Lecture 9 – Impacts of climate change - 2

Increasing human use of fresh water resources

Water uses for humankind

- Water is cycled between the oceans, the atmosphere and the land surface.
- Water is essential to all forms of life (both plant and animal).
- Water is also a key substance for humankind;
  - For drinking, for production of food, for health and hygiene, for industry and transport.
- Water availability for domestic, industrial and agricultural use averaged per capita in different countries varies from less than 100m^3 per year to over 100,000m^3.
- In poor countries people spend a lot of time in walking to fetch drinking water.
- Increase in freshwater use is driven by changes in population, lifestyle, economy, technology and most by demand for food which dries irrigated agriculture.
- 2/3 of human water use is currently for agriculture, much of it for irrigation; about ¼ is used by industry; only 10% is used domestically.

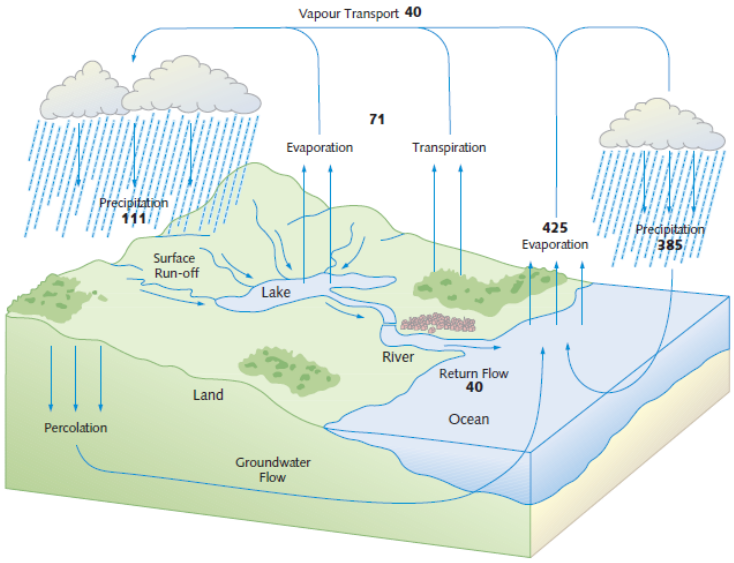


Figure 7.5 The global water cycle (in thousands of cubic kilometres per year), showing the key processes of evaporation, precipitation, transport as vapour by atmospheric movements and transport from the land to the oceans by run-off or groundwater flow.

Water stressed countries

- The extent to which a country is *water stressed is related to the proportion of* the available freshwater supply that is withdrawn for use.
- In global scale assessments, basins with water stress are defined either as having per capita water availability below 1000 m^3 per year (based on long-term average run-off) or as having a ratio of withdrawals to long-term average annual run-off above 0.4.
- Water stressed countries: Africa, Mediterranean region, the Near East, South Asia, northern China, Australia, USA, Mexico, northeast Brazil and the western coast of South America.

Sharing of water resources

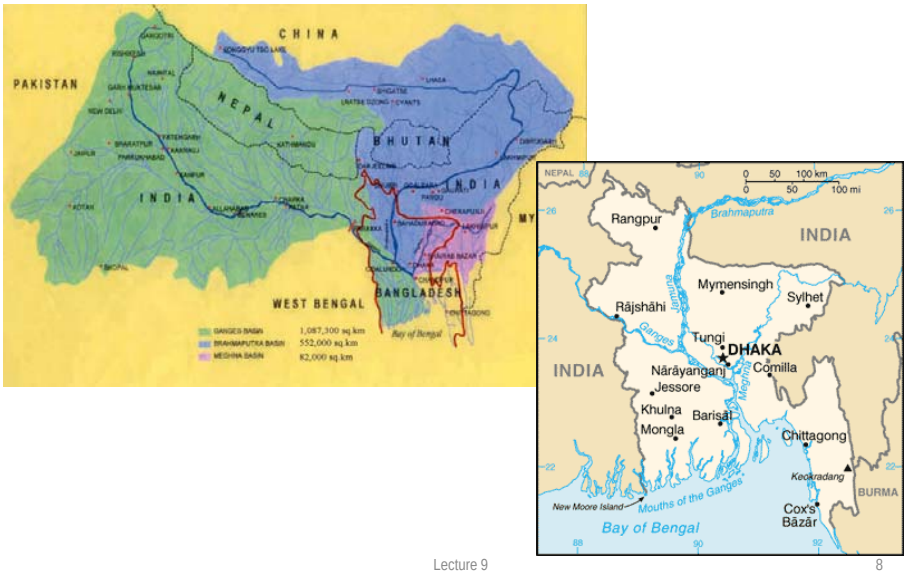
- World's major sources of water are shared.
- There are 44 countries for which at least 80% of their land area falls within such international basins. The Danube, for instance, passes through 12 countries that use its water, the Nile water through nine, the Ganges–Brahmaputra through five.
- The achievements of agreements to share water often bring with them demands for more effective use of the water and better management.
- Failure to agree brings increased possibility of tension and conflict.
- There is possibility of war for water in future.

River Danube

Location

The Danube river basin covers part or all of 19 riparian countries: Albania, Austria, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Germany, Hungary, Italy, Macedonia, Moldova, Poland, Romania, Serbia, Montenegro, Slovakia, Slovenia, Switzerland and Ukraine.

BASIN MAP OF THE GANGES, THE BRAHMAPUTRA AND THE MEGHNA RIVER



Global water withdrawal

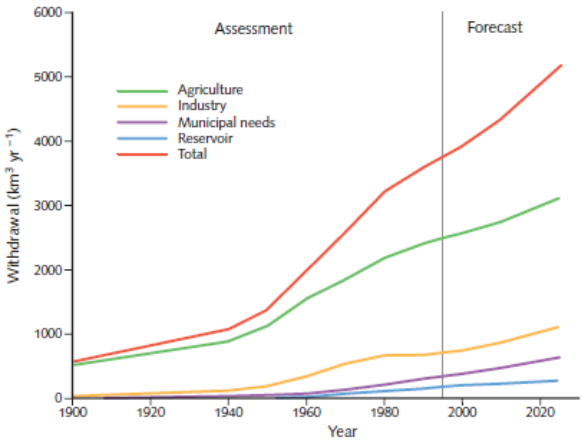


Figure 7.6 Global water withdrawal for different purposes, 1900–95, and projected to the year 2025 in cubic kilometres per year. Losses from reservoirs are also included. As some water withdrawn is reused, the total water consumption amounts to about 60% of the total water withdrawal.

The impact of climate change on fresh water resources

The availability of water will be changed due to global warming.

- For instance, precipitation is expected to increase in high latitudes and in parts of the tropics and decrease in many mid latitude and sub-tropical regions especially in summer.
- Increased precipitation – more water available for higher evaporation at high temperature regions.
- Less precipitation – less water available for evaporation at the surface.
- The combined effect of less rainfall and more evaporation means less soil moisture available for crop growth and also less run-off – in regions with marginal rainfall this loss of soil moisture can be critical.

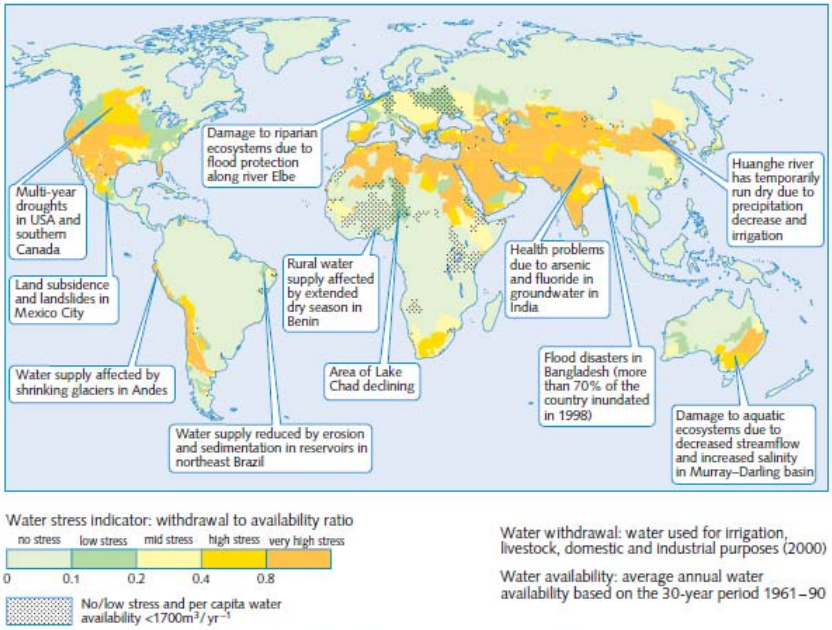
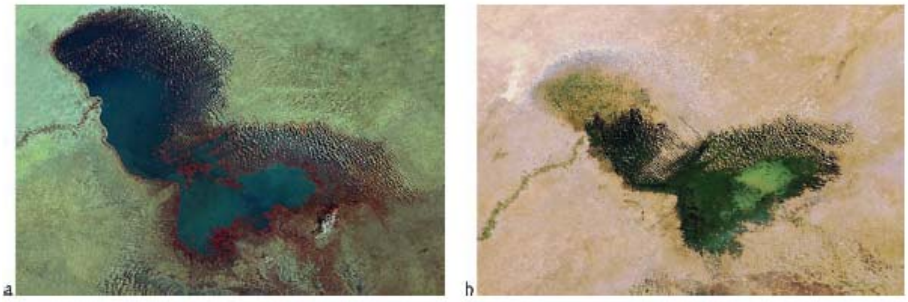


Figure 7.7 Examples of current vulnerabilities of fresh water resources and their management; in the background, a water stress map based on Alcamo *et al.* (2003a). See text for relation to climate change.

The run-off

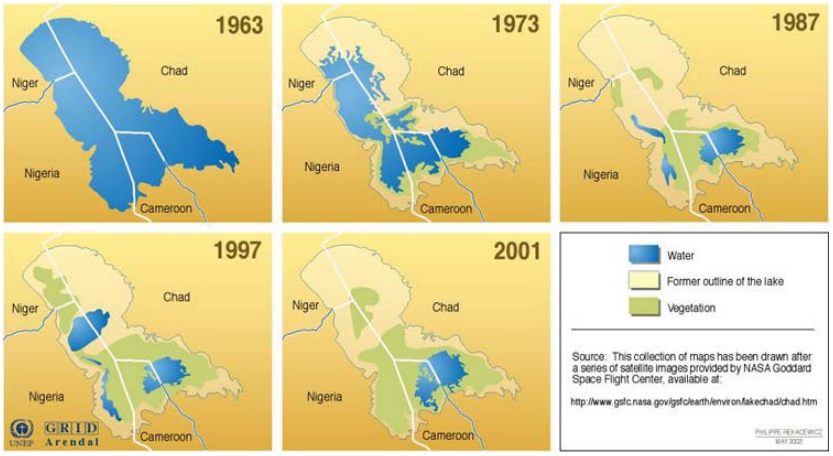
- The run-off in rivers and streams is what is left from the precipitation that falls on the land after some has been taken by evaporation and by transpiration from plants; it is the major part of what is available for human use.
- The amount of run-off is highly sensitive to changes in climate; even small changes in the amount of precipitation or in the temperature (affecting the amount of evaporation) can have a big influence on it.
- Example: Disappearing of Lake Chad

Lake Chad



Desiccation of Lake Chad: (a) 1973 (b) 2007. The lake is very shallow and is particularly sensitive to small changes in average depth, and seasonal variation. An increased demand on the lake's water from the local population has probably accelerated its shrinkage over the past 40 years; also, over-grazing in the area surrounding the lake causes desertification and a decline in vegetation.

The Disappearance of Lake Chad in Africa



The size of Lake Chad has increased and shrunk at regular intervals. Increasing aridity in the Sahel area and more demand for freshwater for irrigation may however entail that Lake Chad will continue shrinking. Lake Chad varies in extent between the rainy and dry seasons, from 50,000 to 20,000 km^2. Precise boundaries have been established between Chad, Nigeria, Cameroon, and Niger.

The boxes in Figure 7.8 illustrate some particular impacts of expected changes.

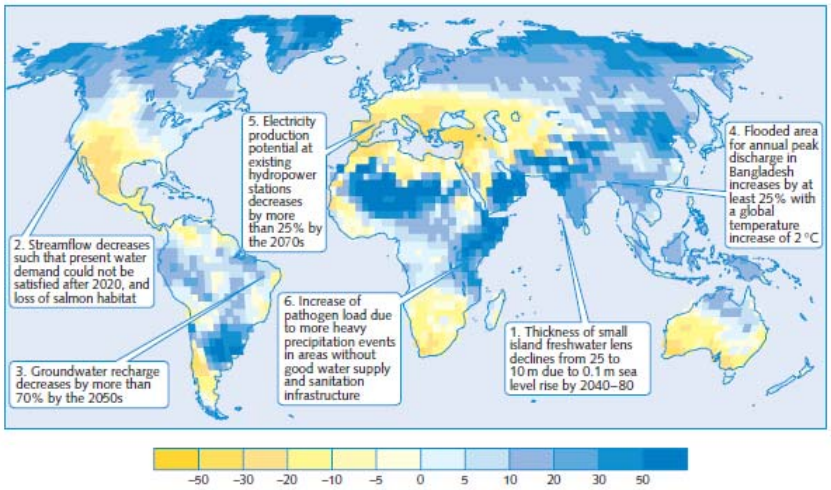


Figure 7.8 Illustrative map of future climate change impacts on fresh water which are a threat to the sustainable development of the affected regions. The background map is of the ensemble mean change in annual run-off in per cent between (1981–2000) and (2081– 2100) for the SRES A1B emissions scenario.

Eight of the changes of particular concern are:

1. Due to global warming up to one-half of the mass of mountain glaciers and small ice caps outside the polar regions may melt away over the next hundred years.
   - Snow melt is an important source of run-off and watersheds will be severely affected by glacier and snow cover decline.
   - Affected area: Hindu-Kush-Himalayan glaciated region in Asia, South American Andes region.

Eight of the changes of particular concern are:

2. Many semi-arid areas (e.g. Mediterranean basin, western USA, southern Africa, northeastern Brazil and parts of Australia) will suffer serious decreases in water resources due to climate change.
   - These problems will be particularly acute in semi-arid or arid low-income countries, where precipitation and stream flow are concentrated over a few months and where the variability of precipitation is likely to increase as climate changes

Eight of the changes of particular concern are:

3. Due to increases in population in addition to climate change, the number of people living in severely stressed river basins is projected to increase from about 1.5 billion in 1995 to 3 to 5 billion in 2050 for the SRES B2 scenario.

Eight of the changes of particular concern are:

4. The more intense hydrological cycle associated with global warming will lead to increased frequency and intensity of both floods and droughts.
   - Increases by 2050 in many parts of the world in the frequency and severity of both floods and droughts of about a factor of 5 that were mentioned in Chapter 6 will have very large implications for water availability and management.

Eight of the changes of particular concern are:

5. Groundwater recharge will decrease considerably in some already water stressed regions where vulnerability may be exacerbated by increase in population and water demand.
6. Sea level rise together with greater use of groundwater will extend areas of salination of groundwater and estuaries, resulting in a decrease in fresh water availability for humans and ecosystems in coastal areas.
7. Higher water temperatures, increased precipitation intensity and longer periods of low flows exacerbate many forms of water pollution, with impacts on ecosystems, human health and water system reliability and operating costs.

Eight of the changes of particular concern are:

8. For the vulnerability of water supplies is the link between rainfall and changes in land use. Extensive deforestation can lead to large changes in rainfall.
   - A similar tendency to reduced rainfall can be expected if there is a reduction in vegetation over large areas of semi-arid regions.
   - Such changes can have a devastating and widespread effect and assist in the process of desertification.

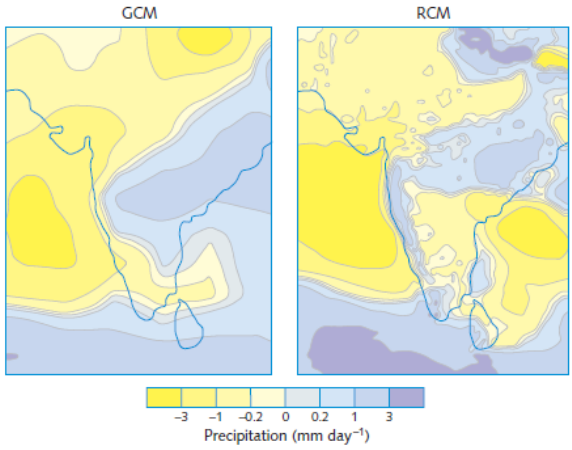


Figure 7.9 Predicted changes in monsoon rainfall (mm day^{-1}) over India between the present day and the middle of the twenty-first century from a 300-km resolution GCM and from a 50-km resolution RCM. The RCM pattern is very different in some respects from the coarser resolution pattern of the GCM.

The monsoon regions of Southeast Asia are an example of an area that may be particularly vulnerable to both floods and droughts. Figure 7.9 shows the predicted change in summer precipitation over the Indian sub-continent as simulated by a regional climate model (RCM) for 2050 under a scenario similar to SRES A1B.

Remedial actions

- Increasing the **efficiency of water use**. Most irrigation is through open ditches, which is very wasteful of water; over 60% is lost through evaporation and seepage.
  - Micro-irrigation techniques, in which perforated pipes deliver water directly to the plants, provide large opportunities for water conservation, making it possible to expand irrigated fields without building new dams.
  - Recycle water where possible, to promote indigenous practices for sustainable water use (e.g. local rainwater storage), to conserve water (and also soil) by avoiding deforestation or increasing forested areas and to use economic incentives to encourage water conservation

Remedial actions

- Secondly, looking for **new water supplies**. For instance, by increasing water storage in reservoirs or dams, by desalination of sea water, by transferring water from areas of greater abundance or by prospecting and extracting groundwater in appropriate areas.
- Thirdly, by introducing more informed management. Many interested experts and bodies are promoting ***Integrated water management*** *that* involves all sectors – agricultural, domestic and industrial – relates to existing infrastructure and plans for new infrastructure and also, most importantly, includes preparation for disasters such as major floods and droughts.

Impact on agriculture and food supply

- Every farmer understands the need to grow crops or rear animals that are suited to the local climate. The distribution of temperature and rainfall during the year are key factors in making decisions regarding what crops to grow.
- These will change in the world influenced by global warming. The patterns of what crops are grown where will therefore also change.

Impact on agriculture and food supply

- There is enormous capacity for adaptation in the growth of crops for food.
- There are concerns that factors such as the degradation of many of the world's soils largely through erosion and the slowed rate of expansion of irrigation because less fresh water is available will tend to reduce the potential for increased agricultural production in the future.

What will be the effect of climate change on agriculture and food supply?

Four factors are particularly important in considering the effect of climate change on agriculture and food production.

- The availability of water is the most important of the factors. The vulnerability of water supplies to climate change carries over into a vulnerability in the growing of crops and the production of food. Thus the arid or semi-arid areas, mostly in developing countries, are most at risk.
- A second factor, which tends to lead to increased production as a result of climate change, is the boost to growth that is given, particularly to some crops, by increased atmospheric carbon dioxide.
- A third factor is the effect of temperature changes; as temperatures rise, yields of some crops are substantially reduced.
- A fourth factor is the influence of climate extremes, heat waves, floods and droughts that seriously interfere with food production.

Impacts on crops

- Warmer temperatures may make many crops grow more quickly, but warmer temperatures could also reduce yields.
- Crops tend to grow faster in warmer conditions. However, for some crops (such as grains), faster growth reduces the amount of time that seeds have to grow and mature. [1] This can reduce yields (i.e., the amount of crop produced from a given amount of land).
- For any particular crop, the effect of increased temperature will depend on the crop's optimal temperature for growth and reproduction. [1] In some areas, warming may benefit the types of crops that are typically planted there. However, if warming exceeds a crop's optimum temperature, yields can decline.

Impacts on crops

- Higher CO_2 levels can increase yields. The yields for some crops, like wheat and soybeans, could increase by 30% or more under a doubling of CO_2 concentrations. The yields for other crops, such as corn, exhibit a much smaller response (less than 10% increase). [3] However, some factors may counteract these potential increases in yield. For example, if temperature exceeds a crop's optimal level or if sufficient water and nutrients are not available, yield increases may be reduced or reversed.
- More extreme temperature and precipitation can prevent crops from growing. Extreme events, especially floods and droughts, can harm crops and reduce yields. For example, in 2008, the Mississippi River flooded just before the harvest period for many crops, causing an estimated loss of $8 billion for farmers. [1]
- Dealing with drought could become a challenge in areas where summer temperatures are projected to increase and precipitation is projected to decrease. As water supplies are reduced, it may be more difficult to meet water demands.
- Many weeds, pests and fungi thrive under warmer temperatures, wetter climates, and increased CO_2 levels. Currently, farmers spend more than $11 billion per year to fight weeds in the United States. [1] The ranges of weeds and pests are likely to expand northward. This would cause new problems for farmers' crops previously unexposed to these species. Moreover, increased use of pesticides and fungicides may negatively affect human health. [1]

Source: http://www.epa.gov/climatechange/impacts-adaptation/agriculture.html

Impact on livestock

- Heat waves, which are projected to increase under climate change, could directly threaten livestock. Heat stress affects animals both directly and indirectly. Over time, heat stress can increase vulnerability to disease, reduce fertility, and reduce milk production.
- Drought may threaten pasture and feed supplies. Drought reduces the amount of quality forage available to grazing livestock. Some areas could experience longer, more intense droughts, resulting from higher summer temperatures and reduced precipitation. For animals that rely on grain, changes in crop production due to drought could also become a problem.
- Climate change may increase the prevalence of parasites and diseases that affect livestock. The earlier onset of spring and warmer winters could allow some parasites and pathogens to survive more easily. In areas with increased rainfall, moisture-reliant pathogens could thrive. [3]
- Increases in carbon dioxide (CO_2) may increase the productivity of pastures, but may also decrease their quality. Increases in atmospheric CO_2 can increase the productivity of plants on which livestock feed. However, studies indicate that the quality of some of the forage found in pasturelands decreases with higher CO_2. As a result, cattle would need to eat more to get the same nutritional benefits.

Impact on fisheries

- Many fisheries already face multiple stresses, including overfishing and water pollution. Climate change may worsen these stresses. In particular, temperature changes could lead to significant impacts.
- The ranges of many fish and shellfish species may change. Many marine species have certain temperature ranges at which they can survive. For example, cod in the North Atlantic require water temperatures below 54°F. Even sea-bottom temperatures above 47°F can reduce their ability to reproduce and for young cod to survive. In this century, temperatures in the region will likely exceed both thresholds. [1]
- Many aquatic species can find colder areas of streams and lakes or move northward along the coast or in the ocean. However, moving into new areas may put these species into competition with other species over food and other resources, as explained on the Ecosystems Impacts page.
- Some diseases that affect aquatic life may become more prevalent in warm water. For example, in southern New England, lobster catches have declined dramatically. A temperature-sensitive bacterial shell disease likely caused the large die-off events that led to the decline. [1

Impact on fisheries

- Changes in temperature and seasons could affect the timing of reproduction and migration. Many steps within an aquatic animal's lifecycle are controlled by temperature and the changing of the seasons. For example, in the Northwest warmer water temperatures may affect the lifecycle of salmon and increase the likelihood of disease. Combined with other climate impacts, these effects are projected to lead to large declines in salmon populations.
- In addition to warming, the world's oceans are gradually becoming more acidic due to increases in atmospheric carbon dioxide (CO_2). Increasing acidity could harm shellfish by weakening their shells, which are created from calcium and are vulnerable to increasing acidity. [1] Acidification may also threaten the structures of sensitive ecosystems upon which some fish and shellfish rely.

Source: http://www.epa.gov/climatechange/impacts-adaptation/agriculture.html

Impacts observed in Nepal [example]

- Nepal is a prime example, where due to an average 0.06 degree Celsius rise of temperature per year, decrease in apple harvest was found due to reduced fruiting, early growing, dying and drying of apple plants, which had brought a huge loss to the economy of the farmers (Lama et al, 2009).
- Even it is reported that Rhododendron, which is supposed to blossom during March-April, is flowering in December and January in Nepalese mountain forests.

Review questions

- What are the impacts of food crops cultivation (rice, wheat, millet, corn etc.) in Nepal due to climate change?
- Will there be any affect on the livestock and fisheries in Nepal due to global warming in Nepal?

Reference:

- Houghton, J., 2009, Global Warming. The complete briefing , 4th edition (www.cambridge.org)