during critical growth stages—e.g. flowering, pollination, fruiting, or grain filling – reducing the quantity and quality of yield.
- **Changes in the patterns of precipitation** alters water supply for crops. Climate change is expected to destabilize pre-existing rainfall regimes in many regions, resulting in changes in duration and intensity of flooding episodes and periods of drought. This is likely to increase the extent and intensity of erosion, water-logging, and periods of desiccation, with negative effects on yields.
- **Increased atmospheric carbon dioxide (CO_2)** concentrations may have positive effects on some crops, the effects being species-dependent. The photosynthesis, growth, and yield of C3 plants such as wheat and rice tend to benefit more from high CO_2 than do C4 plants such as maize. Higher CO_2 in the air also increases the efficiency of water use by crops.
- **Changes in temperature, precipitation, and CO_2 will interact with other environmental stresses,** such as ozone, which tend to reduce crop productivity.

II. Key Concerns for Agriculture

Unless the emissions of GHGs are curbed significantly, their concentrations will continue to rise, leading to changes in temperature, precipitation, and other climate variables that will undoubtedly affect agriculture around the world. These projections hold significant repercussions for water, carbon, and nutrient cycling in agricultural and natural ecosystems. Global temperatures rose 1.25 degrees F (0.75 degrees C) in the 20th century, and are projected to increase 3.22 to 7.20 degrees F (1.8 to 4.0 degrees C) by the end of the 21st century. Changes in temperature have already begun to affect crops, water availability, and pests in some areas. Such changes have advanced spring green-up of perennial crops in the Northern Hemisphere, and contributed (along with drier conditions) to an increase in forest fires and pests in North America and the Mediterranean Basin. These effects are projected to become increasingly severe as climate change becomes more pronounced.

Crop production will face increasing challenges linked to climate change. Even though long-term projections suggest that temperatures will increase gradually, potential increases in variations of temperature and rainfall can produce profound impacts on food and energy security. In near-term decades, higher CO_2 may provide some benefits to plant growth and water use, but these are likely to be offset by negative effects of rising temperatures and altered rainfall, especially in subsequent decades. Such impacts and their interactions will have region-specific and global effects on agricultural systems. Understanding the impacts of climate change variables and their progressive interactions is critical to developing agricultural systems that will enhance productivity even in a changing climate.

Climate Effects on Soils

- Higher soil temperatures alter nutrient and carbon cycling by modifying the habitat of soil biota, which in turn affects the diversity and structure of species and their abundance.
- Heavier downpours in some regions will lead to increased soil erosion. In addition increased precipitation will result in water-logging of soils, thereby limiting oxygen supply to crop roots and increasing emissions of nitrous oxide and methane. Altered rainfall, whether through increased or decreased precipitation, will affect soil chemistry and biology.
- Soil water retention capacity will be affected by rising temperatures and by a decline in soil organic matter due to both climate change and land-management changes. Maintaining water retention capacity is important to reducing the impacts of intense rainfall and droughts, which are projected to become more frequent and severe.
- Prolonged spells of heat and drought between rainy periods may cause wilting, desiccation, and soil salinization, which may in combination reduce crop yields.
- Increased temperature and decreased moisture tend to accelerate the decomposition of organic material in soils, leading to a decline in soil organic carbon stocks and an increase in CO_2 emissions to the atmosphere.

Agriculture's Role in Temperature-Enhancing Gas Emissions

Carbon Dioxide

Carbon dioxide (CO_2) is the most abundant of the increasing greenhouse gases. Land plants fix atmospheric CO_2 via photosynthesis and respire part of it back to the atmosphere. When plant biomass is harvested, burned, or returned to the soil, much of the carbon in plant matter is oxidized and released as CO_2 to the atmosphere as a result of soil microbial respiration or direct combustion. Otherwise, plant matter exists in soil and is broken down over time.

Measured rates of soil carbon storage with the adoption of sequestering practices range from 100 to 1000 kg/ha/year, depending on climate, soil type, and site-specific management. Beneficial agronomic practices which increase yields, while also increasing organic residue in soil include:

- Use of improved crop varieties,
- Cultivation of cover crops,
- Incorporation of perennial crops into crop rotations (to allocate carbon belowground),
- Scheduling irrigation more efficiently,
- Conserving soil moisture, and
- Reducing or avoiding tillage and soil-baring fallow periods.

Carbon sequestration and land restoration practices can have compound benefits. While mitigating CO_2 emissions, they improve the productivity of the cultivated soil. Additionally, building soil carbon provides the indirect benefit of enhanced water filtering capacity, contributing to water quality and nutrient-use efficiency, while effectively increasing the adaptive capacity of soils and crops to climate change.

Methane

Methane (CH_4), is a short-lived gas with a low atmospheric concentration (only 0.5% that of CO_2), however its per-molecule absorption of infrared radiation is over 20 times stronger than CO_2. Agricultural sources of methane include flooded rice paddies, enteric (bacterial) fermentation by domesticated ruminants (e.g. cows, goats, bison, sheep, and buffalo), farm animal wastes, and biomass burning. Drainage of wetlands for agriculture can also result in methane emissions, as can thawing of permafrost in boreal (subarctic and subantarctic) regions. Furthermore, permafrost2 thaws increase with increasing temperature, resulting in greater methane emission and thus more warming.

2 Soil at or below the freezing point of water (0 °C or 32 °F) for two or more years.

Methods to reduce CH_4 emissions from livestock, the primary source of methane in North America, may include:

- genetic development,
- changes in feed formulation, and
- improved manure management.

Limiting CH_4 emissions from rice paddies requires adjustment of cultural practices, including crop, water, and nutrient management. Such practices involve changing:

- rice varieties,
- tillage techniques,
- planting dates,
- fertilization, and
- modes of irrigation.

Nitrous Oxide

Nitrous oxide (N_2O) is a persistent (mean residence time about 120 years) trace gas that is also a much stronger (>290 times) infrared absorber than CO_2. In the soil, N_2O evolves mainly from the metabolic process of soil microorganisms. Factors that determine the level of N_2O emissions include soil aeration, temperature, moisture content, soil texture and the amount of nitrogen fertilizer. Nitrous oxide also originates from the decomposition of livestock manure and other organic residues incorporated into the soil.

Specific agronomic techniques to reduce N_2O emissions include:

- adjusting nitrogen application rates to crop needs,
- improving the timing and placement of nitrogen additions to the soil,
- avoiding excess nitrogen applications,
- using fertilizer approaches that increase fertilizer-use efficiency and reduce N_2O emissions, and
- benefitting, when possible, from biological N fixation.

III. Mitigation Actions for Agriculture

Agricultural activities account for 10-15% of total global emissions of the three main greenhouse gases – CO_2, CH_4, and N_2O – although estimates vary. While agricultural, forest, and grazing land-management emit greenhouse gases, many opportunities exist to mitigate these emissions and to sequester carbon in the soil and in the biomass of perennial vegetation.

Effective climate change mitigation strategies reduce emissions of GHGs, while enhancing carbon sequestration from the atmosphere into stable forms in the soil and vegetation. The global mitigation potential for agriculture is estimated to range between 5,500 and 6,000 Mt CO_2-eq/yr through the large-scale application of practices that improve productivity, reduce GHG emissions, and conserve soil. Increasing soil carbon sequestration will produce additional benefits, enhancing soil fertility, as well as the resilience and adaptability of agriculture systems.

IV. Adapting to Climate Change

Adaptation refers to the process of system adjustment to changes in environmental conditions. It includes actions taken in response to actual climate changes and those that prepare for future climate changes, helping to reduce impacts and/or take advantage of benefits. Given the projected direction of climate change, management strategies can be identified that have the potential to achieve productivity goals in a changing environment while simultaneously enhancing environmental quality.

Currently Available Agricultural Adaptation Strategies

- **Increasing crop diversity** – including both widening the array of crop varieties and broadening the range of crops – can be an effective way to moderate the effects of weather variability and extreme events associated with climate change.
- **Use of drip irrigation can help to manage limited water supplies** more efficiently as hydrological regimes become more unstable and periods of drought become more severe.
- **Integrated pest management** is a means to help agricultural systems respond to changing pest regimes resulting from climate change.
- **Soil management** such as reduced tillage and residue management can be used to conserve water, reduce erosion, and increase soil productivity.

Stages of Adaptation:

As climate changes proceed in agricultural regions, there are three stages of adaptation related to the level of effort required.

Stage 1: When climate changes are relatively small, many current techniques are available to help farmers adapt. These early-stage adaptations include varying sowing dates and cultivars, fertilization, and irrigation scheduling; as well as changing to better-adapted alternative crops.

Stage 2: As climate change proceeds, more extensive changes may be needed including the genetic improvement of crops to create greater tolerance to elevated temperatures and drought and improved responsiveness to rising CO_2 and the development of new technologies.

Stage 3: In later decades, severe climate changes in agricultural regions may necessitate transformative shifts to entirely different agricultural systems, such as from temperate-zone to subtropical or semiarid-zone forms of agriculture.

V. Conclusion

Agricultural production will manifest large climate change impacts. There is pressing need to improve agricultural productivity for food security while simultaneously protecting the environment as climate is changing. The goal is to produce higher yields with reduced greenhouse gas emissions per unit of production and to conserve and enrich the organic content of soils, and to promote efficient water use, and ecosystem integrity. This goal can be implemented through advanced agronomic management aimed at intensifying and sustaining agricultural production and targeting breeding programs based on improved fundamental understanding of crop genetics and physiology, while preserving natural ecosystems in non-agricultural land.

Climate change has the potential to increase weather variability as well as gradually increase global temperatures. Both of these impacts have the potential to negatively impact the adaptability and resilience of the world's food production capacity; current research indicates climate change is already reducing the productivity of vulnerable cropping systems.

Appendix: Major Tasks for Climate Change

Research in Agriculture

For the agricultural sector to anticipate and respond to climate change, the research and development community must develop the knowledge and methods required to ensure food security and ecosystem services. As a result, intensified and focused research is needed in several broad areas.

To ensure food security in a changing climate

- Develop and evaluate locally-based adaptive management and mitigation strategies to enhance the resilience of cropping and rangeland/pasture production systems.
- Develop and employ transdisciplinary assessment tools that incorporate the systematic resource constraints that affect agricultural productivity and include climate and socioeconomic scenarios, including improved characterization of policy and program environments and options.
- Undertake integrated research in genetics, crop physiology, and soil-nutrient-water-crop management to enhance agricultural yields and environmental quality.
- Actively conserve genetic resources to safeguard these assets for use in the future development of improved varieties.
- Use private and public breeding programs to improve overall abiotic and biotic stress resistance of crops, increase nutrient and water use efficiency, and capitalize on atmospheric CO_2.

To understand the effects of elevated carbon dioxide and climate variability on soils and crops

- Advance understanding of the potential impacts of elevated abiotic stresses (increased CO_2, variable temperatures, and unpredictable precipitation patterns) on biological factors in managed and natural systems.
- Characterize interactions among plants, microbes, and soils that affect the resilience and adaptability of agroecosystems.

To improve efficacy of agricultural mitigation practices

- Adopt a whole-systems approach to greenhouse-gas mitigation in agroecosystems by incorporating assessments of both carbon and nitrogen cycling.
- Evaluate agronomic practices based on optimization of both soil carbon sequestration and nitrogen use efficiency.
- Study the role of microorganisms in soil carbon and nitrogen stabilization.
- Develop and incorporate life-cycle analysis to evaluate the energy efficiency of current and alternative farming practices at the local, regional, and national scale.

Carbon Dioxide

- Quantify carbon sequestration resulting from various management practices and evaluate and document other beneficial services, such as changes in soil quality, productivity, erosion, and water and air quality.
- Conduct long-term field studies that enhance process-based understanding and improve models to ensure carbon sequestration practices that result in soil carbon with long-term stability.
- Create programs that coordinate national and international on-farm measurements to reduce uncertainty in estimates of carbon stock change, incorporating existing datasets.
- Build a monitoring network of multiple sites to provide observations that support model-based systems which integrate information from existing long-term field experiments and are capable of using site-specific data on climate, soils, and management practices.
- Implement near-real time methodologies to document soil carbon changes over large areas using field observations, simulation modeling, and remote sensing.

Methane

- Research ways to reduce CH_4 emissions from enteric fermentation.
- Develop methods for livestock manure management that lessen CH_4 emissions.
- Improve efficiency of rice-production systems to reduce CH_4 emissions.

Nitrous Oxide

- Analyze the potential for nitrogen fertilizer-use reduction without negatively impacting crop quality as a climate-change mitigation strategy through studies of cover-crop management, residues, and microbial and physical processes that regulate soil nitrogen cycling and availability.
- Establish monitoring networks, field agricultural experimental sites, and measurement programs for indirect sources to create an inventory of accurate annual N_2O flux estimates in agriculture.

- Use appropriate biogeochemical simulation models that predict N_2O fluxes in simulations with scenarios of climate change.

To improve adaptation options

- Use appropriate models to define crop traits that can provide tolerance to environments with increased climate variability and that take advantage of rising CO_2.
- Develop drought- and/or heat-resistant crops that have been tested for yield stability when subjected to periods of extended water shortage.
- Organize long-term global testing sites and data collection and dissemination efforts, using standard protocols, to conduct adaptive breeding and assess the performance of existing and new genetic material and management systems in today's range of agroclimatic conditions.
- Establish continuous field testing programs to track climate change, resistance to new diseases and pests, and changes in pollinator distribution in order to address adaptation of crops. Field testing should extend beyond traditional areas of crops in order to begin anticipating the performance of crops and cropping systems to new environmental conditions.
- Conduct multi-climate and crop-model ensemble simulations to better characterize uncertainty in agricultural impacts and adaptation projections.
- Model path dependence and optimal timing for a range of adaptation strategies by region.
- Develop management systems that will increase the genetic diversity in the landscape. In many areas, the crop plant genetic diversity has decreased to a point where unexpected climate or pest problems can threaten world food security.

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