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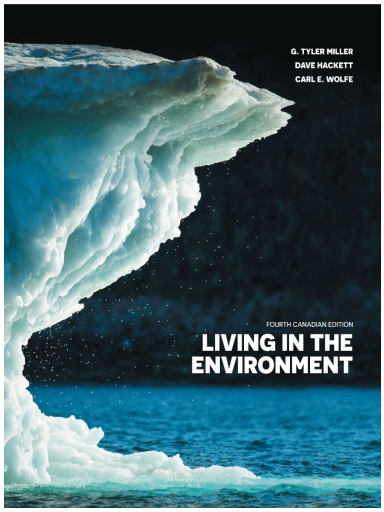


prepared by

Ian Dawe

Chapter 15

Water Resources

Key Concepts

Physical properties of water

Availability of freshwater

Methods of increasing freshwater supplies

Using water more efficiently

Flood risks

Case Study: Water Conflicts in the Middle East

Three shared river basins in the Middle East

– **Nile, Jordan, Tigris-Euphrates**

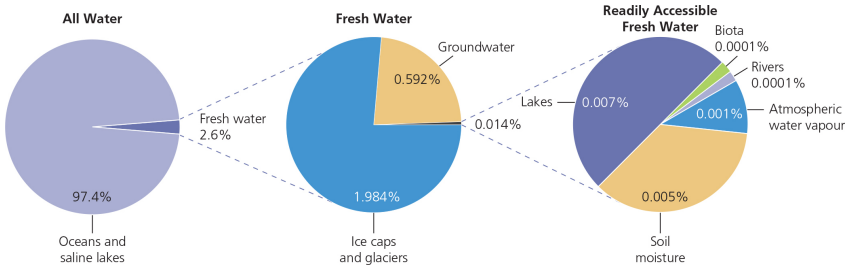
Water shortages in each area are likely to lead to regional conflicts between countries over political rights.

– Construction of dams for electricity
– Diversion of water for irrigation

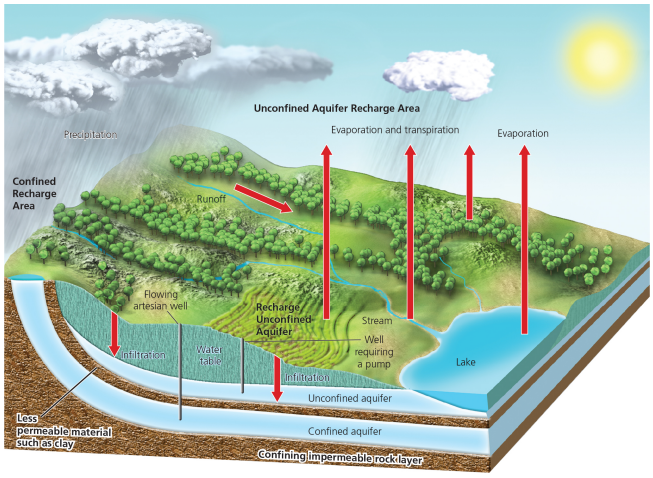
Science Focus: Water's Unique Properties

- Hydrogen bonding
- Liquid over wide temperature range
- Changes temperature slowly
- High heat of evaporation
- Dissolves many compounds
- Filters UV radiation
- Capillary action due to cohesive forces
- Expands when it freezes

How Much Fresh Water Is Available?



Groundwater



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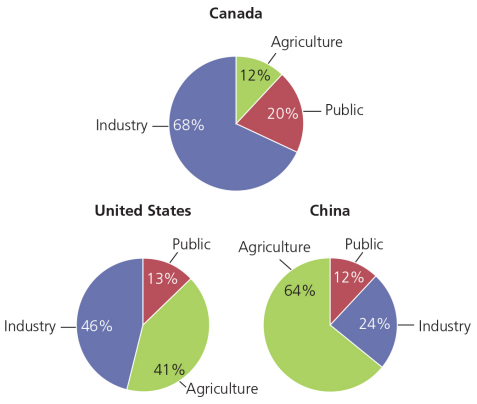
How Much of the Reliable Water Supply Are We Withdrawing?

Currently 54% of reliable runoff used (70–90% by 2025)



Source: Data from Gleick et al., 2011

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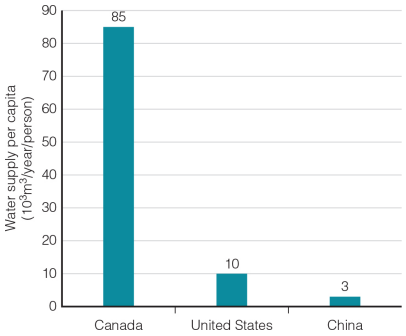
Case Study: Water Resources in Canada—Abundant but Not Problem-Free

- Twenty percent of world's freshwater
- Twenty-five percent of world's wetlands
- Second-highest per capita water use (1493 m^3/yr)
- Groundwater
  - Eighty-five percent of rural use
  - Eighty-nine percent of agricultural use
- Uneven distribution



Source: Data from FAO, 2009

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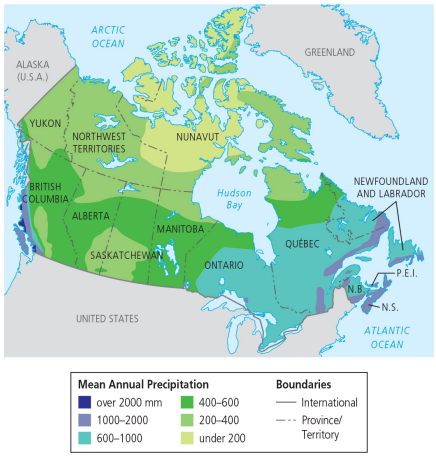
Case Study: Water Resources in Canada—Abundant but Not Problem-Free

Mean Annual Precipitation in Canada



Source: Modified from Stanford 1992

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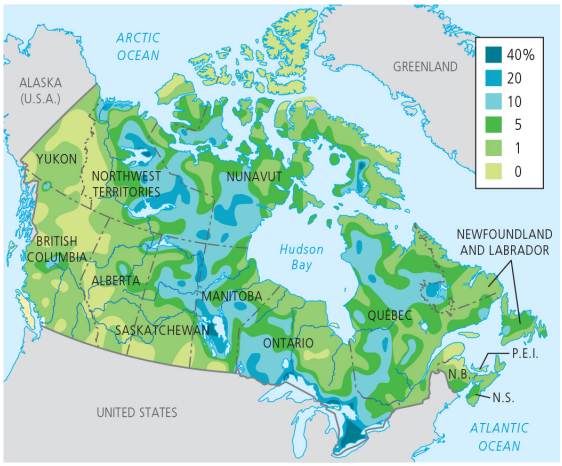
Case Study: Water Resources in Canada—Abundant but Not Problem-Free

Drainage Basins and Deficiencies

Source: Statistics Canada, *Atlas of Canada* (http://atlas.gc.ca), and Draper and Reed 2005

Case Study: Water Resources in Canada—Abundant but Not Problem-Free

Freshwater as a Percent of Land Area

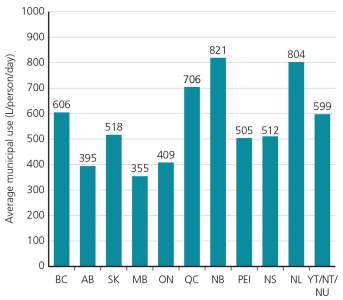


Source: Mathews and Morrow 1985

Case Study: Water Resources in Canada—Abundant but Not Problem-Free

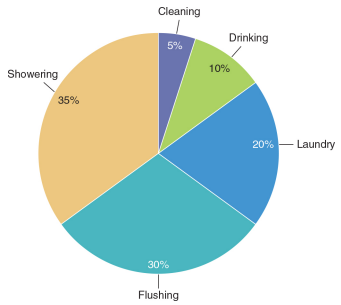
Household Water Use

Canadian municipal water usage



Source: Data from Table 1, p. 4 of 2010 Municipal Water Use Report, Environment Canada, 2010.

Canadian household water uses



Source: Environment Canada 2011

Freshwater Shortage

Drinking water is required by every human, every day.

Fresh water is also needed for sanitation, bathing, food prep, etc.

Less than 1000 m^3 per person, per year is considered a shortage.

Causes:

Dry climate

Drought

– Prolonged period with 70% lower precipitation and increased evaporation

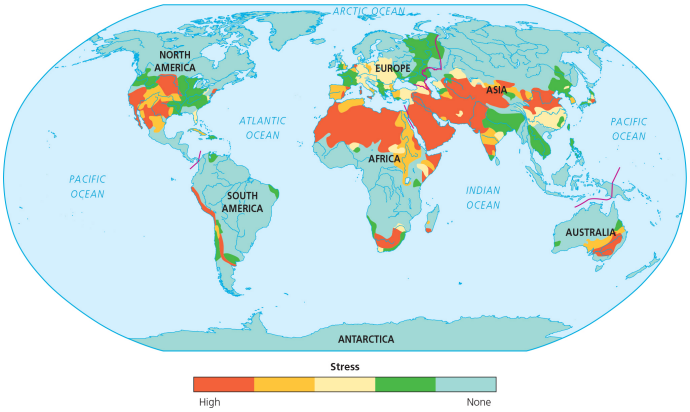
Desiccation

– Drying of exposed soil due to external activities

Water stress

– Low per capita availability due to increased demand

Stress on Major River Basins



Source: Data from World Commission on Water Use in the 21st Century

Degree of Water Stress

Water Stressed

– Reliable runoff per person < 1,700 m^3/yr

– Typically, demand 20% more than supply

Water Scarcity

– Reliable runoff per person < 1,000 m^3/yr

How Can We Increase Freshwater Supplies?

Building dams

Transferring water from another place

Withdrawing groundwater

Converting salt water to fresh

Consider access rights and ownership

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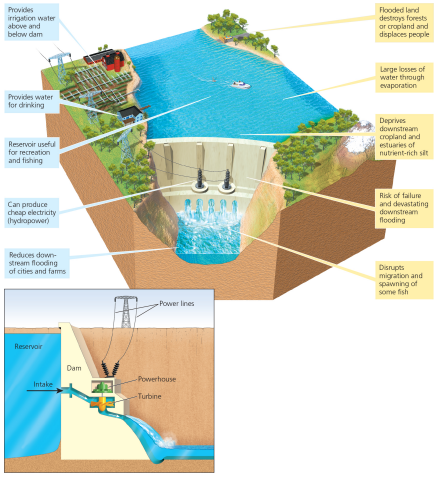
Using Dams and Reservoirs



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Case Study: China's Three Gorges Dam—A Controversial Project

FIGURE 15-16 **TRADE-OFFS**

China's Three Gorges Dam

Advantages and disadvantages of the Three Gorges Dam the Yangtze River in China. Pick the single advantage and disadvantage that you think are the most important.

(Left): © ChinaFotoPress/Getty Images; (Right): © David Evans/National Geographic Creative

Advantages

- Will generate about 10% of China's electricity
- Reduces dependence on coal
- Reduces air pollution
- Reduces CO_2 emissions
- Reduces chances of downstream flooding for 15 million people
- Reduces river silting below dam by eroded soil
- Increases irrigation water for cropland below dam

Disadvantages

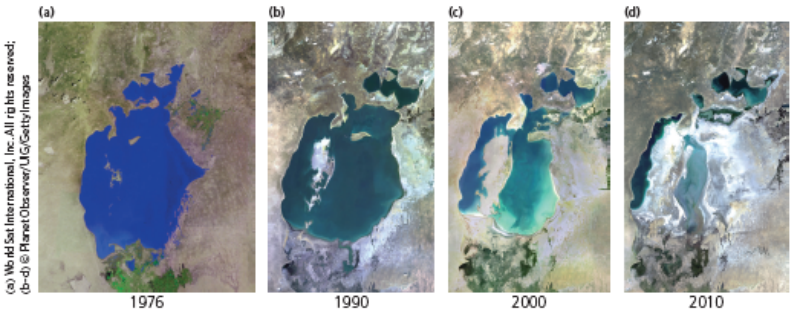
- Floods large areas of cropland and forests
- Displaces more than 13 million people
- Increases water pollution because of reduced water flow
- Reduces deposits of nutrient-rich sediments below dam
- Increases salt water introduced into drinking water near mouth of river because of decreased water flow
- Disrupts spawning and migration of some fish below dam
- High cost

Moving Water From One Place to Another

Diversion of the Aral Sea for irrigation had large impacts on the ecology, economy, and human health

A network of causes and consequences; for example: increased salinity, which causes fish species extinction, devastating the local industry

Changes to the Aral Sea (1976-2010)



Should Canada Sell Water to the United States?

Bargaining issue for NAFTA

– Issues of precedent

Sovereignty over water not so clear

Already have inter-basin transfers

Companies aggressively seeking new sources

Tapping Groundwater

FIGURE 15-18 **TRADE-OFFS**

Withdrawing Groundwater

Advantages and disadvantages of withdrawing groundwater. Pick the single advantage and disadvantage that you think are the most important.

(Left): © Cecilia Lim H/Shutterstock; (Right): © muratart/Shutterstock

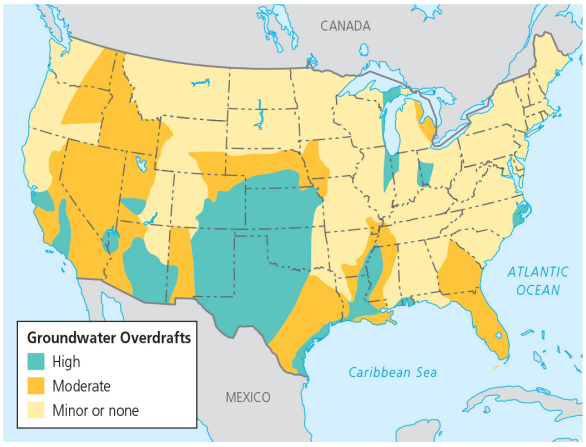
Advantages

- Good source of water for drinking and irrigation
- Available year-round
- Exists almost everywhere
- Renewable if not overpumped or contaminated
- No evaporation losses
- Cheaper to extract than most surface waters

Disadvantages

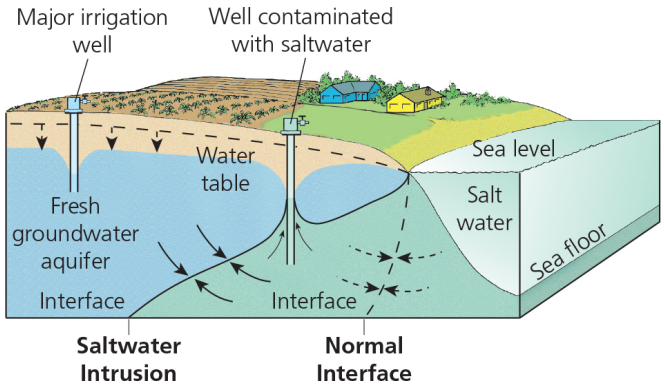
- Aquifer depletion from overpumping
- Sinking of land (subsidence) when water removed
- Polluted aquifers unusable for decades or centuries
- Saltwater intrusion into drinking water supplies near coastal areas
- Reduced water flows into streams, lakes, estuaries, and wetlands
- Increased cost, energy use, and contamination from deeper wells

Aquifer Depletion in the United States



Source: U.S. Water Resources Council and U.S. Geological Survey

Saltwater Intrusion

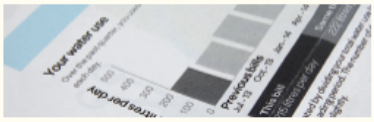


Groundwater Depletion: Solutions

FIGURE 15-21 **SOLUTIONS**

Groundwater Depletion

Ways to prevent or slow groundwater depletion. Which two of these solutions do you believe are the most important?



(Left: © Rene Kohut/Shutterstock; Right: © georgerudy/Shutterstock)

Prevention

- Waste less water.
- Subsidize water conservation.
- Ban new wells in aquifers near surface waters.
- Buy and retire groundwater withdrawal rights in critical areas.
- Do not grow water-intensive crops in dry areas.
- Reduce birth rates.

Control

- Raise price of water to discourage waste.
- Tax water pumped from wells near surface waters.
- Set and enforce minimum stream-flow levels.

Freshwater via Desalination

Removal of salt from sea water

- By distillation
- By reverse osmosis

} *Methods*

- High cost (energy)
- Briny wastewater

} *Problems*

Cloud Seeding, Icebergs, and Water Bags

Cloud Seeding

- Not effective in areas with few clouds
- Minimal evidence for effectiveness
- Introduce chemicals into water system
- Legal disputes over ownership

Towing of Icebergs or Water Bags

- No currently feasible technology

Reducing Water Waste

Some 65–70% of water use is wasted.

– Evaporation, leaks, etc.

Some 60% of irrigation water is wasted.

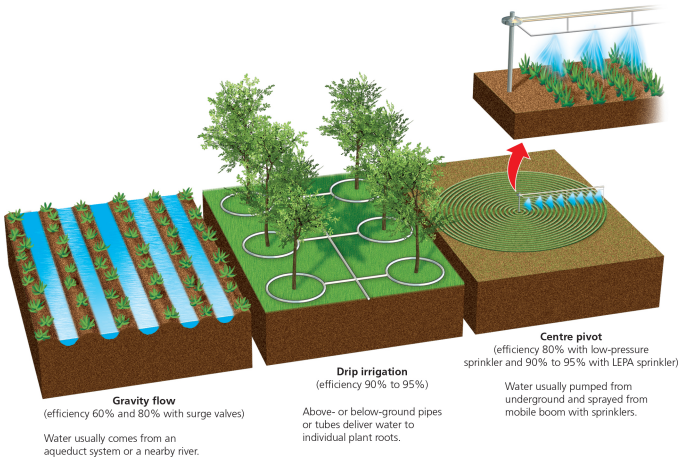
– Flood irrigation delivers more than needed.

Promoting water efficiency

– Stop underpricing the resource.

– Subsidize efficiency improvements.

Types of Irrigation



Reducing Irrigation Water Waste

Line canals that transport water to fields.

Level fields with lasers.

Irrigate at night to reduce evaporation.

Monitor soil moisture and add water only when necessary.

Polyculture

Reducing Irrigation Water Waste

Organic farming

Grow drought-resistant and salt-tolerant crop varieties.

Irrigate with treated urban wastewater (**grey water**).

Importing water-intensive crops and meat.

Reducing Water Waste

- Redesign manufacturing processes.
- Landscape yards with local plants that require little water.
- Use drip irrigation.
- Fix water leaks.
- Use water meters and charge for all municipal water use.
- Raise water prices.

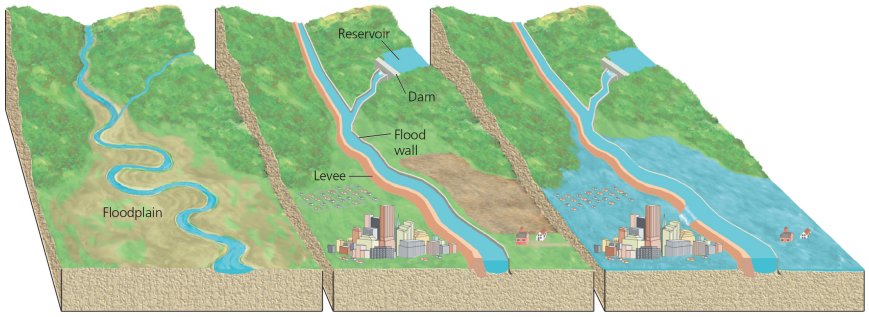
Reducing Water Waste

- Use waterless composting toilets.
- Require water conservation in water-short cities.
- Use water-saving toilets, showerheads, and front-loading clothes washers.
- Collect and reuse household water to irrigate lawns and non-edible plants.
- Purify and reuse water for houses, apartments, and office buildings.

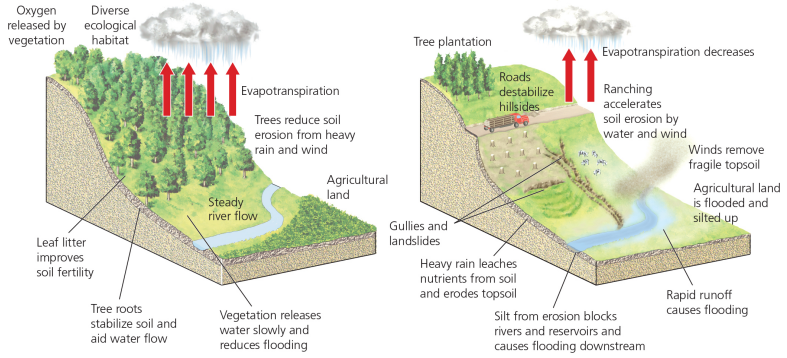
What Causes Flooding?

Natural phenomena, aggravated by human activities

Heavy rain, rapid snowmelt, removal of vegetation, destruction of wetlands



Deforestation and Flooding



Can We Reduce Flood Risks?

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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Sustainable Water Use

FIGURE 15-28 **SOLUTIONS**

Sustainable Water Use

Methods for achieving more sustainable use of the Earth's water resources

© kolabrinay/Getty Images

- Not depleting aquifers
- Preserving ecological health of aquatic systems
- Preserving water quality
- Applying integrated watershed management
- Seeking agreements among regions and countries that share surface water resources
- Having outside party mediation of water disputes between nations
- Marketing of water rights
- Raising water prices
- Wasting less water
- Decreasing government subsidies for supplying water
- Increasing government subsidies for reducing water waste
- Slowing population growth

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Checking Our Progress at Ensuring Environmental Sustainability

Total water resources used

– Still problematic

Improved **drinking water source**

– 2010: Met goal of halving number of people without sustainable access to safe drinking water

– > 600 million people still lacking access

Improved **sanitary facilities**

– 2.5 billion people lack access to basic sanitation

Conclusion

Fresh water is necessary for life.

Limited quantities, and much of it is inaccessible

We need to manage this resource in a more responsible way.