Water Resources

Chapter 13

13-1 Will We Have Enough Usable Water?

- ***Concept 13-1A*** *We are using available freshwater unsustainably by wasting it, polluting it, and charging too little for this irreplaceable natural resource.*
- ***Concept 13-1B*** *One of every six people does not have sufficient access to clean water, and this situation will almost certainly get worse.*

Freshwater Is an Irreplaceable Resource That We Are Managing Poorly (1)

- Why is water so important?
- Earth as a watery world: 71%
- Freshwater availability: 0.024%
- Poorly managed resource
- Hydrologic cycle
- Water pollution

Freshwater Is an Irreplaceable Resource That We Are Managing Poorly (2)

- Access to water is
  - A global health issue
  - An economic issue
  - A women's and children's issue
  - A national and global security issue

Most of the Earth's Freshwater Is Not Available to Us

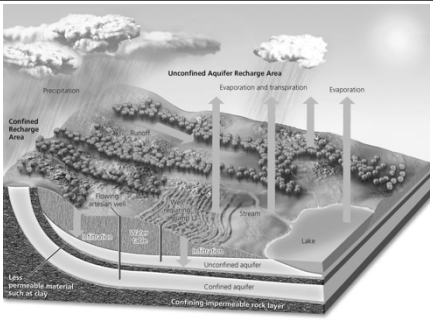
- **Hydrologic cycle**
  - Movement of water in the seas, land, and air
  - Driven by solar energy and gravity
- People divided into
  - Water *haves*
  - Water *have-nots*

Girl Carrying Well Water over Dried Out Earth during a Severe Drought in India

We Get Freshwater from Groundwater and Surface Water (1)

- **Ground water**
- **Zone of saturation**
- **Water table**
- **Aquifers**
  - Natural recharge
  - Lateral recharge

Natural Capital: Groundwater System: Unconfined and Confined Aquifer



We Get Freshwater from Groundwater and Surface Water (2)

- **Surface Water**
  - **Surface runoff**
  - **Watershed (drainage) basin**
  - **Reliable runoff**
    - 1/3 of total (see next slide)

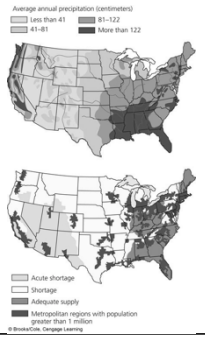
We Use a Large and Growing Portion of the World's Reliable Runoff

- 2/3 of the surface runoff: lost by seasonal floods
- 1/3 runoff usable
  - Domestic: 10%
  - Agriculture: 70%
  - Industrial use: 20%
- Fred Pearce, author of *When the Rivers Run Dry*

Case Study: Freshwater Resources in the United States

- More than enough renewable freshwater, unevenly distributed
- Effect of
  - Floods
  - Pollution
  - **Drought**
- 2007: U.S. Geological Survey projection
  - **Water hotspots**

Average Annual Precipitation and Major Rivers, Water-Deficit Regions in U.S.



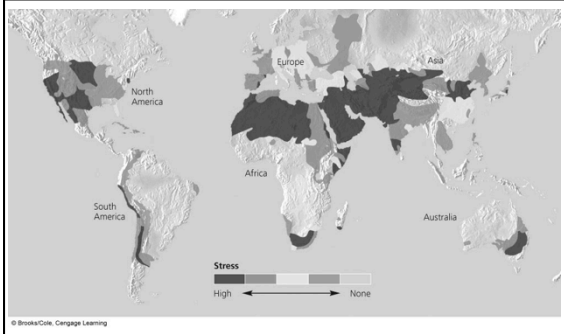
Water Hotspots in 17 Western U.S. States

Water Shortages Will Grow

- **Main factors contributing to water scarcity:**

- Dry climate
- Drought
- **Too many people** using a normal supply of water
- Wasteful use of water
- China and urbanization
- Hydrological poverty

Natural Capital Degradation: Stress on the World's Major River Basins



Long-Term Severe Drought Is Increasing

- Causes
  - Extended period of below-normal rainfall
  - Diminished groundwater
- Harmful environmental effects
  - Dries out soils
  - Reduces stream flows
  - Decreases tree growth and biomass
  - Lowers net primary productivity and crop yields
  - Shift in biomes

In Water-Short Areas Farmers and Cities Compete for Water Resources

- 2007: National Academy of Science study
  - Increased corn production in the U.S. to make ethanol as an alternative fuel
    - Decreasing water supplies
    - Aquifer depletion
    - Increase in pollution of streams and aquifers

Who Should Own and Manage Freshwater Resources? (1)

- Most water resources
  - Owned by governments
  - Managed as publicly owned resources
- Veolia and Suez: French companies
  - Buy and manage water resources
  - Successful outcomes in many areas

Who Should Own and Manage Freshwater Resources? (2)

- Bechtel Corporation
  - Poor water management in Bolivia
- A subsidiary of Bechtel Corporation
  - Poor water management in Ecuador
- Potential problems with full privatization of water resources
  - Financial incentive to sell water; not conserve it
  - Poor will still be left out

13-2 Is Extracting Groundwater the Answer?

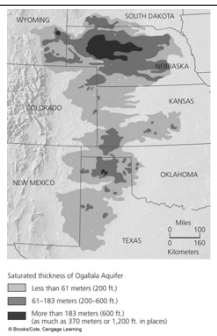
- ***Concept 13-2*** *Groundwater that is used to supply cities and grow food is being pumped from aquifers in some areas faster than it is renewed by precipitation.*

Fig. 13-7, p. 321

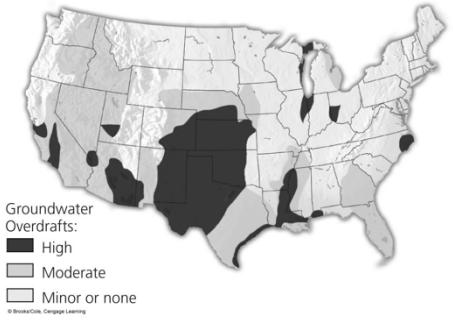
Case Study: Aquifer Depletion in the United States

- Ogallala aquifer: largest known aquifer
  - Irrigates the Great Plains
  - Water table lowered more than 30m
  - Cost of high pumping has eliminated some of the farmers
  - Government subsidies to continue farming deplete the aquifer further
  - Biodiversity threatened in some areas
- California Central Valley: serious water depletion

Natural Capital Degradation: The Ogallala is the World's Largest Known Aquifer

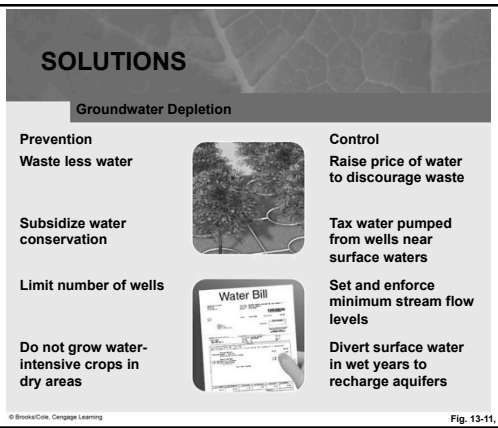


Natural Capital Degradation: Areas of Greatest Aquifer Depletion in the U.S.



Groundwater Overpumping Has Other Harmful Effects

- Limits future food production (esp. poor farmers)
- **Land subsidence (due to emptying aquifers)**
  - Mexico City
- **Sinkholes (underground caverns collapse)**
- Groundwater overdrafts near coastal regions
  - Contamination of the groundwater with saltwater = Undrinkable and unusable for irrigation



Active Figure: Threats to aquifers

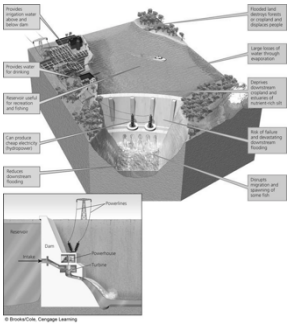
13-3 Is Building More Dams the Answer?

- ***Concept 13-3*** *Building dam and reservoir systems has greatly increased water supplies in some areas, but it has disrupted ecosystems and displaced people.*

Large Dams and Reservoirs Have Advantages and Disadvantages (1)

- Main goals of a **dam** and **reservoir** system
  - Capture and store runoff
  - Release runoff as needed to control:
    - Floods
    - Generate electricity (hydroelectric power)
    - Supply irrigation and municipal water
    - Recreation (reservoirs: swimming, fishing…)

Advantages and Disadvantages of Large Dams and Reservoirs



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Large Dams and Reservoirs Have Advantages and Disadvantages (2)

- Advantages
  - Increase the reliable runoff available
  - Reduce flooding
  - Grow crops in arid regions
- Disadvantages
  - Displaces people (ca. 40-80 million)
  - Flooded regions (usually highly productive land lost)
  - Impaired ecological services of rivers
  - Loss of plant and animal species (ca. one-fifth…)
  - Fill up with sediment within 50 years

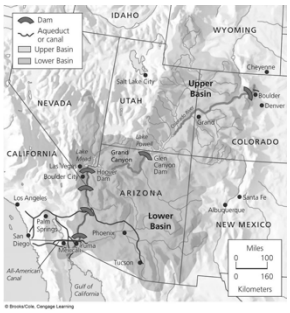
Some Rivers Are Running Dry and Some Lakes Are Shrinking

- Dams disrupt the hydrologic cycle
- Major rivers running dry part of the year
  - Colorado and Rio Grande, U.S.
  - Yangtze and Yellow, China
  - Indus, India
  - Danube, Europe
  - Nile River-Lake Victoria, Egypt
- Lake Chad Africa: disappearing (96% smaller…)

Case Study: The Colorado River Basin—An Overtapped Resource (1)

- 2,300 km through 7 U.S. states
- 14 Dams and reservoirs
- Located in a desert area within the rain shadow of California mountains
- Water supplied mostly from snowmelt of the Rocky Mountains

The Colorado River Basin



Case Study: The Colorado River Basin—An Overtapped Resource (2)

- Supplies water and electricity for more than 25 million people in seven states
- Irrigation of crops (15% of nation's crops, livestock)
- Recreation (rafting, boating, fishing, camping…)

Case Study: The Colorado River Basin—An Overtapped Resource (3)

- Four Major problems
  - Colorado River basin has very dry lands
  - Modest flow of water for its size
  - Legal pacts allocated more water for human use than it can supply
  - Amount of water flowing to the mouth of the river has dropped

Aerial View of Glen Canyon Dam Across the Colorado River and Lake Powell

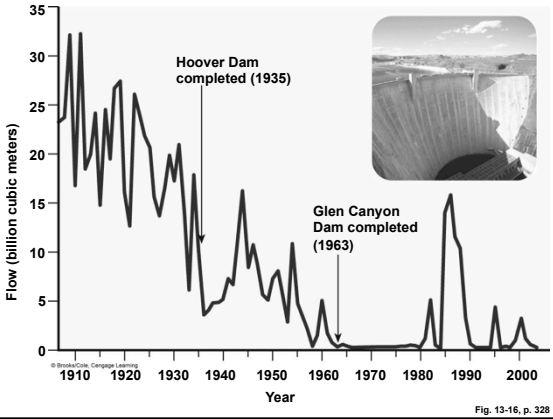
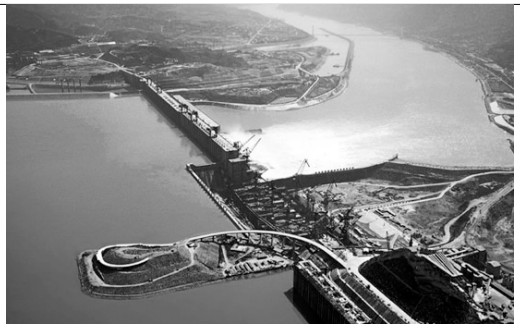


Fig. 13-16, p. 328

Case Study: China's Three Gorges Dam

- World's largest hydroelectric dam and reservoir
  - 2 km long across the Yangtze River
- Benefits
  - Electricity-producing potential is huge
  - Holds back the Yangtze River floodwaters
  - Allows cargo-carrying ships
- Harmful effects
  - Displaces about 5.4 million people
  - Built over a seismic fault
  - Rotting plant and animal matter producing CH_4
    - Worse than CO_2 emissions

Three Gorges Dam



http://www.absolutechinatours.com/UploadFiles/ImageBase/Three-Gorges-Dam%281%29.jpg

13-4 Is Transferring Water from One Place to Another the Answer?

- ***Concept 13-4*** *Transferring water from one place to another has greatly increased water supplies in some areas, but it has also disrupted ecosystems.*

CA, U.S., Transfers Water from Water-Rich Areas to Water-Poor Areas

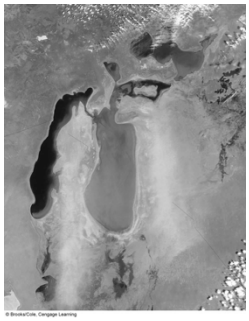
- Water transferred by
  - Tunnels
  - Aqueducts
  - Underground pipes
- May cause environmental problems
- California Water Project

The California Water Project and the Central Arizona Project

Case Study: The Aral Sea Disaster

- Large-scale water transfers in dry central Asia
- Salinity
- Wetland destruction and wildlife
- Fish extinctions and fishing
- Wind-blown salt
- Water pollution
- Climatic changes

Natural Capital Degradation: The Aral Sea, Shrinking Freshwater Lake



China Plans a Massive Transfer of Water

- South-North Water Transfer Project
- Water from three rivers to supply 0.5 billion people
- Completion in about 2050
- Impact
  - Economic
  - Health
  - Environmental

13-5 Is Converting Salty Seawater to Freshwater the Answer?

- ***Concept 13-5*** *We can convert salty ocean water to freshwater, but the cost is high, and the resulting salty brine must be disposed of without harming aquatic or terrestrial ecosystems.*

Removing Salt from Seawater Seems Promising but Is Costly

- **Desalination**
  - **Distillation**
  - **Reverse osmosis, microfiltration**
- 15,000 plants in 125 countries
  - Saudi Arabia: highest number
- Problems w/desal
  - High cost and energy footprint
  - Keeps down algal growth and kills many marine organisms
  - Large quantity of brine wastes

13-6 How Can We Use Water More Sustainably?

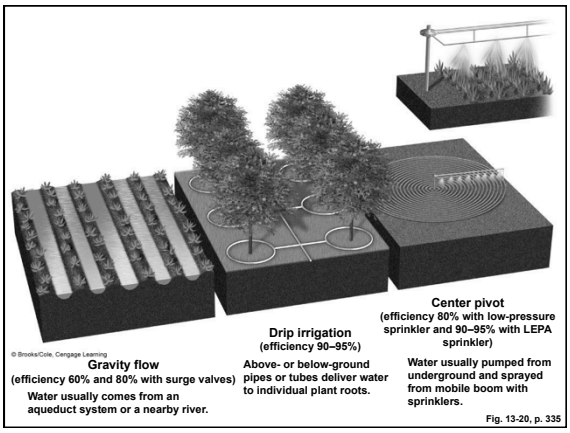
- ***Concept 13-6*** *We can use water more sustainably by cutting water waste, raising water prices, slowing population growth, and protecting aquifers, forests, and other ecosystems that store and release water.*

Reducing Water Waste Has Many Benefits

- Water conservation
  - Improves irrigation efficiency
  - Improves collection efficiency
  - Uses less in homes and businesses
- Worldwide: 65–70% loss
  - Evaporation, leaks, etc.
- Water prices: low cost to user
- Government subsidies: more needed?

We Can Cut Water Waste in Irrigation

- Flood irrigation
  - Wasteful
- Center pivot, low pressure sprinkler
- Low-energy, precision application sprinklers
- Drip or trickle irrigation, microirrigation
  - Costly; less water waste



Solutions: Reducing Irrigation Water Waste

Developing Countries Use Low-Tech Methods for Irrigation

- Human-powered treadle pumps
- Harvest and store rainwater
- Create a canopy over crops: reduces evaporation
- Fog-catcher nets

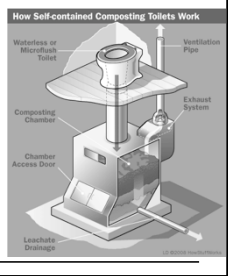
We Can Cut Water Waste in Industry and Homes

- Recycle water in industry
- Fix leaks in the plumbing systems
- Use water-thrifty landscaping: **xeriscaping**
- Use **gray water**
- Pay-as-you-go water use

Solutions: Reducing Water Waste

We Can Use Less Water to Remove Wastes

- Can we mimic how nature deals with waste?
- Waterless composting toilets



We Need to Use Water More Sustainably

- "The frog does not drink up the pond in which it lives"
- **Blue revolution**

SOLUTIONS

Sustainable Water Use

- **Waste less water and subsidize water conservation**
- **Do not deplete aquifers**
- **Preserve water quality**
- **Protect forests, wetlands, mountain glaciers, watersheds, and other natural systems that store and release water**
- **Get agreements among regions and countries sharing surface water resources**
- **Raise water prices**
- **Slow population growth**

Fig. 13-23, p. 337

What Can You Do? Water Use and Waste

WHAT CAN YOU DO?

Water Use and Waste

- Use water-saving toilets, showerheads, and faucet aerators.
- Shower instead of taking baths, and take short showers.
- Repair water leaks.
- Turn off sink faucets while brushing teeth, shaving, or washing.
- Wash only full loads of clothes or use the lowest possible water-level setting for smaller loads.
- Use recycled (gray) water for watering lawns and houseplants and for washing cars.
- Wash a car from a bucket of soapy water, and use the hose for rinsing only.
- If you use a commercial car wash, try to find one that recycles its water.
- Replace your lawn with native plants that need little if any watering.
- Water lawns and yards in the early morning or evening.
- Use drip irrigation and mulch for gardens and flowerbeds.

13-7 How Can We Reduce the Threat of Flooding?

- ***Concept 13-7*** *We can lessen the threat of flooding by protecting more wetlands and natural vegetation in watersheds and by not building in areas subject to frequent flooding.*

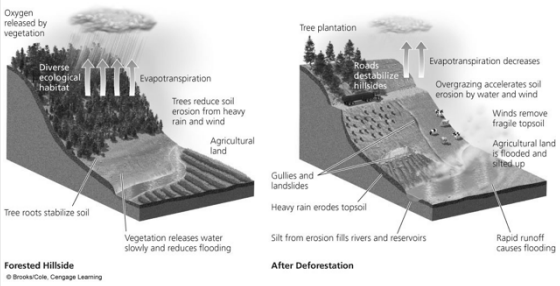
Some Areas Get Too Much Water from Flooding (1)

- **Flood plains**
  - Highly productive wetlands
  - Provide natural flood and erosion control
  - Maintain high water quality
  - Recharge groundwater
- Benefits of floodplains
  - Fertile soils
  - Nearby rivers for use and recreation
  - Flatlands for urbanization and farming

Some Areas Get Too Much Water from Flooding (2)

- Dangers of floodplains and floods
  - Deadly and destructive
  - Human activities worsen floods
  - Failing dams and water diversion
  - Hurricane Katrina and the Gulf Coast
    - Removal of coastal wetlands

Natural Capital Degradation: Hillside Before and After Deforestation



We Can Reduce Flood Risks

- Rely more on nature's systems
  - Wetlands
  - Natural vegetation in watersheds
- Rely less on engineering devices
  - Dams
  - Levees

SOLUTIONS

Reducing Flood Damage

Prevention

Preserve forests on watersheds

Preserve and restore wetlands in floodplains

Tax development on floodplains

Use floodplains primarily for recharging aquifers, sustainable agriculture and forestry

Control

Straighten and deepen streams (channelization)

Build levees or floodwalls along streams

Build dams

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Fig. 13-26, p. 340