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| ***Field: Agroproduction***  **CLIMATE CHANGE ADAPTATION AND MITIGATION**  türkiyede kuraklık ile ilgili görsel sonucutürkiyede kuraklık ile ilgili görsel sonucu    kuraklığa dayanıklı bitkiler ile ilgili görsel sonucutürkiyede kuraklık ile ilgili görsel sonucu        **Author: Dr. Fatih BARUTÇU**  **Prof. Dr. Suha BERBEROĞLU**  **2017**  **Boosting Adult System Education In Agriculture - AGRI BASE**  **Erasmus+ K2 Action Strategic Partnership** |

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# Descriptions

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| Course name | CLIMATE CHANGE ADAPTATION AND MITIGATION |
| Field/subfield within agriculture | Agroproduction |
| Objective of the course | This course enables participants to learn and develop the knowledge and skills necessary to overcome climate change effects and ensure adaptation of necessary pratices that minimize climate change effects. |
| Learning outcomes | 1. Learning general definition of climate change 2. Causes of climate change 3. Learning effects of climate change on ecosystems 4. Improving skills and pratices that minimise climate change effects on agriulture 5. Importance of water resources and irrigation management 6. Importance of minimising Carbon (C) release 7. Drought and Salt Resistant Crops |
| Target groups | Individuals who wish to develop their understanding of the technical aspects of application, improve their efficiency and environmental practices.   * Agricultural Extensionist * Agricultural Advisors * Technical staff * Trainers |
| Content | * What is Climate Change? Causes of Climate Change * Climate Change Scenarios * Effects of Climate Change * Global Warming and Use of Energy Resources that Minimize the effects of Climate Change * Renewable energy sources * Biodiesel/ bioethanol production and the crops used in biodiesel and bioethanol production. * Minimising Carbon (C) Release * Protective agriculture * Direct seeding (No-tilllage) * Mulching * Minimising Methane gas release * Minimising CO2 gas release * Reduction in Water resources * Irrigation Management * River basin management * Water harvest * Appropriate irrigation methods to Climate Change * Closed irrigation network (on demand) * Pressurized irrigation system * Surge irrigation * Physical damage that may occur in plants caused by climate change and necessary measures. * Measures against frost * Measures against sun burn * Measures against Pollination Biology * Drought and Salt Resistant Crops |

# Introduction

Agriculture and the future of global food security figure very importantly in climate change negotiations. Over the next decades, it is predicted that billions of people, particularly those in developing countries, face shortages of water and food and greater risks to health and life as a result of climate change Concerted global action is needed to enable developing countries to adapt to the effects of climate change that are happening now and will worsen in the future (UNFCCC, 2007).

Observations show that warming of the climate is unequivocal. The world’s climate is changing, and it will continue to change throughout the 21st century and beyond. The global warming observed over the past 50 years is due primarily to human-induced emissions of heat-trapping gases. These emissions come mainly from the burning of fossil fuels (coal, oil, and gas), with important contributions from the clearing of forests, agricultural practices, and other activities. If emissions continue to rise at or near current rates, temperature increases are more likely to be near the upper end of the range (Karl et al., 2009). Rising temperatures, new precipitation patterns, and other changes are already affecting many aspects of human society and the natural world. Climate change is transforming ecosystems on an extraordinary scale, at an extraordinary pace (Hewitt, 2013).

There is growing consensus in the scientific community that climate change is occurring. Research summarized in the Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report indicates that global average surface temperatures are increasing, and that snow cover and ice extent are decreasing in the higher latitudes of the Northern Hemisphere (IPCC, 2001). According to the report the global atmosphere is warming, noting that the average global surface temperature has increased by nearly 1 °C over the past century and is likely to rise by another 1.4 to5.8 °C over the next century (IPCC, 2001).

Rising fossil fuel burning and land use changes have emitted, and are continuing to emit, increasing quantities of greenhouse gases into the Earth’s atmosphere. These greenhouse gases include carbon dioxide (CO2), methane (CH4) and nitrogen dioxide (N2O), and a rise in these gases has caused a rise in the amount of heat from the sun withheld in the Earth’s atmosphere, heat that would normally be radiated back into space.

Climate change affects average temperatures and temperature extremes; timing and geographical patterns of precipitation; snowmelt, runoff, evaporation, and soil moisture; the frequency of disturbances, such as drought, insect and disease outbreaks, severe storms, and forest fires; atmospheric composition and air quality; and patterns of human settlement and land use change. Warming temperatures have led to effects as diverse as altered timing of bird migrations, increased evaporation, and longer growing seasons for wild and domestic plant species. Increased temperatures often lead to a complex mix of effects. Warmer summer temperatures have led to longer forest growing seasons but have also increased summer drought stress, vulnerability to insect pests, and fire hazard. Changes to precipitation and the size of storms affect plant-available moisture, snowpack and snowmelt, stream flow, flood hazard, and water quality (CCSP, 2008).

Reducing emissions of carbon dioxide would lessen warming over this century and beyond. Sizable early cuts in emissions would significantly reduce the pace and the overall amount of climate change. Earlier cuts in emissions would have a greater effect in reducing climate change than comparable reductions made later. In addition, reducing emissions of some shorter-lived heat-trapping gases, such as methane, and some types of particles, such as soot, would begin to reduce warming within weeks to decades (Karl et al., 2009).

# Definitions of Climate Change

Climate change refers to a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity (IPCC, 2007) . This usage differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods (UNFCCC, 2007).

# Causes of Climate Changes

It is now clear that global warming is mostly due to man-made emissions of greenhouse gases (mostly CO2). Over the last century, atmospheric concentrations of carbon dioxide increased from a pre-industrial value of 278 parts per million to 379 parts per million in 2005 and the average global temperature rose by 0.74° C. According to scientists, this is the largest and fastest warming trend that they have been able to discern in the history of the Earth. An increasing rate of warming has particularly taken place over the last 25 years, and 11 of the 12 warmest years on record have occurred in the past 12 years. The IPCC Report gives detailed projections for the 21st century and these show that global warming will continue and accelerate. The best estimates indicate that the Earth could warm by 3°C by 2100. Even if countries reduce their greenhouse gas emissions, the Earth will continue to warm. Predictions by 2100 range from a minimum of 1.8° C to as much as 4° C rise in global average temperatures (IPCC, 2007).

There is no doubt among scientists that the recent spike in carbon dioxide and other greenhouse gases in the atmosphere is the result of human activities. The World Meteorological Organization and many other scientific organizations have confirmed this relationship. While there are natural processes that produce these gases, they are balanced out by other natural process that consume them. Therefore, the current rise in atmospheric greenhouse gases can only be explained by human activities that pump additional gases into the atmosphere at a rate of billions of tons each year. A recent review of more than 900 journal articles on climate change revealed that not one of the authors disagreed with the evidence showing that human greenhouse gas emissions impact the climate (C2ES, 2011).

# Impacts of Climate Changes

Climate change is transforming ecosystems on an extraordinary scale, at an extraordinary pace. As each species responds to its changing environment, its interactions with the physical world and the organisms around it change too. This triggers a cascade of impacts throughout the entire ecosystem. These impacts can include expansion of species into new areas, Intermingling of formerly nonoverlapping species, and even species extinctions. Climate change is happening on a global scale, but the ecological impacts are often local and vary from place to place (Hewitt, 2013).

Human actions have been a primary cause of the climate changes observed today. Fortunately, though, humans are also capable of changing their behavior in ways that can reduce the rate of future climate change and help wild species adapt to climate changes that cannot be avoided. How we approach other human activities that affect ecosystems, such as agriculture, water management, transportation, fishing, biological conservation, and many other activities will influence the ways and the extent to which climate change will alter the natural world - and the ecosystems on which we depend (Anonymous, 2008).

***Global Warming*:** Temperature increases, increasing CO2levels, and altered patterns of precipitation are already affecting water resources, agriculture, land resources, and biodiversity. Observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases.Early decades of the twenty-first century will see a moderate warming of 1‑2oC, resulting in reduced crop yields in seasonally dry and tropical regions, while crop and pasture yields in temperate regions may benefit. Further warming in the second half of the century will negatively affect all regions, although agriculture in many developing countries in semi-tropical and tropical regions will bear the brunt of the effects (FAO, 2008).

According to scientists, this warming trend has accelerated in recent years. The ten warmest years since thermometer records became available in 1860 all occurred between 1995 and 2005. The World Meteorological Organization has reported that 2005 was the second hottest year on record, surpassed only by 1998, when El Niño conditions in the Pacific Ocean contributed to above-average temperatures worldwide. For the United States, the first six months of 2006 were the warmest such period on record (C2ES, 2011).

Accompanying the increased temperatures at the earth’s surface has been a significant rise in ocean temperatures to a depth of 700 meters. Scientists from the U.S. National Oceanic and Atmospheric Administration have demonstrated that the ocean as a whole has been warming for the past five decades. The highest level of warming was recorded at the upper levels of the oceans, evidence that the oceans are absorbing most of the increased heat from the earth’s surface. Even if greenhouse gas concentrations were stabilized today, the heat that is already in the ocean will warm the atmosphere over time, bringing an additional 1 degree Fahrenheit of warming by the end of the twenty-first century (C2ES, 2011).

The increases in global temperatures will continue in the decades ahead, scientists say. According to the Intergovernmental Panel on Climate Change (IPCC), which includes more than 2,000 scientists from the United States and other countries, over the next century, average global temperature will rise by two-and-a-half to ten degrees Fahrenheit. Regional increases may be greater or less than the global average, according to the IPCC.

Global temperatures have experienced natural shifts throughout human history. For example, the climate of the Northern hemisphere varied from a relatively warm period between the eleventh and fifteenth centuries to a period of cooler temperatures between the seventeenth century and the middle of the nineteenth century. However, scientists studying the rapid rise in global temperatures during the late twentieth century say that natural variability cannot account for what is happening now. The main culprit, they say, is emissions of carbon dioxide and other greenhouse gases from human activities, primarily the burning of fossil fuels such as coal and oil. Other human sources of these gases include deforestation, agriculture and industrial processes.

The greenhouse effect keeps the earth warm and habitable; without it, the earth’s surface would be about 60 degrees Fahrenheit colder on average. Since the average temperature of the earth is about 45 degrees Fahrenheit, the natural greenhouse effect is clearly a good thing. But the enhanced greenhouse effect means even more of the sun’s heat is trapped, causing global temperatures to rise (C2ES, 2011).

***Extreme Climate Events*:** Increased frequency and severity of extreme climate events, such as more heat stress, droughts and flooding, is expected in coming decades due to climate change. It will increase negative impacts on agriculture, forestry and fisheries in all regions. In particular, it will modify the risks of fires, and pest and pathogen outbreaks, with negative consequences for food, fiber and forestry (FAO, 2008).

It is not just rising average global temperatures that concern scientists but also their effects on weather extremes, declining global ice cover and sea level rise. In fact, many of the predictions that scientists have made in the past about the impacts of global warming are already upon us, including disappearing glaciers, loss of sea ice, more extreme heat waves, accelerated sea level rise, and stronger hurricanes. Scientists say these effects are likely to worsen in the decades ahead.

**Rising Sea Level:** Among the most serious and potentially catastrophic effects of global warming is sea level rise, caused by a combination of melting glaciers all over the world and the “thermal expansion” of the seas as oceans warm. By the end of the century, if nothing is done to rein in emissions of greenhouse gases, global sea level may be three feet higher than today and rising (C2ES, 2011). Rising sea level will have severe impacts in low-lying coastal communities throughout the world. In Bangladesh, for example, even a one-meter rise would inundate 17 percent of the country. In the United States, where 54 percent of the population lives in close proximity to the ocean, the most vulnerable areas are the Southeast and Mid-Atlantic coasts. Also at risk are low-lying areas and bays such as North Carolina’s Outer Banks, the Florida Coast, and much of southern California (C2ES, 2011).

**Melting Polar Ice:** In November 2004 an international team of 300 scientists from 15 countries, including the United States, issued a report on the impacts of climate change in the Arctic. In addition to painting a stark picture of how climate change already is affecting the region, the report of the Arctic Climate Impact Assessment predicted that at least half the summer sea ice in the Arctic will melt by the end of this century, along with a significant portion of the Greenland Ice Sheet

**Loss of Mountain Glaciers and Snow Pack:** In addition to the loss of polar ice, climate change is causing a worldwide loss of mountain glaciers at all latitudes. Scientists have observed that glaciers are in retreat in all regions of the world, from the Himalayas to tropical South America to the western United States. By mid-century, scientists say, most mountain glaciers may be gone. If the current rate of global warming continues, there will be no glaciers left in Glacier National Park by 2030.In addition to contributing to sea level rise, the melting of mountain glaciers also poses a threat to global water supplies. Billions of people around the world depend solely on glaciers for irrigation and drinking water (C2ES, 2011).

**More Droughts and Flooding:** Otherweather impacts from climate change include a higher incidence of drought and flooding and changes in precipitation patterns. According to the Intergovernmental Panel on Climate Change, future changes in weather patterns will affect different regions in different ways. In the short term, for instance, farms and forests may be more productive in some regions and less productive at others. Among the reasons: precipitation will increase in high-latitude regions of the world in summer and winter, while southern Africa, Australia and Central America may experience consistent declines in winter rainfall. As a result of these changes, agriculture in developing countries will be especially at risk. Wheat, for example, may virtually disappear as a crop in Africa, while experiencing substantial declines in Asia and South America (C2ES, 2011).

**Expansion of the Oceans:** Another cause of sea level rise is what scientists refer to as the “thermal expansion” of the oceans—put simply, as the oceans continue to warm, they will expand (C2ES, 2011). Even if no more greenhouse gases are added to the atmosphere, global sea level will rise by four inches over the next century because of thermal expansion alone, according to researchers at the National Center for Atmospheric Research.

**Changing Weather Patterns:** Scientists predict that climate change will have a significant effect on global weather patterns, causing both more floods and more droughts. Extended heat waves, more powerful storms, and other extreme weather events have become more common in recent years and will continue on this trend. These changes in weather patterns will have serious and potentially severe impacts on human societies and the natural world.

**Stronger Hurricanes:** The 2005 hurricane season in the Atlantic Ocean, with four Category 5storms for the first time in recorded history, raised questions in many Americans’ minds about the potential connections between hurricanes and climate change. Now, scientists have confirmed that hurricanes are becoming more intense—not just in the Atlantic but in all oceans where they occur (C2ES, 2011).

**Undernourishment:** The number of undernourished is likely to increase by 5‑170 million people by 2080, with respect to a baseline with no climate change. Even small amounts of warming will increase risk of hunger in poor developing countries, due to negative impacts on food production and availability. Most of the increases are projected in sub-Saharan Africa (FAO, 2008).

**Food stability, utilization and access:** Additional negative impacts of climate change on food security, with the potential of reducing access to and utilization of food in many regions already vulnerable today, are expected but have not been quantified. In particular, stability of food supply is likely to be disrupted by more frequent and severe climate extremes (FAO, 2008).

The most important challenge for agriculture in the twenty-first century is the need to feed increasing numbers of people – most of whom are in developing countries – while at the same time, conserving the local and global environment in the face of limited soil and water resources and growing pressures associated with socio-economic development and climate change.

Food insecurity will continue to be a serious issue in coming decades. Despite significant projected overall reductions in hunger projected by the end of the century – from the current 850 million to about 200-300 million – many developing countries will continue to experience serious poverty and food insecurity, due to localized high population growth rates, poor socio-economic capacity and continued natural resource degradation. By the end of the century, 40 to 50 percent of all undernourished are expected to live in sub-Saharan Africa. Projections indicate that MDGs for undernourishment will not be met, despite robust projected economic growth. Indeed, prevalence of hunger may indeed be halved, but not before 2030, unless additional policy measures are implemented (FAO, 2008).

Projected population and socio-economic growth will double current food demand by 2050. To meet this challenge in developing countries, cereal yields need to increase by 40 percent, net irrigation water requirements by 40-50 percent, and 100-200 million ha of additional land may be needed, largely in sub-Saharan Africa and Latin America. Utilization of food may be affected negatively by increases in crop, livestock and human pests and diseases, as well as by reduced water availability and water quality, of importance for food preparation (FAO, 2008).

**Effects on Human Health:** A recent United Nations report blamed climate change, along with worsening air and water quality and poor disposal of solid waste, for an increase in malaria, cholera and lower respiratory tract infections in African societies. Africans also are suffering from the effects of reduced crop yields and decreased availability of water. The U.N. report on Africa provides an early glimpse of some of the ways in which scientists say climate change will affect people’s health in the decades to come, no matter where they live. Climate change can affect human health directly (for example, because of extreme temperatures and heat waves) and indirectly (for example, by contributing to the spread of infectious disease or threatening the availability and quality of food and water). The elderly, the infirm and the poor will be especially at risk (C2ES, 2011).

**Effects on Ecosystems:** It is very likely that the magnitude and frequency of ecosystem changes will continue to increase during this period, and it is possible that they will accelerate. As temperature rises, crops will increasingly experience temperatures above the optimum for their reproductive development, and animal production of meat or dairy products will be impacted by temperature extremes (CCSP, 2008).

Climate change holds the potential of inflicting severe damage on the ecosystems that support all life, from hazards to coral reefs due to warmer and more acidic ocean waters to threats to polar bears because of declines in sea ice. Ecosystems around the world already are reacting to a warming world. For example, one study found that 130 species, including both plants and animals, have responded to earlier spring warming over the last 30 years. These organisms have changed their timing of flowering, migration and other spring activities.

The changes occurred regardless of regional difference and were linked directly to enhanced greenhouse warming. Researchers also have established that climate change is driving some species to extinction. For instance, in the past 20 years dozens of species of mountain frogs in Central America have disappeared because of a disease that formerly did not occur where they live. In 2006, a paper in the journal *Nature* revealed that the disease-causing organism, a fungus, has spread to higher elevations as a result of human-induced climate change (C2ES, 2011).

Climate change impacts on ecosystems will affect the services that ecosystems provide, such as cleaning water and removing carbon from the atmosphere, but we do not yet possess sufficient understanding to project the timing, magnitude, and consequences of many of these effects (CCSP, 2008).

As each species responds to its changing environment, its interactions with the physical world and the organisms around it change too. This triggers a cascade of impacts throughout the entire ecosystem. These impacts can include expansion of species into new areas, intermingling of formerly on overlapping species, and even species extinctions. Climate change is happening on a global scale, but the ecological impacts are often local and vary from place to place.

**Biodiversity:** Climate change is one of many possible stressors on biodiversity. Climate change may manifest itself as a shift in mean conditions, or as changes in the variance and frequency of extremes of climatic variables. There is a growing recognition that planning for changes in variance and an increase in the frequency of extreme events may pose the most challenging problems for natural resource managers (IPCC 2001).

These changes in climate can impact biodiversity either directly or indirectly through many different impact mechanisms. Climate change is expected to have a significant influence on terrestrial biodiversity at all system levels – ecosystem, species and genetic diversity. The changing climate will stimulate species-level changes in range and abundance, life cycle and behavior, and, over time, genetic evolutionary responses. These changes will in turn be linked with changes in natural disturbance patterns and changes in ecosystem structure and function.

Many studies provide evidence that species have expanded their range pole wards and upwards in elevation in response to climate warming. This has been particularly evident in the case of species that can disperse easily, such as birds and strong flying butterflies. In a meta-analysis study covering a wide variety of more than 1700 species, more than half displayed statistically significant changes in range in the direction predicted by regional changes in climate. Species that are not easily dispersed will respond more slowly to climate change, likely resulting in range contractions and reduced abundances. Ample evidence now exists that upper and lower temperature and precipitation thresholds are a strong determinant in the abundance of wild species. As the geographic range of these thresholds shifts, so too will the local abundance of many species.

The impacts of climate change on freshwater biodiversity are highly uncertain. With warming air temperatures, evaporation and evapotranspiration are expected to increase, as is precipitation in some areas. In essence, warming is expected to accelerate the water cycle, increasing rates at which water enters the atmosphere and rains down again. However, the impacts of this on freshwater biodiversity are uncertain since it is not clear whether evapotranspiration will be greater than, smaller than, or equal to precipitation. Given these possibilities, different impacts of these changes to the water cycle will have different consequences in different watersheds.

# Effects of Climate Change

Ecosystems and their services (land and water resources, agriculture, biodiversity) experience a wide range of stresses, including pests and pathogens, invasive species, air pollution, extreme events, wildfires and floods. Climate change can cause or exacerbate direct stress through high temperatures, reduced water availability, and altered frequency of extreme events and severe storms (Lichtfouse, 2013). It can ameliorate stress through warmer springs and longer growing seasons, which, assuming adequate moisture, can increase agricultural and forest productivity. Climate change can also modify the frequency and severity of stresses

Weather and climate factors such as temperature, precipitation, CO2 concentrations, and water availability directly impact the health and well-being of plants, pasture, rangeland, and livestock. For any agricultural commodity, variation in yield between years is related to growing season weather; weather also influences insects, disease, and weeds, which in turn affect agricultural production (CCSP, 2008). It may be summed up of effect of climate change under four topic:

1. Agriculture

* Cropping systems
* Pasture and grazing lands
* Animal management

1. Land Resources

* Forests
* Aid lands

1. Water Resources

* Quantity, availability, and accessibility
* Quality

1. Biodiversity

* Species diversity
* Rare and sensitive ecosystems

## Agriculture

While CO2 and temperature is increasing, the life cycle of grain and oilseed crops will likely progress more rapidly. But, as temperature rises, these crops will increasingly begin to experience failure, especially if climate variability increases and precipitation lessens or becomes more variable.

High value crops yield of many crops – e.g., tomatoes, onions, fruits – is very likely to be more sensitive to climate change than grain and oilseed crops.

Risk of disease on crops and domestic animals will likely increase with earlier springs and warmer winters, which will allow proliferation and higher survival rates of pathogens and parasites.

Regional variation in warming and changes in rainfall will also affect spatial and temporal distribution of disease.

Increases in temperature and a lengthening of the growing season of plants will likely extend forage production into late fall and early spring, thereby decreasing need for winter season forage reserves. However, these benefits will very likely be affected by regional variations in water availability.

Climate change-induced shifts in plant species are already under way in rangelands. Establishment of perennial herbaceous species is reducing soil water availability early in the growing season. Shifts in plant productivity and type will likely also have significant impact on livestock operations.

Higher temperatures will very likely reduce livestock production during the summer season, but these losses will very likely be partially offset by warmer temperatures during the winter season.

## Land Resources

Climate strongly influences forest productivity, species composition, and the frequency and magnitude of disturbances that impact forests. The effect of climate change on disturbances such as forest fire, insect outbreaks, storms, and severe drought will command public attention and place increasing demands on management resources. Disturbance and land use will control the response of arid lands to climate change. Many plants and animals in arid ecosystems are near their physiological limits for tolerating temperature and water stress and even slight changes in stress will have significant consequences. In the near term, fire effects will trump climate effects on ecosystem structure and function

Climate change has very likely increased the size and number of forest fires, insect outbreaks, and tree mortality

Rising CO2 will very likely increase photosynthesis for forests, but this increase will likely only enhance wood production in young forests on fertile soils

Nitrogen deposition and warmer temperatures have very likely increased forest growth where adequate water is available and will continue to do so in the near future.

The combined effects of rising temperatures and CO2, nitrogen deposition, ozone, and forest disturbance on soil processes and soil carbon storage remains unclear.

Higher temperatures, increased drought, and more intense thunderstorms will very likely increase erosion and promote invasion of exotic grass species in arid lands.

Climate change in arid lands will create physical conditions conducive to wildfire, and the proliferation of exotic grasses will provide fuel, thus causing fire frequencies to increase in a self-reinforcing fashion.

Arid lands very likely do not have a large capacity to absorb CO2 from the atmosphere and will likely lose carbon as climate-induced disturbance increases.

River and riparian ecosystems in arid lands will very likely be negatively impacted by decreased stream flow, increased water removal, and greater competition from nonnative species.

Changes in temperature and precipitation will very likely decrease the cover of vegetation that protects the ground surface from wind and water erosion

## Water Resources

Plants, animals, natural and managed ecosystems, and human settlements are very responsive to variations in the storage, flow, and quality of water, all of which are sensitive to climate change. The effects of climate on the nation’s water storage capabilities and hydrologic functions will have significant implications for water management and planning as variability in natural processes increases.

We experienced increases in precipitation and stream flow and decreases in drought during the second half of the 20th century. It is likely that these trends are due to a combination of decadal-scale variability and long-term change.

Water quality is sensitive to both increased water temperatures and changes in precipitation.

Stream temperatures are likely to increase as the climate warms, and are very likely to have both direct and indirect effects on aquatic ecosystems. Changes in temperature will be most evident during low flow periods, when they are of greatest concern.

Trends toward increased water use efficiency are likely to continue in the coming decades. Pressures for reallocation of water will be greatest in areas of highest population growth, Declining per capita (and, for some cases, total) water consumption will help mitigate the impacts of climate change on water resources.

## Biodiversity

Biodiversity, the variation of life at the genetic, species, and ecosystem levels of biological organization, is the fundamental building block of the services that ecosystems deliver to human societies. It is intrinsically important both because of its contribution to the functioning of ecosystems, and because it is difficult or impossible to recover or replace, once it is eroded. Climate change is affecting biodiversity and ecosystems, including changes in growing season, phenology, primary production, and species distributions and diversity.

There has been a significant lengthening of the growing season and increase in net primary productivity (NPP) in the higher latitudes of North America. Over the last 19 years, global satellite data indicate an earlier onset of spring across the temperate latitudes by 10 to 14 days.

In an analysis of 866 peer-reviewed papers exploring the ecological consequences of climate change, nearly 60 percent of the 1598 species studied exhibited shifts in their distributions and/or phenologies over the 20- and 140-year time frame. Analyses of field-based phenological responses have reported shifts as great as 5.1 days per decade, with an average of 2.3 days per decade across all species.

Subtropical and tropical corals in shallow waters have already suffered major bleaching events that are clearly driven by increases in sea surface temperatures. Increases in ocean acidity, which are a direct consequence of increases in atmospheric carbon dioxide, are calculated to have the potential for serious negative consequences for corals.

The rapid rates of warming in the Arctic observed in recent decades, and projected for at least the next century, are dramatically reducing the snow and ice covers that provide denning and foraging habitat for polar bears.

There are other possible, and even probable, impacts and changes in biodiversity (e.g., disruption of the relationships between pollinators, such as bees, and flowering plants), for which we do not yet have a substantial observational database. However, we cannot conclude that the lack of complete observations is evidence that changes are not occurring.

# Climate Change Adaptation and Mitigation

## Minimizing Carbon (C) Release

### No-tillage seeding in Conservation Agriculture

Conservation tillage and conservation agriculture are the collective umbrella terms commonly given to no-tillage, minimum tillage and/or ridge tillage, to denote that the inclusive practices have a conservation goal of some nature (Baker et al., 2007). Conservation agriculture is a key tool in sustainable production systems throughout the world and is developed around soil management technology that minimizes soil disturbance, maximizes the soil cover and promotes crop diversity to offer benefits to farmers and to the environment. Central Anatolian soils have high risk of erosion, degradation and intensive cultivation. Consequently, they are in danger of exhausting their agricultural use unless conservation agricultural practices are adopted. Results showed that the conventional system, in addition to being ecologically unfriendly, is unprofitable as compared with other conservation practices regarding the updated cost analysis; similarly, tillage depth in primary spring tillage was determined to be shallower than the depths currently practiced by farmers, in agreement with the conservation principles; fallow tillage operations in summer to create dust mulch for eliminating soil moisture loss did not increase the crop yields and soil moisture as compared with chemical fallow; no-till fallow was similar to the conventional clean fallow system in terms of moisture and yield levels. However, no-tillage resulted in 50% reduction in the cost of tillage besides its ecologically-friendly effects; the existing dryland agricultural systems in the plateau should be transformed into or changed toward sustainable systems, although further research is required on residue and stubble management, and integrated weed control methods to drill the soil with high amounts of residue on the field (Avci, 2011).

### Mulching

Mulching is covering the soil with an organic or inorganic material for a certain time of year. Mulching is used to increase the soil temperature because the solar radiation is absorbed at higher rates by mulch and also the water evaporation from soil is prevented. Mulching can be used to decrease the soil temperature using a cover material with lower absorption coefficient than the soil surface. Because soil surface temperature and soil temperature at different depths can be change by using mulching method, it provides very useful opportunities for agricultural applications.

**Benefits of Proper Mulching**

* Helps reduce soil moisture loss through evaporation
* Helps control weed germination and growth
* Insulates soil, protecting roots from extreme summer and winter temperatures
* Can improve soil biology, aeration, structure (aggregation of soil particles), and drainage over time
* Can improve soil fertility as certain mulch types decompose
* Inhibits certain plant diseases
* Reduces the likelihood of tree damage from “weed whackers” or the dreaded “lawn mower blight”
* Gives planting beds a uniform, well-cared-for look

### Minimizing Methane gas release

Methaneconcentration has increased mainly as a result of agriculture; raising livestock (which produce methane in their digestive tracts); mining, transportation, and use of certain fossil fuels; sewage; and decomposing garbage in landfills. About 70 percent of the emissions of atmospheric methane are now related to human activities. Agriculture contributes significantly to emissions of greenhouse gases and other pollutants. It is also one of the sectors which any potential climate change will affect the most. CO2 and Methane gas has an extremely high global warming potential and continues to increase each year. Methane comes from, among other things, the decomposition of organic matter. Methane is responsible for 24% of global warming to date. Most of the methane produced by agriculture is from the normal digestive processes of livestock - the rest comes from animal excreta. The biggest man-made contributor however, isn't oil or manufacturing, but rather agriculture. The annual amount of greenhouse gases emitted by the agricultural sector is estimated to be 10 to 12% of total global greenhouse gas emissions and growing, according to the Intergovernmental Panel on Climate Change (IPPC)

Direct losses of methane from animals are due to fermentation caused by bacteria in the stomach. Cows produce the most methane per animal - followed by horses, sheep, goats and pigs. Emissions from lactating dairy cows are particularly high.

These are several ways you can help reduce the level of methane in our atmosphere:

* Reducing livestock numbers
* Improving productivity and fertility
* Modifying the diets of livestock
* Support Organic Farming Practices

### Reducing CO2 emissions on farms

The concentration of carbon dioxide in the atmosphere has increased by roughly 35 percent since the start of the industrial revolution. Carbon dioxideconcentration has increased due to the use of fossil fuels in electricity generation, transportation, and industrial and household uses. It is also produced as a by-product during the manufacturing of cement. Deforestation provides a source of carbon dioxide and reduces its uptake by trees and other plants. Globally, over the past several decades, about 80 percent of human-induced carbon dioxide emissions came from the burning of fossil fuels, while about 20 percent resulted from deforestation and associated agricultural practices. CO2 is the greenhouse gas responsible for 70% of the global warming to date. This has been caused by a 37% increase in atmospheric CO2 (Karl et al., 2008). The main causes of this are:

* burning fossil fuels - e.g. coal, oil and gas
* burning/clearing forests
* draining and degradation of peatlands

The following techniques can help to reduce CO2 emissions and farm running costs:

* regularly servicing engines - this can reduce fuel consumption by 5-15%
* choosing suitable tractors/machinery - eg using the lowest-powered tractor capable of the task
* avoiding unnecessary journeys and cultivation passes
* maintaining the efficiency of fixed equipment - eg grain driers, refrigerated stores and bulk milk tanks

## Renewable energy

Renewable energy plays a key role in mitigating global greenhouse gas emissions by radically lowering the emissions profile of the global energy system. Action to reduce the impact of climate change is critical, and limiting the increase in average global temperatures to less than 2 °C requires concerted global action.

In order to minimise the effect of climate change, it is important reduced use of conventional energy sources and shift towards renewable energy. Renewable energy sources can play an important role, as biofuels (mainly biodiesel and bioethanol) can be admixed with conventional fuels.

Some important renewable energy sources are listed below:

* 1. Solar energy
  2. Wind energy
  3. Geothermal energy
  4. Biomass energy
  5. Biogas energy
  6. Hydropower energy
  7. Sea wave energy

## Water Resources Management

Climate change is one of the main driving forces of change for water resources management, together with demographic, economic, environmental, social and technological forces. If conceived in isolation, solutions to the major challenges that these driving forces create may become self-defeating. Decision-makers and policymakers in other disciplines have the solution to many water management problems. They need to recognize that all major decisions should take into account the potential impact on water, recognizing water as the lifeblood. While tackling these issues, decision-makers should think beyond their own sectors and consider the wider ramifications of their decisions on water availability and the forces affecting it, and should adopt a balanced, integrated and coherent approach

Global warming, due to the enhanced greenhouse effect, is likely to have significant effects on the hydrological cycle. The hydrological cycle will be intensified, with more evaporation and more precipitation, but the extra precipitation will be unequally distributed around the globe. Some parts of the world may see significant reductions in precipitation, or major alterations in the timing of wet and dry seasons.

Climate change, however, is just one of the pressures facing water resources and their management over the next few years and decades. In the most general terms, there are both supply-side and demand side pressures. The supply-side pressures include climate change (reducing or increasing the amount of water available), but also include environmental degradation, where for example pollution reduces the amount of water available for use. Demand-side pressures include population growth and concentration, leading to increased demands for domestic, industrial and agricultural (particularly irrigation) water, increased environmental demands, and the effects of changes in the way demands for water are managed. Climate change may affect the demand side of the balance as well as the supply side.

Adaptation measures can be categorized in the following ways, which water managers have of adapting to contemporary climate variability and that could ultimately serve as the foundation for adapting to climate change:

1. Planning and constracting new investments (for example, reservoirs, irrigation systems, capacity expansions, levees, water supply, wastewater treatments, ecosystem restoration).

2. Adjusting operation, monitoring and regulation practices of existing systems to accommodate new uses or conditions (for example, ecology, pollution control, climate change, population growth).

3. Working on maintenance, major rehabilitation and re-engineering of existing systems (for example, dams, barrages, irrigation systems, canals, pumps, rivers, wetlands).

4. Making modifications to processes and demands for existing systems and water users (for example, rainwater harvesting, water conservation, pricing, regulation, legislation, basin planning, funding for ecosystem services, stakeholder participation, consumer education and awareness).

5. Introducing new efficient technologies (for example, desalination, biotechnology, drip irrigation, wastewater reuse, recycling, solar panels).

There are several factors influencing the growth of future water resource use:

* **Population growth:** an increase in population means greater demand for water.
* **Population concentration:** population, particularly in developing countries, is becoming increasingly concentrated in large cities. This has two implications. First, water use is different in an urban environment than in a rural environment. For example, water will be supplied through a pipe network, so more is used than in rural areas, and water is lost through leakage. Second, the increasing concentration of demand means greater pressure on resources in speci"c areas.
* **Industrial change:** industrial development increases the demand for water, but industrial restructuring may reduce it (as in large parts of Europe). As water is seen as more of an economic good, it will be used more efficiently in industry.
* **Expansion of irrigation:** the growth in irrigated areas will lead to more usage by agriculture, but this may be offset to a certain extent by improvements in irrigation efficiency.
* **Water use efficiency and demand management:** more generally, increased water use efficiency and demand management measures will bring down domestic, municipal and service industry demands, particularly in western countries.
* **Environmental requirements:** increasing demands for environmental protection will put additional constrains on water resource use. These demands are currently *not* included in estimates of resource use.

The largest percentage increases are in the developing world, particularly in Africa. The largest absolute increases are in Southeast Asia. Agriculture remains the biggest user, although its share of the total falls.

Managing the competing demands for water from various sectors will become more onerous in conditions of water scarcity and drought. Different interests (with regard to water supply, sanitation, agriculture, irrigation, hydropower, navigation/transportation and environment) shape these sectors’ management principles, rules and incentives, which often conflict with one another. Cross-sectoral, integrated and system-wide approaches to climate change adaptation must be developed, placing water management at the center of any development plan.

Effective adaptation for water requires different approaches within a comprehensive, integrated framework. A combination of bottom-up and top-down decision-making, where all major players – at community, national and regional levels – can agree, should be envisaged. Water and climate do not respect borders, and many adaptation measures will have effects on neighboring countries. This fact calls for cooperative solutions that help prevent the negative effects of unilaterally taken adaptation measures and identify more comprehensive solutions. Many countries have embarked on water sector reforms based on the Integrated Water Resources Management (IWRM) approach, employing a variety of tools based on multidisciplinary inputs, public participation, and regulatory, financial and political incentives. Well-functioning institutions are therefore needed to effectively administer this array of fairly complex management measures.

For effective adaptation, institutions should be strengthened and capacities built for holistic land and water management – building on the principles of participation of civil society, equality and decentralization (26, 27). This will require the creation of authorities based on hydrological rather than political boundaries; more effective regional water institutions; and improved transboundary cooperation (28). The stronger and more accountable institutions are, the better able they will be to plan and adjust to changes in water availability and extreme water events.

## Irrigation Management

At the global scale, the largest user of water is irrigated agriculture. It represents 70% of present freshwater withdrawals with these withdrawals concentrated in particular countries. Industrial uses account for 22% globally, through manufacturing and, particularly, thermoelectric power generation (for cooling). Much of the cooling water is in fact returned to the water system, although at higher temperature. Domestic, municipal and service industry use accounts for just 8% of global water use. The proportions of water used in each sector by country, however, can vary considerably around these global estimates. In much of Europe, for example, water used for domestic, municipal and service industries is a very high proportion of total demand (Arnell, 1999).

Given the dominant role of irrigated agriculture in global water use, management practices that increase the productivity of irrigation water use (defined as crop output per unit of consumptive water use) can greatly increase the availability of water for other human and environmental uses. Of all sectoral water demands, the irrigation sector will be affected most strongly by climate change, as well as by changes in the effectiveness of irrigation methods. In areas facing water scarcity, changes in irrigation water use will be driven by the combined effects of changes in irrigation water demand, changes in demands for higher value uses (e.g., for urban areas), future management changes, and changes in availability.

**Appropriate irrigation methods to Climate Change**

Efficient irrigation systems include sprinkler and drip systems. They ensure a means for sustainable water use and management and strengthening the adaptive capacities of people living in rural areas. It is important to address the issue of irrigation in agriculture and design methods or technologies that would make the use of water for irrigation more efficient and sustainable. These methods are Sprinkler and drip irrigation methods also called pressurized irrigation systems.

**Sprinkler irrigation**

Sprinkler irrigation is a method of applying irrigation water like natural rainfall. Water is distributed through a system of pipes usually by pumping. It is then sprayed into the air through sprinklers so that it breaks up into small water drops which fall to the ground. The pump supply system, sprinklers and operating conditions must be designed to enable a uniform application of water (Brouwer et al., ?)

There are many advantages of this system.

* Benefits from improved crop productivity and income, employment opportunities and food security
* These systems eliminate water transportation channels, so that reducing water loss
* It is well adapted to a range of topographies and suitable in all types of soil, except heavy soils
* It provides a more even application of water to soil, promoting steady crop growth.
* The risk of soil erosion can be reduced, which can occur when using irrigation by gravity
* System can provide additional protection for plants against freezing.

**Drip Irrigation**

Drip irrigation is also called trickle irrigation and includes dripping water onto the soil at very low rates (2-20 litres/hour) from a system of small diameter plastic pipes fitted with outlets called emittersor drippers. Water is applied close to plants so that only part of the soil in which the roots grow is wetted, unlike surface and sprinkler irrigation. In drip irrigation system water applications are more frequent (usually every 1-3 days) than with other methods and this provides a very favorable high moisture level in the soil in which plants can flourish (Brouwer et al., ?).

Some advantages of drip irrigation;

* Drip irrigation system reduces water run-off through deep percolation and almost no evaporation from soil.
* As water consumption is reduced, production costs are lowered. Also, there is less diseases including fungus.
* It promotes irrigation scheduling to precisely meet crop demands, providing the yield and quality.
* Agricultural chemicals can be applied more efficiently and precisely with drip irrigation,
* The drip system technology is adaptable to terrains where other systems cannot work well due to climatic or soil conditions.
* Drip irrigation technology can be adapted to lands with different topographies and crops growing in a wide range of soil characteristics (including salty soils). It is particularly efficient in sandy areas with permanent crops such as citric, olives, apples and vegetables

## Water Harvest

Water harvest is an application which reduce the impacts of drought as a result of climate change. Basic principle of water harvest is to collecting and storing rain water from the surfaces and use for agricultural and household activities.

Water harvesting can be useful for such conditions:

* Drought areas where rainfall is not sufficient and not regular
* Drought areas where there is a high risk of product losses
* Drought areas where the crop yield is low
* The areas where the water is not sufficient for animals and household needs.
* The areas where the risk of desertification and soil protection problems are high.

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