The last two decades have been the warmest in the past 100 years. Sea levels are rising, rainfall patterns are changing, Arctic ice is thinning, and the frequency and intensity of El Niño events appear to be increasing. In many parts of the world, major heatwaves, floods, droughts, and extreme weather patterns have led to significant loss of life. Associated economic losses totaled US$40 billion in 1999; one-fourth of the losses occurred in developing countries. The question is no longer whether the earth’s climate will change, but rather how much it will change, how fast, and where.

The Intergovernmental Panel on Climate Change (IPCC) has warned that the latest scientific evidence points strongly toward a steadily warming world in the twenty-first century. An overwhelming majority of scientific experts around the world, while recognizing that some scientific uncertainties exist, nonetheless believe that climate change caused by human activities (primarily burning of fossil fuels, deforestation, and agricultural practices) is already occurring, and that further climate change is inevitable.

For developing countries in particular the incremental costs of adapting to a continuously changing climate would be a major burden, even assuming that they possess the institutional and technical capability to adapt. The good news is that significant reductions in net emissions of man-made greenhouse gases are technically feasible. When they are released into the atmosphere, carbon dioxide, methane, and nitrous oxide are the primary contributors to the greenhouse effect. The bulk of their emissions, particularly that of carbon dioxide, is related to energy processes. Historically, industrialized nations are responsible for almost three-fourths of carbon dioxide emissions worldwide.

The IPCC was established by the United Nations in 1988 to provide governments with a scientific consensus on climate change and its consequences; recently the IPCC completed the most comprehensive review and update of the state of climate change since its Second Assessment Report, Climate Change 1995. According to the panel’s new assessment report, the earth’s average surface temperature could rise by as much as 5.8 degrees Celsius (10.4 degrees Fahrenheit) over the next 100 years. This warming, the most rapid climate change in 10,000 years, would be more than 60 percent higher than that predicted by scientists just five years ago.

The panel concluded that “there is stronger evidence” of humanity’s influence on climate and that man-made greenhouse gases have probably already “contributed most of the observed warming over the last 50 years.” Unless concentrations of greenhouse gases are stabilized, the probable rise in their concentrations in the atmosphere could mean:

- Severe water stress in the arid and semiarid land areas in southern Africa, the Middle East, and southern Europe
- Decreased agricultural production in many tropical and subtropical countries, especially countries in Africa and Latin America, as a result of almost any increases in temperature
- Higher worldwide food prices as supplies fail to keep up with the demand of an increasing population
- Increased vector-borne diseases, such as malaria, in tropical countries
- Major changes in the productivity and composition of critical ecological systems, particularly coral reefs and forests
- Tens of millions of people at risk from flooding and landslides, driven by projected increases in rainfall intensity and, in coastal areas, rising sea levels.

The magnitude of the climate change phenomenon must be understood in the context of global environmental degradation and threats to sustainable development. World leaders today face enormous challenges to:

- Reduce poverty for the 1.3 billion people who live on less than US$1 per day and the 3 billion who live on less than US$2 per day
Provide adequate food, especially for the nearly 800 million people who are malnourished today, by doubling food production in the next 35 years.

Provide clean water for the 1.3 billion people who do not have clean drinking water, and provide sanitation for the 2 billion people who lack access to sanitation.

Provide electrification for the 2 billion people who lack electricity.

Provide a healthy environment for the more than 1 billion people who are exposed to dangerous levels of indoor and outdoor air pollution.

Predictions that climate change will mean severe flooding of coastal areas, an increase in storms and heavy rains in some regions, and more rapid desertification in others have enormous implications for agricultural productivity, water resources, and natural ecosystems.

**EFFECTS OF CLIMATE CHANGE ON CROPS**

Crop yields and changes in productivity as a result of climate change will vary considerably across regions and among localities, thus changing production patterns. While an increase of less than 2 degrees Celsius in the average global temperature in the next 100 years would bring some benefits to the technically advanced countries with temperate climates in the form of milder winters, extended growing seasons, and higher yields of some crops, the ability to deal with warming depends heavily on economic resources and access to technology. In developing countries, even a modest warming will mean net losses. In the tropics and subtropics, where some crops are near their maximum temperature tolerance, and where dryland, nonirrigated agriculture dominates, yields are likely to decrease with even small increases in atmospheric temperature. Overall agricultural productivity in Africa and Latin America could decrease during the next century, leading to hunger and malnutrition in vulnerable areas, especially in drought-prone regions of Africa.

**EFFECTS OF CLIMATE CHANGE ON WATER**

Climate change will increase flooding in some regions, but will further exacerbate the frequency and magnitude of droughts in central Asia, northern and southern Africa, the Middle East, the Mediterranean region, and Australia. More frequent and longer droughts will have a potentially adverse effect on agriculture, particularly in developing countries located in arid and semiarid areas. Moreover, changing patterns of rainfall and runoff, coupled with population growth, will lead to huge pressures on water supplies. At present, 1.7 billion people live in areas where water resources are scarce. This number is expected to increase to about 5.4 billion over the next 25 years. At the same time, unfortunately, in many regions of the world a significant amount of water is wasted, largely through inefficient water management practices, including irrigation.

**EFFECTS OF CLIMATE CHANGE ON BIODIVERSITY**

Natural ecosystems will suffer from climate change. The structure, composition, and geographic distributions of many ecosystems will shift as individual species respond to changes in climate, resulting in loss of habitat and species. Forests, especially boreal systems, are vulnerable to projected
changes in climate. Those changes will affect the composition and geographic range of forests, as well as their health and productivity. Increased temperatures threaten coral reefs—the biologically diverse marine ecosystems on which fisheries, coastal protection, and erosion control depend.

**CLIMATE CHANGE AND AGRICULTURE: WHAT CAN BE DONE?**

Carbon dioxide is the leading heat-trapping greenhouse gas. Human activities result in some 7 billion tons of carbon in the form of carbon dioxide annually, with fossil fuel use the largest single source. Since the Industrial Revolution, carbon dioxide concentrations have increased by about 30 percent, primarily due to the burning of coal, oil, and natural gas for industry, electricity-generation, and transportation, and, to a lesser extent, the oxidation of biomass and decomposition of soil organic matter from conversion of forests to agriculture.

Agriculture’s role in climate change is just starting to be recognized. Clearing trees for fields and pastures, transforming soil into cultivated land, flooding areas for rice and sugarcane production, burning crop residues, raising ruminant animals, and using nitrogen fertilizers all release greenhouse gases into the atmosphere. Global agriculture is now estimated to account for about 20 percent of total anthropogenic emissions of greenhouse gases.

Thus, agriculture plays a significant role in climate change. Cost-effective reductions in greenhouse gases can be achieved by:

- Better managing agricultural soils, rangelands, and forests
- Improving the efficiency of fertilizer use
- Restoring degraded agricultural lands and rangelands
- Improving ruminants’ digestion through better feed
- Improving rice farming to reduce the amount of methane escaping into the atmosphere
- Slowing deforestation by reducing slash-and-burn agriculture and establishing appropriate tree plantations.

In *Climate Change and the Global Harvest: Potential Impacts of the Greenhouse Effect on Agriculture*, scientists Cynthia Rosenzweig and Daniel Hillel conclude:

“While environmental policy for agriculture has traditionally been tied to water quality and soil conservation, these policies may be expanded to limit emissions of greenhouse gases—especially carbon dioxide, methane, and nitrous oxide—from agricultural activities. Further, policies aimed at encouraging carbon sequestration through agroforestry may become important for the industry.”

Forest and agricultural soils are potential repositories of carbon and could hold down concentrations of carbon dioxide in the atmosphere. Their potential for trapping additional carbon each year is high if farmers adopt improved management practices, including agroforestry. According to IPCC estimates, the potential for carbon sequestration in tropical ecosystems by the year 2010 is 125 megatons of carbon a year for croplands, 170 megatons for forests, and 240 megatons for grazing lands.

As an international research organization with a global network of research centers and partnerships, the CGIAR is ideally positioned to provide the research backbone, technical advice, and capacity building on the implications of land use, land-use change, and forestry management on climate change—and for biodiversity and land degradation in developing countries, as well. CGIAR scientists have already made a tremendous contribution in their role as architects of the Green Revolution that greatly increased food production and helped “save” 426 million hectares (nearly 1 billion acres of land) from use as farmland.

A new global challenge program that couples advances in agricultural science with research to mitigate climate change and adapt agriculture to its anticipated effects could have profound effects on the global environment. That research could focus on development of rice varieties and water-management practices that reduce methane emissions; crop varieties that resist higher temperatures, tolerate greater disease and insect pressures, and withstand exposure to drought and excess water; more efficient use of nitrogen fertilizers; simpler and more accurate ways to measure soil carbon; and farming systems that sequester carbon more effectively.

For the world’s poorest farmers the global response to climate change could be an enormous opportunity to grow higher-yielding crops, healthier animals, and more sustainable forests, and improve their livelihoods; for all of us, the correct response could protect the environment for future generations.
Projected Changes in Annual Precipitation for the 2050s

Projected yield changes for wheat, maize, and rice, taking into account carbon dioxide effects (for 2020s, 2050s, and 2080s).

Source: Jackson Institute, University College London/Goddard Institute for Space Studies/International Institute for Applied Systems Analysis.
Projected Changes in Annual Temperatures for the 2050s

Source: The Met Office. Hadley Centre for Climate Prediction and Research.

Projected changes in annual temperatures for the 2050s compared with the present day (with an increase in greenhouse gas concentrations equivalent to about a one percent increase per year in carbon dioxide).
People at Risk from a 44 cm Sea-Level Rise by the 2080s

People at risk from a 44 cm sea-level rise by the 2080s, assuming 1990s level of flood protection.