

Chapter 13

Water Resources

Summary

1. Approximately 0.024% of the earth's water supply is available as liquid freshwater. Management of the world's water supply is a huge 21st century challenge.
2. Freshwater shortages are caused by dry climate, droughts, desiccation, and water stress. Solutions for this problem include building dams and reservoirs, transporting freshwater between locations, withdrawing groundwater, and desalination.
3. Advantages of dams and reservoirs include cheap electricity, reduction of downstream flooding, and year-round water for irrigation. Disadvantages include displacement of people and disruption of aquatic systems, and the hydrological cycle.
4. Transferring large amounts of water from one area to another can give stream runoff from water-rich areas to water-poor areas and aid in irrigation of farmland. It can also cause ecological, economical, and health disasters.
5. The advantages of withdrawing groundwater include water for drinking and irrigation; availability and locality; low cost, no evaporation losses; and it is renewable. Disadvantages include aquifer depletion from over pumping, subsidence, pollution, saltwater intrusion, and reduced water flow. Desalination increases the supply of fresh water but is expensive and produces large quantities of wastewater.
6. We can waste less water by lining canals, leveling fields, irrigating at night or using new irrigation techniques, polyculture or organic farming, seasonal farming, irrigating with treated waste water, and importing water-intensive crops and meat.
7. Flooding is caused by heavy rain or melting of snow within a short time. To reduce flood damage or the risk of flooding we can avoid building on floodplains, removing water-absorbing vegetation, or draining wetlands.
8. Methods for achieving more sustainable use of the earth's water include not depleting aquifers, preserving aquatic systems and water quality, integrated watershed management, agreements among regions and countries sharing surface water resources, outside party mediation of water dispute nations, marketing of water rights, raising water prices, wasting less water, decreasing government subsidies for reducing water waste, and slowing population growth.

Key Questions and Concepts

13-1 Will we have enough usable water?

CORE CASE STUDY: The Colorado River is 1,400 miles long and has been altered by 14 major dams and reservoirs. This river provides water and electricity for 30 million people and irrigation to grow 15% of the nation's crops and livestock.

- A. Water keeps us alive, moderates climate, sculpts the land, removes and dilutes wastes and pollutants, and moves continually through the hydrologic cycle.

- B. Only about 0.024% of the earth's water supply is available to us as liquid freshwater in accessible groundwater deposits and in lakes, rivers, and streams. The hydrologic cycle collects, purifies, recycles, and distributes the world's freshwater supply. Some countries have more water than they need; some countries have far less.
- C. Some precipitation infiltrates the ground and percolates downward through spaces in the soil, gravel, and rock. This water is known as groundwater, an important fresh water source.
- D. Water that does not sink into the ground or evaporate into the air runs off into bodies of water. This is known as surface water.
- E. We currently withdraw 34% of the world's reliable runoff of surface water and could be using 90% by 2025.
- F. Irrigation is the biggest user of water (70%), followed by industries (20%) and cities and residences (10%).

CASE STUDY: The United States has plenty of freshwater, but supplies vary in different areas depending on climate. This unequal distribution of water can be seen in Figure 14-4. There are water hot spots in 17 western states (Figure 14-5), that could trigger intense conflict in the next 20 years.

SCIENCE FOCUS: Water footprint refers to the rough measure of volume of water used by each of us directly and indirectly. Direct use in the United States amounts to about 69 gallons per person. In addition, virtual water accounts for water that is not directly consumed, but is used to produce food and other products.

G. More than 30 countries now face water scarcity. By 2050, 60 countries, mostly in Asia, with $\frac{3}{4}$ of the world population will suffer from water stress.

H. Conflicts between nations over water resources are likely to grow, as many nations that share water supplies do not have water sharing agreements.

13-2 Is extracting groundwater the answer?

- A. Most aquifers are renewable resources unless water is removed faster than it is replenished or the aquifers are contaminated. Aquifers provide almost one-fourth of the world's water.
- B. In many parts of the world, aquifers are being depleted faster than they are renewed.
1. Water tables are falling in many areas of the world because the rate of pumping out water (mostly to irrigate crops) exceeds the rate of natural recharge from precipitation.
 2. The widespread drilling of inexpensive tube wells by small farmers, especially in Asia, has accelerated aquifer overpumping.
 3. Saudi Arabia gets 70% of its water from the world's largest desalination complex.

CASE STUDY: In the United States, groundwater is being withdrawn four times faster than it is being replenished. In the Central U.S., government subsidies to farmers have increased depletion of the Ogallala aquifer.

- C. Groundwater overpumping can increase the gap between the rich and the poor, cause land to sink, and contaminate freshwater aquifers near coastal areas with saltwater.
- D. Deep aquifers may be a future water source. There are major concerns with their use.
1. They are nonrenewable.
 2. Little is known of the geological or ecological impacts of their use.
 3. Some flow under more than one nation.
 4. The costs are unknown and could be high.

13-3 Is building more dams the answer?

A. Large dams and reservoirs can produce cheap electricity, reduce downstream flooding, and provide year-round water for irrigating cropland, but they also displace people and disrupt aquatic systems.

1. There are more than 45,000 large dams in the world.

B. The Colorado River is an example of unsustainable water use.

1. 80% of this water is used for agriculture, and much is lost to seepage and evaporation.

13-4 Is transferring water from one place to another the Answer?

A. Transferring water can make unproductive areas more productive but can cause environmental harm.

CASE STUDY: The California Water Project provides for a massive transfer of water from water-rich northern California to water-poor southern California. This has allowed for the development of agriculture and urban areas in desert-like conditions. However, this has degraded river ecosystems and fisheries.

CASE STUDY: Diverting water from the Aral Sea and its two feeder rivers mostly for irrigation has created a major ecological, economic, and health disaster. This activity has increased the salinity of the sea sevenfold since 1961, the surface area has decreased, and 90% of its water volume has been lost. About 85% of the area's wetlands have been eliminated; roughly half the birds and mammal species have disappeared. The fishing industry has disappeared, and salt and contaminant-rich dust from exposed lake sediments are creating a major dust pollution source for the region. Some artificial wetlands and lakes have been constructed to help restore aquatic vegetation, wildlife, and fisheries. With the various improvements, the water volume in the Aral Sea has stabilized though at a much lower level than prior to water diversions.

Is converting salty seawater to freshwater the answer?

Removing salt from seawater by current methods is expensive, produces large amounts of salty wastewater that must be disposed of properly, and can be detrimental to many marine organisms. The process is known as desalination. Methods include distillation and reverse osmosis.

SCIENCE FOCUS: The search for improved desalination technology has led to dramatic reductions in cost, and many ideas and methods that would reduce the environmental impact.

How can we use water more sustainably?

We waste about two-thirds of the water we use, but this waste could be cut to 15% through reduced evaporation and leakage and improved efficiency of use.

Higher water costs would reduce waste.

Sixty percent of the world's irrigation water is currently wasted, but with improved irrigation techniques such as center-pivot, low-pressure sprinkler irrigation, Low-Energy Precision Application (LEPA), and drip irrigation systems could cut this waste to 5–20%.

Many poor farmers in developing countries use low-tech methods to pump groundwater and make more efficient use of rainfall.

Industries can recycle much of the water they use; and homeowners can use water-saving toilets, appliances, and showerheads, fix leaks, use drip irrigation and yard plants that need little water (xeriscaping), save and reuse rainwater, and reuse wastewater for some purposes.

13-7 How can we reduce the threat of flooding?

Heavy rainfall, rapid snowmelt, removal of vegetation, and destruction of wetlands cause flooding. Floods occur when a stream overflows its normal channel and spills into a floodplain.

Flood can be beneficial in recharging groundwater and depositing nutrients.

Floods can also be detrimental to communities and property.

Several factors increase flooding

The removal of water absorbing vegetation

Draining and building on wetlands

Climate change

CASE STUDY: Bangladesh has experienced increased flooding because of upstream deforestation of Himalayan mountain slopes and the clearing of mangrove forests on its coastal floodplains. Bangladesh is one of the world's most densely populated countries, and is very flat. The people of Bangladesh depend on the moderate annual flooding to maintain soil fertility. Great floods used to occur about every 50 years or so, but since the 1970s they now occur about every 4 years.

We can reduce flooding risks by controlling river water flows, protecting mountainside forests, preserving and restoring wetlands, identifying and managing flood-prone areas, and, if possible, choosing not to live in such areas.

Key Terms aquifers

dam

desalination

drainage basin

drought

floodplain

groundwater

reliable surface runoff

reservoir

surface runoff

surface water

water table

watershed

zone of saturation