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Science and Sustainability: An Introduction to Environmental Science

Chapter Objectives

This chapter will help students:

- Define the term *environment* and describe the field of environmental science
- Explain the importance of natural resources and ecosystem services to our lives
- Discuss the consequences of population growth and resource consumption
- Describe the steps of the scientific method
- Understand the nature and importance of science, and characterize aspects of the process of science
- Compare and contrast various approaches in environmental ethics
- Diagnose and illustrate major pressures on the global environment
- Articulate the concepts of sustainability and sustainable development

Lecture Outline

I. Our Island, Earth

A. Our environment surrounds us.

1. Our **environment** consists of all of the living and non-living things around us.
2. It includes continents, oceans, clouds and ice caps, as well as animals and plants, and the structures, urban centers, and living spaces that people have created.
3. The fundamental insight of environmental science is that we humans are also a part of the "natural" world, and that our interactions with the rest of it matter a great deal.

B. Environmental science explores our interactions with the world.

1. **Environmental science** is the study of how the natural world works, how our environment affects us, and how we affect our environment.
2. Environmental scientists study issues centrally important to our world and its future. Rapidly changing global conditions demand that we act now to solve problems.

C. We rely on natural resources.

1. **Natural resources** are the various substances and energy sources we need to survive. Our island Earth is finite and bounded, and places limitations on the availability of these resources.
2. **Renewable natural resources** such as sunlight, wind, and wave energy are essentially inexhaustible while others, such as timber, water, and soil can be replenished by the environment over periods of time varying from months to decades.
3. In contrast, resources such as mineral ores and crude oil are formed more slowly than we use them and are considered to be **nonrenewable natural resources**. Once we deplete them they are no longer available.
4. Renewability is a continuum. Some renewable resources may turn nonrenewable if we deplete them too drastically. Pumping groundwater from underground aquifers faster than it can be restored is an example of this.

D. We rely on ecosystem services.

1. Earth's natural systems provide **ecosystem services** such as air and water purification, climate regulation and plant pollination. We could not survive without these processes.
2. We have degraded nature's ability to provide these services by depleting resources, destroying habitat, and generating pollution.

E. Population growth amplifies our impact.

1. Today, our population has grown beyond seven billion people.
2. Two phenomena triggered remarkable increases in population size.
   a) One was the **agricultural revolution**, which occurred around 10,000 years ago as humans transitioned from a hunter-gatherer lifestyle to an agricultural way of life.
   b) The second, **industrial revolution** began in the mid-1700s, entailing a shift from rural, agricultural life to an urban society provisioned by mass-produced manufactured goods and powered by **fossil fuels.**

F. Resource consumption exerts social and environmental pressures.

1. The "tragedy of the commons"
   a) Garrett Hardin analyzed how people approach resource use.
   b) Resources that are open to unregulated exploitation, the "commons," will eventually be depleted. Hardin called this the **tragedy of the commons**.
2. Our ecological footprint
   a) Mathis Wackernagel and William Rees developed the concept of the **ecological footprint** that expresses the environmental impact of an individual or a population in terms of the cumulative amount of land and water required to provide the raw materials consumed and to recycle the waste produced.
   b) Wackernagel and his colleagues used these calculations to determine that we are depleting our resources about 30% faster than they are being replenished. **Overshoot** is the term that describes the actions of humans surpassing the productive capacity of the planet.

G. Environmental science can help us avoid past mistakes.

1. Most great civilizations have fallen after degrading their environments and left devastated landscapes in their wake.

2. The stakes are higher than ever today. If we cannot forge sustainable solutions, the societal collapse will be global.

II. The Nature of Environmental Science

A. Environmental science is interdisciplinary.

1. Environmental science is an **interdisciplinary** field, drawing techniques from multiple disciplines and brings their research into a broad synthesis.

2. Interdisciplinary fields are valuable because their practitioners consolidate and synthesize the specialized knowledge from many different disciplines and make sense of it in a broad context to better serve the interests of society.

3. Environmental science is broad because it encompasses both the **natural sciences** and the **social sciences**. The term **environmental studies** is often used to describe programs that incorporate the social sciences extensively.

B. Environmental science is not the same as environmentalism.

1. **Environmentalism** is a social movement dedicated to protecting the natural world from undesirable changes brought about by human actions.

2. Environmental scientists strive to keep research objective, remaining open to whatever conclusions the data demand.

III. The Nature of Science

A. Scientists test ideas by critically examining evidence.

1. **Science** is a systematic process for learning about the world and testing our understanding of it.
2. Scientists make observations, take measurements, and design tests to determine if ideas are supported by evidence.
3. Most scientific work is **observational science** or **descriptive science** based on information gathering.
4. If enough is known about a subject, scientists pursue **hypothesis- driven science**, trying to answer specific questions, using the scientific method.

B. The scientific method is the traditional approach to research.

1. The **scientific method** is a technique for testing ideas with observations and involves several assumptions and a series of interrelated steps.
2. The steps of the scientific method are:
    a) Make observations. Observations set the scientific method in motion and also function through the process.
    b) Ask questions. Determining which questions to ask is one of the most important steps in investigation process.
    c) Develop a hypothesis. A **hypothesis** is a statement that explains a phenomenon or answers a scientific question.
    d) Make predictions. A **prediction** is a specific statement that can be directly and unequivocally tested.
    e) Test the predictions. An **experiment** is an activity designed to test the validity of a hypothesis; it involves manipulating **variables,** or conditions that can change. The **independent variable** is the variable that the scientist manipulates, while the **dependent variable** is the one that depends upon the first variable. Scientists conduct **controlled experiments** by controlling for the effects of all variables except the tested one. Often, controlled experiments have a **treatment** area that is manipulated and another that is not, called a **control.**
    f) Analyze and interpret results. Scientists record **data** from their studies and analyze the data using statistical tests to see if the hypothesis is supported. If the results disprove a hypothesis, the hypothesis is rejected and a new one may be proposed. If the repeated tests fail to reject a particular hypothesis, it will ultimately be accepted as true.

C. We can test hypotheses in different ways.

1. A *manipulative experiment* is an experiment in which the researcher actively chooses and manipulates the independent variable.
2. When variables cannot be manipulated—climate change is an example of this—a *natural experiment* is performed. In such experiments, researchers test their hypothesis by searching for *correlation,* a statistical relationship between variables.
3. Natural experiments provide evidence that is weaker than manipulative experiments, but can still make for strong science.

D. The scientific process continues beyond the scientific method.

1. Peer review. Research results are submitted to a journal for publication. Other scientists who specialize in the subject area are asked to provide comments and critiques, and judge whether the work merits publication. This process is known as **peer review**.

2. Conference presentations. Scientists frequently present their work at professional conferences and receive informal comments on their work prior to publication.

3. Grants and Funding. Most scientists spend considerable time writing grant applications to private foundations or government agencies for support of their research. These applications are also usually subjected to peer review. Conflicts of interest sometimes arise when results are in conflict with the interests of the funding agency. This has occurred in the case of private industry funding. Government agencies have also occasionally suppressed findings to avoid policy implications.

4. Repeatability. The careful scientist may test a hypothesis repeatedly in various ways before submitting it for publication. After publication, other scientists will attempt to reproduce the results in their own analyses.

5. Theories. If a hypothesis survives repeated testing by numerous research teams, it may potentially be incorporated into a **theory.** A theory is a widely accepted, well-tested explanation of one or more cause-and-effect relationships that has been extensively validated by a large amount of research. In science, a theory is not speculation or a hypothesis.

E. Science goes through "paradigm shifts."

1. A **paradigm** is a dominant view regarding a topic, based on the facts and experiments known at that time.
2. Thomas Kuhn argued that science goes through periodic revolutions in which one dominant view is abandoned for another, as more information becomes available.

IV. Environmental Ethics

A. Environmental ethics pertains to people and the environment.

1. **Ethics** is a branch of philosophy that involves the study of good and bad, right and wrong. Some ethicists are **relativists**, who believe that ethics

do and should vary with social contexts. Others are **universalists** who maintain that there exist objective notions of right and wrong that hold across cultures and contexts. **Ethical standards** are the criteria that differentiate right from wrong. The categorical imperative advises us to treat others as we would prefer to be treated ourselves, while the principle of utility holds that something is right when it produces the greatest practical benefits for the most people.

2. The application of ethical standards to relationships between people and nonhuman entities is known as **environmental ethics**.
3. **Anthropocentrism** describes a human-centered view of our relationship with the environment.
4. **Biocentrism** ascribes value to certain living things or to the biotic realm in general.
5. **Ecocentrism** judges actions in terms of their effects on whole ecological systems.

B. Conservation and preservation arose with the 20th century.

1. **John Muir** promoted the **preservation** ethic, which holds that we should protect our environment in a pristine, unaltered state.
2. **Gifford Pinchot** espoused the **conservation** ethic, which holds that people should put natural resources to use, but that we have a responsibility to manage them wisely.

C. Aldo Leopold's land ethic inspires many people.

1. **Aldo Leopold** chose a more holistic prospective, saying healthy ecosystems depend on protecting all interacting parts.
2. Leopold argued that people should view themselves and "the land" as members of the same community, and that we are obligated to treat the land in an ethical manner.
3. Leopold intended that the land ethic would help guide decision making.

D. Environmental justice seeks fair treatment for all people.

1. **Environmental justice** involves the fair and equitable treatment of all people, with respect to environmental policy and practice.

V. Sustainability and the Future of Our World

A. Population and consumption drive environmental impact.

1. **Sustainability** is a guiding principle of environmental science that means living within our planet's means. Currently, we are drawing down Earth's **natural capital**, its accumulated wealth of resources.
2. The most comprehensive assessment of the condition of the world's ecological systems and their capacity to continue supporting us was completed in 2005, and called the **Millenium Ecosystem Assessment**.

B. Sustainable solutions abound.

C. Sustainable development involves environmental protection, economic well being, and social justice.

1. Today's search for sustainable solutions centers on **sustainable development**, the use of resources in a manner that satisfies our current needs, but does not compromise future availability.
2. Sustainability and the triple bottom line (meeting environmental, economic, and social goals simultaneously) require that we limit our environmental impact, while promoting economic well-being and social equity.

VI. Conclusion

A. Finding effective ways of living peacefully, healthfully, and sustainably on our diverse and complex planet requires a solid ethical grounding and a thorough scientific understanding of natural and social systems.

B. Science in general, and environmental science in particular, can aid us in our efforts to develop balanced, workable, sustainable solutions and to create a better world for ourselves and our children.

Key Terms

agricultural revolution
anthropocentrism
biocentrism
conservation
control
controlled experiment
data
dependent variable
descriptive science
ecocentrism
ecological footprint
ecosystem services
environment
environmental ethics

environmental science
environmentalism
ethical standards
ethics
experiment
fossil fuels
hypothesis
hypothesis-driven science
independent variable
industrial revolution
interdisciplinary
Leopold, Aldo
Millennium Ecosystem Assessment
Muir, John
natural resources
natural sciences
nonrenewable natural resources
observational science
overshoot
paradigm
peer review
Pinchot, Gifford
predictions
preservation
relativists
renewable natural resources
science
scientific method
social sciences
sustainability
sustainable development
theory
tragedy of the commons
treatment
universalists
variables

Teaching Tips

1. Begin class by asking the students to define the term *environment* in their own words. Bring old magazines for the students to clip out a picture that matches their definition. Ask students to put their definitions and pictures on a note card to be submitted. At the end of the semester, return the note cards to the students and ask them to redefine the term based on what they learned during the course. Lead a discussion about how their definitions changed.
2. To teach the scientific method, present a situation to the class and ask students to work in groups to address the issue using the scientific process. For example: A farmer in South Carolina notices that the pond on his property has an unusually high amount of algae in it. Because of the algal growth, his cattle will not drink from the pond. What is happening, and what could he do? Based on this information (the observation), ask students to formulate a hypothesis, make a prediction, and design an experiment.
3. To make environmental science more appealing to students, present information about local environmental issues. When students are faced with environmental problems where they live, they see how they relate to them personally and realize that they can make a difference. One possibility is to look at the Environmental Protection Agency's Superfund Sites in your state. The National Priorities List of sites in the United States can be found at: http://www.epa.gov/superfund/sites/npl/. From there you can choose your state or territory. Click on any site shown on the state map to see site names and

locations, then click on the site name to go to a page devoted to that site, its description, cleanup approach, progress, potentially responsible parties, and many other site-related documents.

4. Ask students to conduct Internet research on Easter Island. What is it like today? How many people live on the island? What are the main resources? Now research one of the success stories, the island of Tikopia, which lies in the Pacific Ocean east of Australia and New Guinea, west of Tonga and Fiji. Look in Jared Diamond's book *Collapse* (2005, Viking Press) or at some of the Internet sites (such as Diamond's lecture at: http://www.tannerlectures.utah.edu/lectures/documents/Diamond93.pdf)

   Compare and contrast the stable culture that has lasted at least 3,000 years on Tikopia with the fallen and failed culture of Easter Island. What are the major differences in how the people approached the idea of sustainability?

5. Quick feedback: Use a technique known as "muddiest point" to assess student understanding of the material. During the last 5 minutes of class, pass out 3 × 5 cards (or have students use their own paper, but in a large class 3 × 5 cards will be faster to assess) and ask students, anonymously, to write down the one point from the day that they don't quite grasp—the "muddiest point." Students leave cards in a pile as they exit. You don't need to read every one of them in a large class—a random sample of 20 will give you a good indication of whether there are a couple of concepts that many students find unclear and you need to go over again, or whether most everyone understood most everything. The technique has two benefits: First, the students must engage in some higher-order thinking to quickly review the lesson and their notes, assessing for clarity; and, second, you will get a snapshot of whether there are small, scattered misunderstandings or a single issue that needs to be revisited. (From Thomas A. Angelo and K. Patricia Cross, *Classroom Assessment Techniques: A Handbook for College Teachers,* 2nd ed., 1993. Josses-Bass Publishers, San Francisco.)

6. Divide the class into six teams. Assign a chapter from *Overshoot* by William Catton, Jr. (see text reference below) to each team. Ask students to summarize the main points, analyze the information presented by the author and explain if or how the text is relevant today. Encourage discussion about how issues raised in the text were addressed with legislation and action, or not. Consider dividing students into small groups each of which will have responsibility for making an oral presentation during the semester. This chapter's group might seek out the current research on carbon sequestration by the oceans, terrestrial capture by forests, or direct burial of CO_2 from power generation.

7. Consider dividing students into small groups each of which will have responsibility for making an oral presentation during the semester. This chapter's group might investigate the ecological footprint of the community where the school is located and explore sustainability issues there. Are there identifiable groups impacted by current transportation or energy issues in the community?
8. Community Service: Ask students to brainstorm, individually or as a group, ways in which they might explore the issues of this chapter in their community and take action. A specific example might be to educate consumers about the use of phosphates in dishwashing detergents. If your course contains a community service component some students might want take an idea from this section as a project.

Additional Resources

Websites

1. NASA *Spacelink Curriculum Support*, NASA (http://spacelink.nasa.gov/_Instructional.Materials/Curriculum.Support)
   This website provides educator guides for life science activities that integrate the scientific method.
2. *Sustainable Development Issues A to Z,* United Nations Division of Sustainable Development (www.un.org/esa/sustdev/sdissues/sdissues.htm)
   Information, documents, and publications related to sustainable development and Agenda 21 can be accessed from this website.
3. *U.S. and World Population Clocks—POPClocks,* U.S. Census Bureau (www.census.gov/main/www/popclock.html)

   This website provides the current total population of the world.
4. *Fished Out: The Rise and Fall of the Cod Fishery,* Canadian Broadcasting Corporation (http://archives.cbc.ca/economy_business/natural_resources/topics/1595/)

   Archival video reports can be found here about the collapse of the cod fishery in the Grand Banks off the eastern coast of Canada.

Audiovisual Materials

1. *Earth on Edge,* Bill Moyers Reports, 2001, distributed by Films for the Humanities and Sciences (www.shoppbs.com)
   In collaboration with the World Resources Institute, Bill Moyers assesses the state of the environment in interviews with scientists from around the world (2001).
2. *Scientific Methods and Values,* distributed by Hawkhill Video (www.hawkhill.com)

3. This 35-minute program describes the history of the scientific method and explains how the technique is used by scientists.
4. *State of the Planet: A Biosphere in the Balance,* 2001, produced by BBC Worldwide and distributed by Films for the Humanities and Sciences (www.films.com) This video, narrated by David Attenborough, is the first in a three-part series that describes worldwide biodiversity and the human activities that are destroying it.
5. *World in the Balance,* 2004, produced by NOVA and distributed by WGBH/PBS (http://shop.wgbh.org)
   This video is a 2-hour program that investigates social and environmental strains placed on the world due to rapidly increasing human populations.
6. *Planet Earth,* 2007, produced by the BBC, this series first aired on the Discovery Channel and captured the attention of very diverse viewers. The compelling footage highlights many interesting and rare species, their habitat preferences, and also projects the viewer into the future, inspiring one to ask, "What next?" "What will happen if these areas and creatures are not recognized and protected?" (www.pbs.org)

Suggested Texts

1. *People and the Land Through Time: Linking Ecology and History*. 1997. Emily Russell. Yale University Press, New Haven. For students who want an in depth analysis of ecological issues based on human settlement patterns, this text provides valuable insights into the evolution of contemporary environmental issues. The author begins with geology, moves through disturbance features such as anthropogenic fire and finishes with actual case studies grounded in historical ecology.
2. *Overshoot: The Ecological Basis of Revolutionary Change*. 1980. William R. Catton, Jr. University of Illinois Press, Chicago. The term "overshoot" is used and described in your textbook. *Overshoot*, now several decades in print, was a validation of Garrett Hardin's *Tragedy of the Commons* and Paul Ehrlich's *The Population Bomb*. *Overshoot* skillfully unpacks the growing dependence of human culture on technologies that enabled the exploitation of more land. Sobering and well-written, with chapters reviewing issues of carrying capacity, the cornucopian myth, drawdown, "cargoism," overshoot, and crash.

Weighing the Issues: Facts to Consider

Tragedy of the Commons

Facts to consider: Biologically based resources are somewhat more resilient to exploitation, as populations of harvested animals are usually replenished year after year depending on environmental conditions. However, as more fishers enter an area and move further away from fishing grounds used in the past, the reproductive adult lobsters that restocked the fished-out population are taken as well, and populations begin to decline as the number of reproductive adults decreases. With more fishers, more reproductive adults are taken until most of the lobsters harvested are small, one molt above minimum size. At this size, the lobsters are only 50% mature, and because they are harvested, these lobsters will never reproduce, further depleting the population of reproductive adults for the future. A real-life example of this scenario is the closing of the Grand Banks fishery off the east coast of Canada to commercial fishing. See Additional Resources for a website link to archival television and radio reports about this topic. Individual responses will vary about whether government regulation or private cooperative regulation would be more appropriate solutions.

Preservation and Conservation

Facts to consider: Remember that preservation means to protect the environment in a pristine, unaltered state. The conservation ethic holds that people should put natural resources to use, but that we have a responsibility to manage them wisely. The answer to the first question will be subjective, and rooted in the students' own values. Situations provided in the second question, will also be dependent on the student—however, encourage them to choose something in their municipality, county or state, so they can more easily relate to their examples. The third question is also subjective, but would be interesting to compare responses to this question between two students, such as a biology major and a business major.

Environmental Justice

Facts to consider: Remember that environmental justice involves the fair and equitable treatment of all people with respect to environmental policy and practice, regardless of income, race or ethnicity. The answers to these questions will depend on the personal experience of the student, as well as what hometown, what section of your campus town, or what community college district they come from.

Ecological Footprints

Facts to consider: The science behind the ecological footprint can be found in Wackernagel and Rees' text, *Our Ecological Footprint* (New Society Publishers, 1996), and a number of footprint calculators can be found online. The answers to these questions are clearly rooted in values, not in science, except that the authors make a strong case for our inability as a society to continue to use resources at our current rate, and that the richer nations are responsible for the excess use.

The Science Behind the Stories: Thinking Like a Scientist

The Lesson of Easter Island

Observation: While presently denuded of large vegetation, examination of sediment cores from lakes, ancient nut casings, carbon-channels in the soil, charcoal, and analysis of ancient script all indicate that Easter Island once had a thriving palm forest.

Hypothesis: The forest was lost due to climate change.

Results: Evidence disproved this hypothesis, supporting an alternative hypothesis that the forest was lost due to human-caused environmental degradation. Archeological evidence indicates that, traditionally, the palms and other trees were used for fuel, for building materials for houses and canoes, and as fibers for clothing, and that the fruit was eaten. However, as tribes began to make and move massive stone statues, palms were harvested for rope and to use as rollers to move the statues. Pollen analysis of the lake sediment cores shows decreasing plant populations and plant species diversity until there was very little vegetation by A.D. 1400. Deforestation led to increased erosion, as revealed by the increasing depth of the lake sediment layers. Higher erosion rates decreased soil quality, resulting in smaller crop yields. Other evidence of forest loss can be seen in the decreasing diversity of animal species used as food, with early islanders eating many species of forest birds and marine animals and later islanders eating only domesticated chickens. Archeological evidence supports the conclusion that extreme scarcity of food led to intertribal warfare and collapse of the Easter Island society.

Answers to End-of-Chapter Questions

Testing Your Comprehension

1. Human population grew markedly as a result of both the agricultural and industrial revolutions. The agricultural revolution made it easier for humans to meet their nutritional needs than as hunter-gatherers; thus they lived longer and had more children. The industrial revolution brought improved sanitation and medical technology, and increased agricultural productivity fueled by fossil fuels and fertilizer. This significantly increased life expectancy, decreased mortality, and expanded the capacity to feed a growing population.
2. The "tragedy of the commons" refers to a situation in which resources that are open to unregulated exploitation will eventually be depleted. In a publicly held pasture, each person whose animals graze there would benefit from grazing more animals. If each individual makes the rational decision to graze more, eventually the pasture will be overgrazed and its value destroyed. In the case of an industry that pollutes waterways, publicly accessible fresh water is the "commons," and pollution is analogous to overgrazing.
3. Environmental science seeks to understand how Earth's natural systems function, how humans are influenced by them, and how we are influencing them. It includes the disciplines of ecology, earth sciences, economics, political science, demography, and ethics, among others.
4. *Science* is both the systematic process for learning about the world and the accumulated body of knowledge that arises from this process. It can be applied to the development of new technologies, such as electrical lighting, nuclear power, and antibiotics. It can also be applied to policy decisions and resource management strategies.
5. The scientific method includes making observations, asking questions, developing a hypothesis, making predictions, and testing those predictions, often by means of an experiment. Before being published, a researcher's results go through a process of peer review, which provides a valuable guard against faulty science contaminating the literature.
6. Ethics is a branch of philosophy that involves the study of good and bad, right and wrong. It can also refer to the set of moral principles or values held by a person or society. The categorical imperative advises us to treat others as we would prefer to be treated ourselves, while the principle of utility holds that something is right when it produces the greatest practical benefits for the most people. The application of ethical standards to relationships between people and non-human entities is known as environmental ethics.

7. Anthropocentrism describes a human-centered view of the environment. Biocentrism ascribes value to certain living things, or to the biotic realm in general; this encompasses anthropocentrism, but takes this concept further to embrace other living things. Ecocentrism is the most holistic, and judges actions in terms of their effects on whole ecological systems.
8. The preservation ethic holds that we should protect our environment in a pristine, unaltered state. Conservation states that people should put natural resources to use, but that we have a responsibility to manage them wisely. John Muir was motivated by the rapid deforestation of North America, and promoted the preservation ethic. Gifford Pinchot took a more anthropocentric view of how and why we should value nature, and supported conservation.
9. Aldo Leopold's land ethic is based in the idea that healthy ecological systems depend on protecting all their interacting parts. Leopold argued that people should view themselves and "the land" as members of the same community, and that we are obligated to treat the land in an ethical manner.
10. Sustainable development is the use of renewable and nonrenewable resources to maintain or increase human living standards in ways that satisfy our current needs without compromising the resources' future availability. Sustainable development will be necessary if we are to continue human civilization far into the future. The triple bottom line refers to three goals of sustainability: social justice, economic equity, and environmental health.

Calculating Ecological Footprints

Nation	Ecological footprint (hectares per person)	Proportion relative to world average footprint	Proportion relative to world area available
Bangladesh	0.6	0.2 (0.6÷2.7)	0.3 (0.6÷1.8)
Tanzania	1.2	0.4	0.7
Colombia	1.9	0.7	1.1
Thailand	2.4	0.9	1.3
Mexico	3.0	1.1	1.7
Sweden	5.9	2.2	3.3
United States	8.0	3.0	4.4
World average	2.7	1.0 (2.7÷2.7)	1.5(2.7÷1.8)
Your personal footprint (see Question 4)			

1. Bangladesh has a low per-capita income.
2. The United States has a high per-capita income.
3. Higher per-capita income suggests a higher consumption of goods which require natural resources in their production. There is also a correlation between the use of energy resources, especially for transportation, and income.