

The Human Denominator We consider the totality of human impact on Earth to be the *human denominator*. Just as the denominator in a fraction tells how many parts a whole is divided into, so the growing human population and its increasing demand for resources and rising planetary impact suggest the stresses on the whole Earth system that must support us. Yet Earth's resource base—the numerator in this fraction—remains relatively fixed.

The population in just two countries makes up 37% of Earth's human count: 19.1% live in China and 17.9% in India—2.63 billion people combined. Considered overall, the planetary population is young, with some 26% still under the age of 15 years.*

Population in most of the more-developed countries (MDCs) is no longer increasing. In fact, some European countries are actually declining in growth or are near replacement levels. However, people in these developed countries have a greater impact on the planet per person and therefore constitute a population impact crisis. The United States and Canada, with about 5% of the world's population, produce about 25% (\$16.2 trillion and \$1.8 trillion in 2012, respectively) of the world's gross domestic product (GDP). These two countries use more than 2 times the energy per capita of Europeans, more than 7 times that of Latin Americans, 10 times that of Asians, and 20 times that of Africans. Therefore, the impact of this 5% on the state of Earth systems, natural resources, and sustainability of current practices in the MDCs is critical.

Global Sustainability Recently, **sustainability science** emerged as a new, integrative discipline, broadly based on concepts of sustainable development related to functioning Earth systems. Geographic concepts are fundamental to this new science, with its emphasis on human well-being, Earth systems, and human–environment interactions.

Dr. Carol Harden, past president of the Association of American Geographers, pointed out the important role of geographical concepts in sustainability science in 2009. She wrote that the idea of a human “footprint,” representing the human impact on Earth systems, relates to sustainability and geography. When the human population of over 7 billion is taken into account, the human footprint on Earth is enormous in terms of both its spatial extent and the strength of its influence. Shrinking this footprint ties to sustainability science in all of its forms—for

example, sustainable development, sustainable resources, sustainable energy, and sustainable agriculture. Geographers are now part of the effort to articulate this emerging field, which seeks to directly link science and technology with sustainability.

If we consider some of the key issues for this century, many of them fall beneath the umbrella of sustainability science, such as global food supply, energy supplies and demands, climate change, loss of biodiversity, and air and water pollution. These are issues that should be addressed in new ways if we are to achieve sustainability for both human and Earth systems. Understanding Earth's physical geography and geographic science informs your thinking on these issues.

Earth Systems Concepts

The word *system* is in our lives daily: “Check the car's cooling system”; “A weather system is approaching.” *Systems analysis* techniques in science began with studies of energy and temperature (thermodynamics) in the 19th century. Today, systems methodology is an important analytical tool. In this book's 4 parts and 17 chapters, the content is organized along logical flow paths consistent with systems thinking.

Systems Theory

Simply stated, a **system** is any set of ordered, interrelated components and their attributes, linked by flows of energy and matter, as distinct from the surrounding environment outside the system. The elements within a system

CRITICAL thinking 1.1

What Is Your Footprint?

The concept of an individual's “footprint” has become popular—ecological footprint, carbon footprint, lifestyle footprint. The term has come to represent the costs of affluence and modern technology to our planetary systems. Footprint assessments are gross simplifications, but they can give you an idea of your impact and even an estimate of how many planets it would take to sustain that lifestyle and economy if everyone lived like you. Calculate your carbon footprint online at <http://www.epa.gov/climatechange/ghgemissions/ind-calculator.html>, one of many such websites, for housing, transportation, or food consumption. How can you reduce your footprint at home, at school, at work, or on the road? How does your footprint compare to the U.S. and worldwide average footprints?

*Data for 2013 from the Population Reference Bureau (<http://www.prb.org>) and the U.S. Census Bureau's *POPclock Projection* (<http://www.census.gov/popclock>).



GEOREPORT 1.1 Welcome to the Anthropocene

The human population on Earth reached 7 billion in 2011. Many scientists now agree that the *Anthropocene*, a term coined by Nobel Prize-winning scientist Paul Crutzen, is an appropriate name for the most recent years of geologic history, when humans have influenced Earth's climate and ecosystems. Some scientists mark the beginning of agriculture, about 5000 years ago, as the start of the Anthropocene; others place the start at the dawn of the Industrial Revolution, in the 18th century. To see a video charting the growth of humans as a planetary force, go to <http://www.anthropocene.info>.