
## Climate Change Impacts on Agricultural Water Resources

**Lesson: 19**

**National Science Education Standards for Grades 9-12**

**Content Standard A: Abilities Necessary to Do Scientific Inquiry**

- *Design and conduct scientific investigations.*

**Content Standard C: Life Science: The Interdependence of Organisms**

- *Human beings live within the world's ecosystems. Increasingly, humans modify ecosystems as a result of population growth, technology and consumption. Human destruction of habitats through direct harvesting, pollution, atmospheric changes and other factors is threatening current global stability, and if not addressed, ecosystems will be irreversibly affected.*

**Content Standard D: Earth Science: Energy in the Earth System**

- *Global climate is determined by energy transfer from the sun at and near the earth's surface. This energy transfer is influenced by dynamic processes such as cloud cover and the earth's rotation, and static conditions such as the position of mountain ranges and oceans.*

**Content Standard D: Earth Science: Geochemical Cycles**

- *The earth is a system containing essentially a fixed amount of each stable chemical atom or element. Each element can exist in several different chemical reservoirs. Each element on earth moves among reservoirs in the solid earth, oceans, atmosphere and organisms as part of geochemical cycles.*

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**Content Standard F: Science in Personal and Social Perspectives: Environmental Quality**

- *Natural ecosystems provide an array of basic processes that affect humans. Those processes include maintenance of the quality of the atmosphere, generation of soils, control of the hydrologic cycle, disposal of wastes and recycling of nutrients. Humans are changing many of these basic processes, and the changes may be detrimental to humans.*

**Content Standard F: Science and Technology in Local, National and Global Challenges**

- *Humans have a major effect on other species. For example, the influence of humans on other organisms occurs through land use—which decrease space available to other species—and pollution—which changes the chemical composition of air, soil and water.*

**Student Learning Objectives**

19 Predict how climate change might alter water resources, particularly agricultural water use, in their state.

**Teacher Info Table Time**

Instruction time for this lesson: 50 minutes for reading and discussions

**Resources, Tools, Equipment and Supplies**

Resources

- Agriculture in Wisconsin: http://www.wicci.wisc.edu/report/WICCI-Chapter-5.pdf
- *Climate Change Wildlife and Wildlands: A Toolkit for Formal and Informal Educators*, U.S. Global Change Research Program: http://www.globalchange.gov/resources/educators/toolkit
- *Climate Connections: A Global Journey*, National Public Radio: http://www.npr.org/news/specials/climate/interactive

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**Resources, Tools, Equipment and Supplies**

Resources

- *Climate Change: Public Skeptical, Scientist Sure*, Richard Harris, National Public Radio, http://www.npr.org/2011/06/21/137309964/climate-change-public-skeptical-scientists-sure
- *Climate Prediction Center*, National Weather Service: http://www.cpc.ncep.noaa.gov/products/expert_assessment/drought_assessment.shtml
- *DOI Climate Science Centers*, Department of Interior/ USGS: http://nccwsc.usgs.gov/csc.shtml
- *Climate Science News*, U.S. Global Change Research Program: http://globalchange.gov/whats-new/climate-science-news
- *The Effects of Climate Change on Water Resources in the United States*, USDA, http://www.usda.gov/oce/climate_change/files/SAP4_3/WaterBrochure.pdf
- Frequently Asked Questions about Global Warming and Climate Change: Back to Basics http://www.epa.gov/climatechange/downloads/Climate_Basics.pdf
- *Global Warming Facts and Our Future*, Marian Koshland Science Museum of the National Academy of Science: http://www.koshland-science-museum.org/exhibitgcc/index.jsp
- *National Climate Change and Wildlife Science Center*, USGS: http://nccwsc.usgs.gov/csc.shtml
- U.S. EPA's *A Student's Guide to Global Climate Change* website at http://www.epa.gov/climatechange/students/index.html
- U.S. EPA Climate Change: http://www.epa.gov/climatechange/
- The U.S. EPA's Climate Change: Basic Information website, http://www.epa.gov/climatechange/ basicinfo.html. (Provides a good primer for teachers on climate change.)
- *USDA's Agricultural Research Service (ARS)* is a source of more detailed information on climate change and agricultural impacts: "http://www.ars.usda.gov/research/

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**Resources, Tools, Equipment and Supplies**

Resources

- U.S. EPA Climate Change Kids Site: Water Cycle, http://epa.gov/climatechange/kids/water_cycle_version2.html
- U.S. Global Change Research Program, http://www.globalchange.gov/
- *Wisconsin's Changing Climate: Impacts and Adaptation. 2011. Wisconsin Initiative on Climate Change Impacts. Nelson Institute for Environmental Studies, University of Wisconsin-Madison and the Wisconsin Department of Natural Resources, Madison, Wisconsin. http://www.wicci.wisc.edu/publications.php*

Equipment

Computer with Internet connection

LED projector

**Key Terms**

Climate change

Conservation

Decision maker

Safe Drinking Water Act

Stakeholder

Underground storage tank

Watershed

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## SUMMARY OF CONTENT AND TEACHING STRATEGIES: (BACKGROUND FOR TEACHERS)

Plants, animals, natural and managed ecosystems and human settlements are susceptible to variations in the storage, fluxes, and quality of water. All of these, in turn, are sensitive to climate change. With scientific evidence showing that human-induced climate change is occurring, it is critical to understand how water quantity and quality might be affected.

Effects of climate on the nation's water storage and hydrologic functions will have significant implications for water management as variability in natural processes increases. Although U.S. water management technology is quite advanced, reliance on past conditions as the foundation for current and future planning and practice will no longer be tenable as climate change and variability increasingly create conditions well outside of historical parameters and erode predictability.

### Climate Change – Human Health and Environmental Effects: Water Resources[1]

> Some regions of the world may be showing a negative impact of climate change on water resources and freshwater. Areas in which runoff is projected to decline are likely to face a reduction in the services provided by water resources. The beneficial impacts of increased precipitation in other areas are likely to be tempered in some areas by negative effects of increased precipitation variability and seasonal runoff shifts on water supply, water quality and flood risks.[2]

The future effects of climate change on water resources in the U.S. and other parts of the world will depend on trends in both climatic and non-climatic factors. Evaluating these impacts is challenging because water availability, quality and streamflow are sensitive to changes in temperature and precipitation, and also affected by many natural and anthropogenic factors e.g... increased demand for water caused by population growth, changes in the economy, development of new technologies, changes in watershed characteristics (land use) and water management decisions by a variety of actors with frequently competing agendas.

In addition to the anticipated impacts on water management, climate change introduces an additional element of uncertainty about future water resource management. While surface water resources in the United States are heavilyto moderately managed, ground water resrouces are unmanaged or lightly managed in many areas, and supplies are scarce in some regions of the country. Strategies have been developed and continue to evolve to address these issues. Implementation of adaptation measures, such as

1 From *Climate Change—Health and Environmental Effects*, U.S. EPA: http://www.epa.gov/climatechange/effects/water/#ref

2 IPCC, 2007: *Climate Change 2007: Impacts, Adaptation, and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Parry, M. L., et al. (Eds.). Cambridge University Press, Cambridge, United Kingdom, 1000 pp

water conservation and the application of appropriate management practices will have an important role to play in determining the impacts of climate change on water resources.

**Water Availability**

The movement of water between the land surface and its underlying aquifers, oceans and atmosphere is called the hydrologic cycle. Water in the atmosphere is transported to the land surface and oceans as precipitation (rain, snow or sleet). Upon reaching the land surface, water may immediately become streamflow, or it may infiltrate into the soil where it may later be taken up by plants or it can percolate to the groundwater. Streamflow moves water to lakes and the oceans.. Ground water also contributes to surface waters. Water re-enters the atmosphere as vapor either via evaporation from surface waters (ocean, lakes, etc.,) or evapotranspiration from plants. This cyclical movement of water is driven in part by solar energy and other factors. An increase in net solar radiation or temperature could effectively speed up the processes within this cycle (evaporation, condensation, precipitation, etc).

Due to complex interactions of changes in the hydrologic cycle with global circulation patterns (ocean and air currents) and local weather patterns, an increase in energy in the hydrologic cycle does not necessarily translate into an increase in precipitation in all geographic regions. It is difficult to predict future changes in regional precipitation patterns. Predicting regional changes in streamflow and groundwater recharge due to climate change also remains challenging, particularly because of the uncertainty in regional projections of how precipitation may change (IPCC, 2007).

Changes in temperature, precipitation patterns and snowmelt can have impacts on water availability. Temperature is predicted to rise in most areas, but is generally expected to increase more in inland areas and at higher latitudes. Higher temperatures will increase loss of water through evaporation. The net impact on water supplies will depend on changes in precipitation (including changes in the total amount, form, and seasonal timing of precipitation). Generally speaking, in areas where precipitation increases sufficiently, net water supplies may not be affected or they may even increase. In other areas where precipitation remains the same or decreases, net water supplies would be expected to decrease. Where temperatures increase, there is likely to be an increase in demand, which could be particularly significant for agriculture (the largest consumer of water) and also for municipal, industrial and other uses.

Increases in temperature can affect the amount and duration of snow cover which, in turn, can affect timing of streamflow. Glaciers are expected to continue retreating, and many small glaciers may disappear entirely. Peak streamflow may move from late spring to early spring/late winter in those areas where snowpack is important in determining water availability. Changes in streamflow have important implications for water and flood management, irrigation, and planning. If supplies are reduced, off-stream users of water such as irrigated agriculture and in-stream users such as hydropower, fisheries, recreation and navigation, could be most directly affected (IPCC, 2007).

### Water Quality

Higher water temperatures and changes in the timing, intensity, and duration of precipitation can affect water quality. Higher temperatures reduce dissolved oxygen levels, which can have an effect on aquatic life. Where streamflow and lake levels fall, there will be less dilution of pollutants; however, increased frequency and intensity of rainfall will produce more pollution and sedimentation due to runoff (IPCC, 2007).

Flood magnitudes and frequencies will very likely increase in most regions — mainly a result of increased precipitation intensity and variability — and increasing temperatures are expected to intensify the climate's hydrologic cycle and melt snowpacks more rapidly (IPCC, 2007). Flooding can affect water quality, as large volumes of water can transport contaminants into water bodies and also overload storm and wastewater systems.

Higher temperatures, particularly in the summer, earlier snowmelt, and potential decreases in summer precipitation could increase risk of drought. The frequency and intensity of floods and droughts could increase, even in the same areas.

Sea level rise may also affect freshwater quality by increasing the salinity of coastal rivers and bays and causing saltwater intrusion, movement of saline water into fresh ground water resources in coastal regions.

Changes in water quality could have implications for all types of uses. For example, higher temperatures and changes in water supply and quality could affect recreational use of lakes and rivers or productivity of freshwater fisheries. Certain species of fish could find temperatures too warm and migrate to more northern or higher altitude locations where water is cooler.

### Possible Water Resource Impacts in North America

In general, the Intergovernmental Panel on Climate Change (IPCC, 2007) concludes that climate change will strain many of North America's water resources, increasing the competition for water. A warmer climate will affect the seasonable availability of water by increasing evaporation and reducing snowpacks. The Columbia River and other heavily used water systems of western North America are expected to be particularly vulnerable. Groundwater-based systems in the Southwest are also likely to be stressed by climate change. Heavier precipitation will very likely increase waterborne diseases and affect water quality, and higher variability of precipitation will make water management more difficult.

### Impacts of Global Climate Change: Agriculture[3]

The impacts of climate change will be felt across the globe. These are a few of the many examples of the impacts of climate change on water resources and agriculture.

3 IPCC, 2007: Climate Change 2007: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Parry, M. L., et al. (Eds.). Cambridge University Press, Cambridge, United Kingdom, 1000 pp

### Implications for Crop Production[4]

Changes in temperature, CO2, and precipitation under the scenarios of climate change for the next 30 year present a challenge to crop production. Events that agriculture could be vulnerable to include (a) increasing frequency, severity and duration of drought [e.g., CA], (b) flooding [e.g., Mississippi River Basin], (c) impact of changing precipitation patterns on planting and harvesting schedules, (d) wild fires [e.g., AZ, CA, TX] and (e) infestation by invading species [e.g., pine bark beetle]. The impact of temperature, CO2, and ozone on agronomic crops and the implications for crop production is still unclear. Understanding these implications for agricultural crops is critical for developing cropping systems resilient to stresses induced by climate change. There is variation among crops in their response to CO2, temperature, and precipitation changes and, with the regional differences in predicted climate, a situation is created in which the responses will be further complicated. For example, the temperature effects on soybeans could potentially cause yield reductions of 2.4 percent in the South but an increase of 1.7 percent in the Midwest. The frequency of years when temperatures exceed thresholds for damage during critical growth stages is likely to increase for some crops and regions. The increase in CO2 contributes significantly to enhanced plant growth and improved efficiency of how plants use water, however, there may be a diminution of these positive impacts due to higher temperatures plants will experience during their growth cycle. A challenge is to understand the interactions of the changing climatic parameters because of the interactions among temperature, CO2, and precipitation on plant growth and development and also on the biotic stresses of weeds, insects, and diseases. Agronomists will have to consider the variations in temperature and precipitation as part of the production system if they are to ensure the food security required by an ever increasing population.

4 Adapted from Hatfield, J.L., et al. (2011). Climate Impacts on Agriculture: Implications for Crop Production. *Agronomy Journal*, Vol. 103, Issue 2, p. 352.

## INTEREST APPROACH:

A video from the homepage of the U.S. EPA's A Student's Guide to Global Climate Change website, http://www.epa.gov/climatechange/students/index.html, can be used to review the homework material and to introduce this lesson. You will need a computer with Internet and an LCD projector to view the video as a class.

The video gives a brief overview of the causes and possible impacts of climate change. After viewing the video, ask students to reflect on the many ways we use water in our lives. They should be mindful of some of the hidden agriculture water costs discussed in Lesson 18. Then ask them to discuss how we might use water in the future; do they predict that water use will change? How do they predict agriculture and water resources in their community might be impacted by climate change? Make a list of their responses.

## OBJECTIVE BY OBJECTIVE:

### Activity Outline and Teacher Support Information:

Students should complete the Lesson 18 homework assignment to learn or review basic information about climate change before starting this activity.

19 Predict how climate change might alter water resources, particularly agricultural water use, in their state.

#### ACTIVITY: Climate Change in the News[5]

*Students will:*

- Read, review and critique the way newspapers report on climate change.
- Describe how different locations and regions view the issues and effects of climate change.

#### Materials/Resources

Current local, state and international **newspapers**

Science and water-related **magazines and journals** such as *Scientific American, Science Daily, Science News, Real Climate (web), Science, Nature,* and your state's department of natural resources magazine.

Other media: Check online **radio and TV archives** such as this National Public Radio article:

*Climate Change: Public Skeptical, Scientist Sure*, Richard Harris, National Public Radio, http://www.npr.org/2011/06/21/137309964/climate-change-public-skeptical-scientists-sure

#### Background

Depending on where you live, the local media can have a profound effect on what and how information gets reported to you. Small town weekly papers tend to focus on issues closer to home while papers with larger circulations focus on local as well as state, national and international issues.

Climate change can be a large and complex issue to cover. Climate change affects all of us and is an important issue that may be reported on differently according to the circulation size of the newspaper and the target audience.

5 From Wisconsin Department of Natural Resources • CLIMATE CHANGE: A Wisconsin Activity Guide, Grades 7-12

## ACTIVITY

### News Analysis

*Students will look through magazines and newspapers from different areas for articles, advertisements, and opinions on climate change for discussion. They will pay particular attention to those articles that discuss issues regarding water and agriculture.*

### Procedure

1) Collect an assortment of newspapers and scientific journals and magazines from different regions of your state, the United States, and the world. Many larger newspapers have current articles and archives on the Web. Divide students into groups. Assign each group a different news publication. Have each group search for articles, opinions, and advertisements directly or indirectly related to climate change and water or agriculture. Students should read the items found and write down specifics and key points to be shared later.

2) Students should also get a sense of the relative amount of coverage of climate change in each publication by counting the number of articles mentioning climate change and comparing it to the total number of articles.

3) Once everyone has finished their review, ask each group to share their findings and discuss whether there were differences among the publications. Follow the discussion questions below.

### Discussion Questions

1) What, if any, were the differences between the urban and rural papers?

2) What, if any, were the differences between papers from various regions of the U.S.? Discuss how they were different.

3) What differences were noticed between publications from the US and foreign newspapers?

4) Does the paper have an editorial slant (e.g. conservative vs. liberal, business focused, etc.)? How do you know? If there is a slant, how might it affect the coverage? Does the paper have an editorial position related to climate change and, if so, what is it? How do you know?

5) How many editorials were in the paper on climate change issues? Were they positive or negative? In what ways?

6) Of all the articles you found on climate change, how many addressed issues related to ***water*** and climate change? How about ***agriculture*** and climate change? How many addressed both ***water and agriculture*** in the same article?

7) Share with classmates one story that was reported that you found particularly interesting, compelling or unusual.

## REVIEW / SUMMARY:

Respond in your journal to the following:

What conclusions are you able to draw from the information shared in the class discussion of reporting on climate change? What factors do you think influence the range of approaches and opinions about climate change?

## EVALUATION AND ANSWERS:

Teachers should observe discussion closely for individual comprehension of climate change issues and ability to extrapolate the impacts on agriculture and on water quality and quantity.