# Essay

## Brock Brown's Geographical Summary of Earth as a Natural/Physical Environmental System and Humans Interacting with the System

*Brock Brown, Associate Professor of Geography at Texas State University–San Marcos, explores the Earth's dynamic energy/matter system and how humans impact that system through the use of technology.*

### HERE WE ARE . . .

You, and I, and about 6.5 *billion* other humans, are flying around the sun on a tiny speck of rock at about 67,000 miles an hour. Over the course of a year, we travel 586,920,000 miles through space. We are orbiting around a nuclear fusion reactor known as the *sun*, which has already used half of its fuel supply and will expand and possibly engulf the Earth in a mere four to six billion years. We are, at least for the present, stranded on this speck of rock we call Earth.

Life is capable of existing here because the planet remains within a narrow margin of distance from the sun, where water occurs in both liquid and gaseous states and temperatures are conducive for life. Maintenance of this position is held precariously by a delicate balance between the centripetal gravitational pull of the sun and the centrifugal velocity of Earth's orbit around the sun. A change in either would end the relationship and result in disaster for Earth and the life that inhabits the planet.

### THE EARTH AS AN ENERGY/MATTER SYSTEM

Planet Earth is an energy/matter *system*. For our purposes we will assume that *all change* that occurs on the planet is a result of energy: inputs; storage; transformation; or outputs. Solid water melts (changes) because of *inputs* of heat energy, and liquid water becomes solid ice because of *outputs* of heat energy. With regard to *Earth's environmental systems*, there are really only two types of *energy inputs* that are responsible for most activity and change of planet Earth: 1) *solar energy*, and 2) *internal Earth energy*.

### SOLAR ENERGY IN THE SYSTEM

*Solar energy* is emitted from the sun and follows two paths through the Earth system. Along one path, sunlight is transformed into *chemically bonded* energy by green plants through the process of photosynthesis, and is stored in carbon molecules that make up plant tissue. Along the second path, solar energy is converted into *heat energy*.

*Chemically bonded energy* derived from sunlight through photosynthesis is the source of energy found in all fossil fuels and almost all food energy for life on the planet. Hence, the energy used to drive an automobile, generate electricity from coal, or to heat a cozy room by burning wood in a fireplace is energy that entered the Earth system as solar energy—sunlight. Energy used by humans to jog or birds to fly also entered the Earth system as solar energy before being converted into chemically bonded energy, more commonly known as food.

  

In the food web, chemically bonded energy is produced by green plants through *photosynthesis*. Plants are known as *producers*. This process supports most of life on planet Earth. *First-order consumers* are those that directly consume photosynthetic plant producers and the energy stored in plant tissue. Energy can then be passed through the food web as one organism consumes another organism. Each time chemically bonded energy passes from one organism to another, only about 10 to 20 percent of the energy is converted back into chemically bonded energy stored in animal tissue of the consuming organism. About 80 to 90 percent of the energy is lost to heat and biological decomposition.

Because of the inefficiency of transfer of energy from one organism to another in the food web, it takes—on average—about 10 pounds of grain to produce one pound of beef. Hence, there's little doubt why poor people do not eat much meat. It simply wastes too much energy. Ten pounds of grain will go a lot further toward filling hungry stomachs than one pound of meat. Losing food energy by converting it to meat is a luxury that the affluent are more likely to enjoy than the poor. As people around the world become more affluent they quickly add meat to their diets, which dramatically increases the demand for grain that is fed to animals.

The energy that drives a hurricane or a tornado also entered the Earth's system as solar energy, but followed a different path; it was converted into **heat energy** and then into **kinetic energy** (motion). The driving force for the circulation of the atmosphere and hydrosphere is a result of inputs of *solar energy* (in the form of sunlight) into the Earth's system and subsequent transformations, storage, and outputs. In this case the planet's circulation system can be thought of as a large solar engine. The energy that drives a hurricane or tornado first entered the Earth's system as sunlight.

## INTERNAL EARTH ENERGY IN THE SYSTEM

Movement of the Earth's crust and associated earthquakes, volcanic eruptions, mountain formation, and the sinking of landmasses beneath the sea are also due to inputs and flows of energy that we will call *internal Earth energy*. This energy is a function of radioactive decay deep within the Earth. This energy entered Earth's system during the formation of the planet, 4.5 billion years ago, and is responsible for the pattern of oceans and continents, and mountains, plateaus, and plains.

## ENERGY PASSING THROUGH THE SYSTEM

Energy flows *into* the Earth system, *through* the Earth system, and *out* of the Earth system. Sometimes this occurs as fast as the speed of light. For example, solar energy in the form of light from the sun can enter the Earth system and then be reflected off a snow-covered mountain peak back into space in less than a second. On the other hand, energy can be stored in the Earth system for millions of years. For example, the energy in coal entered the Earth system as solar energy several hundred million years ago, was changed by photosynthesis into chemically bonded energy, and since then has been stored in the crust as carbon.

The laws of thermodynamics state that energy can neither be created nor destroyed, but only transformed from one kind of energy to another. Thus, burning coal does not destroy the chemically bonded energy in the coal, but merely converts it into another kind of energy—heat energy—that eventually radiates out into space.

  

The same is true when gasoline is burned in an automobile. No energy is lost; it can all be accounted for. Some is directly converted into heat, and some of this heat is converted into kinetic energy (motion) in the engine. This motion is then ultimately converted into heat through friction from the tires or when the brakes are applied.

When you eat pizza, some of the chemically bonded energy is converted into kinetic energy that allows you to move. Some is converted into heat energy that keeps your body warm. Some will be stored as chemically bonded energy in the tissue that makes up body cells. Much of it will pass through your body system without experiencing change and eventually will be converted to heat by biological decomposers.

Because energy flows into, through, and out of the Earth system, it is considered to be an ***open energy system. Solar energy and internal Earth energy are the two inputs from which virtually all other energy, hence change, is derived.***

## MATTER IN THE SYSTEM

Matter, or the "stuff" that things are made of, is quite a different story. The Earth is considered to be a ***closed matter system***. Except for minute amounts of matter such as stellar dust, meteorites, and water in the form of ice from outer space, the Earth gains very little matter. Because of gravity, it looses very little matter. What we have is all we have. Recycling is not a new idea. It has been around a lot longer than people. Eventually everything is recycled by the Earth system. When you last took a drink of water were you so naive as to think you were the first organism those molecules of water ever passed through? If so, think again! Water, carbon, hydrogen, and all the other stuff, or matter, of the Earth is used over and over again. Practically nothing is gained or lost.

Matter can change *form* and it can change *location* within the Earth's system, but it does not leave the Earth's system! When wood is burned, the wood appears to disappear. Indeed, the wood is gone, but all the matter that made up the wood is still in the Earth matter system. Some has been converted to ash. Other elements of wood, such as carbon, have been converted to a gas, entered the atmosphere, and are ready to be used again by plants. Matter is never lost, just changed!

Matter recycling can be either fast or slow. Recycling of carbon, for example, can be fairly fast. Assume that a corn plant absorbs carbon dioxide from the atmosphere, separates and discharges the oxygen back into the atmosphere, and stores carbon as the plant tissue. When you eat the corn, it is combined in your digestive tract with oxygen that you have inhaled. This releases the chemically bonded energy and makes it available for your body to use. You exhale the carbon in the form of newly combined carbon dioxide, which can again be used by plants. Carbon stored as coal, however, was removed from the Earth's energy system millions of years ago and will perhaps only be returned to the atmosphere when it is mined and burned by humans.

Let's look at the case of water. Follow this scenario: It rains, the water is captured in a reservoir, purified and passed through a municipal water system, consumed by residents of the municipality, flushed away, routed through a sewage treatment plant, dumped into a river, pumped out of the river, purified and passed through another municipal system, continually changing form and location as it is recycled over and over and over.

  

Water can be either in an active cycle or in storage, sometimes for long periods of time; for example, as glacial ice in Antarctica or Greenland. Water in the Ogallala Aquifer under the Great Plains has been in storage for thousands of years. For many years it has been taken out of storage by pumping and utilized for irrigation to support agriculture. Once out of storage it reenters the active hydrologic cycle.

For many years withdrawal of water from the Ogallala Aquifer greatly exceeded its recharge. It has been estimated that until recent changes in irrigation technology were implemented water was being withdrawn much faster than it was being replaced by nature. This worked much like a bank account in which one withdraws more money than is deposited. The aquifer, like such a bank account, began to be depleted. The United States Department of Agriculture once predicted that by the year 2000 the aquifer would no longer support irrigation in many areas and the agricultural yields of those regions would no longer contribute to the world supply of food and fiber. As the problem of water depletion became more serious farmers utilized more efficient irrigation technologies. Today the level of the Ogallala Aquifer has been stabilized in many areas.

## INTERACTION OF ENERGY AND MATTER

Energy and matter are intertwined within the Earth's system. Energy is responsible for ***all*** changes in *form and location* that occur in matter, and matter is the medium in which energy exists and works. Matter cannot change without energy acting upon it through inputs, storage, transformation, or outputs. We can think of the spatial distributions of matter as the result of how energy is interacting with matter. Because energy and matter are so closely interconnected, we can think of the Earth as an energy-matter system.

## A DYNAMIC AND EVOLVING ENVIRONMENT AND LANDSCAPE

The Earth's energy/matter system, and, hence, the planet itself, is constantly changing. It is believed that the Earth formed about 4.5 billion years ago. It was a very different place then. The original atmosphere, which was not at all like the present atmosphere, but made up of very light gasses, was lost to space. Volcanic activity and out-gassing provided a second atmosphere. It would be considered toxic and dangerous by today's standards. No ozone layer existed above the planet to filter out dangerous ultraviolet radiation. The planet was not a very hospitable place for life. Thus, when life finally did appear, it should come as no surprise that it could only live in the environment of the oceans, where water protected it from hazards such as the sun's ultraviolet rays.

It is currently believed that life itself was responsible for the oxygen in the atmosphere and, thus, the oxygen that eventually formed the ozone. Only after the evolution of the ozone, which filtered out damaging ultraviolet radiation, were life-forms able to migrate from the oceans to land surfaces. Imagine a landscape with no life-forms! No soil, which contains organic matter, would exist. Only rocks, gravel, sand, silt and clay would be found at the surface. The Earth was very susceptible to massive erosion by water and wind because no plants were present to hold the surface material in place. Land surfaces would have been very inhospitable, indeed!

  

As a result of internal Earth energy, the continents are continually moving. South America was once connected to Africa. So was India, which broke off and collided with Asia. The great rift valleys of Africa mark the next major split of the continent. North America is moving away from Europe at the rate a human fingernail grows. Paris is farther away from North America today than yesterday, but not by much. Ocean floors are uplifted, mountains are created, worn away, and disappear. Landmasses sink and become ocean floors. The limestone of the Hill Country in Central Texas was formed as an ocean floor millions of years ago!

Change is constant. Many scientists believe that every 26 million years the planet experiences a massive extinction of life-forms. Glacial periods come and go every hundred thousand years or so. Only 10 to 12 thousand years ago there was still glacial ice in excess of one mile thick on North America. Because of the effect of the ice on atmospheric circulation, Lubbock, Texas, and the surrounding region was swampy and woolly mammoths roamed the landscape. A boreal forest of pine, spruce, and fir could be found in northern Kansas. The environmental systems of the Earth are constantly undergoing change. This change is a result of changes in the inputs, transformations, storage, and outputs of energy and changes in matter cycles. Change in the system occurs naturally.

When looking at the natural/physical environmental system it is important to realize that it is really one large interrelated system with many connected subsystems and components. It is driven by inputs of internal Earth energy and solar energy. These energy inputs flow through the system altering the states and location of matter. A change in the flow of energy and matter in one part of the system starts a cascade effect that causes changes in other parts of the system, which causes yet further changes, which in turn causes a cascade of even more changes. For example, when *internal Earth energy* uplifted the Rocky Mountains, the climate of the area to the east became very dry; grasslands evolved. Volcanic activity, which can increase dust in the atmosphere, is another example of change. This "volcanic ejecta" can block out enough sunlight to cause temperatures to be cooler. Some scientists claim that the Great Flood of 1993 in the United States was partly due to the eruption of Mount Pinatubo, in the Philippines.

Change does not occur in isolation from other components of the system. Heavy rain in one location may result in a flood in another location. It appears that the drought in North America during the summer of 1988 was due, in part, to cooler sea surface temperatures along the Equator in the Pacific Ocean. While the Midwest was flooding in the summer of 1993, the South was experiencing a drought. These are not unrelated events, but connected parts of a larger system experiencing change.

A change in climate, such as drought or cool wet episodes, can cause a change in the spatial distributions of biota (life-forms) and soil characteristics. On the other hand, a change in biota, for example deforestation, can cause a change in local climate, soil, and other biota, such as extinctions of plants and animals. A change in soil, perhaps due to changes in the water table, can cause a change in biota and local climate. Everything is connected!

  

## CHANGING LANDSCAPES OF THE EARTH ENERGY/ MATTER SYSTEM

Because the Earth's energy/matter (natural/physical environmental) system is constantly changing, the resultant *landscapes* on the planet are also changing constantly. *Natural/physical landscapes* are a result of natural processes in the energy/matter system. Hence, as the system changes so do the landscapes. Swamps and marshes no longer exist in the Texas panhandle. Glacial ice no longer covers large parts of Canada and the United States. Woolly mammoths, small horses, and camelids no longer roam the plains of the U.S. as they did only 10,000 years ago. These creatures became extinct as the environment changed. It is in the context of the natural/physical landscape that frail and inconsequential humans emerged and, over time, increasingly developed the technological ability to alter the flow of energy and matter through natural/physical systems and, therefore, alter the nature of the Earth's environment itself.

## THE RELATIONSHIP BETWEEN HUMANS AND THE ENVIRONMENT

The environment influences cultural development and, at the same time, cultural activities impact and modify the nature of the environment. During the transition from hunting and gathering to sedentary agriculture, and eventually the evolution of large high-technology/high-energy societies, the role the local and regional environment played in determining the direction and level of cultural development has somewhat diminished, at least in the short run. Technology has allowed people to overcome some environmental limitations. The large population currently residing in the Las Vegas, Nevada, region is due to the use of energy and technology to provide water and cool air that do not naturally occur there. It is uncertain whether the massive level of energy and technology subsidies, which allow humans to overcome environmental limitations, can continue indefinitely.

Although the environment has never been the sole determining factor in cultural development, such a view, known as ***environmental determinism***, was widely accepted a century ago. This view argued that climate and landform determined the level of cultural development. An opposite view, known as ***cultural determinism***, became popular during the 20th century. Cultural determinism professed that cultures were totally free of environmental influences, which was also incorrect. More recently, a realistic view of the relationship between people and the environment emerged. This view acknowledges that there exists a *two-way, reciprocal relationship between environment and culture*. In geography the study of this interactive relationship between culture and environment is known as ***cultural ecology.***

## HUMAN IMPACTS ON THE ENVIRONMENT

Environmental change resulting from natural causes may require that cultures adapt to the changes in order to survive. In some cases, cultures themselves modify the environment to such a degree that they must themselves adapt to survive. The degree to which humans modify an environment is a function of three controls:

1) *Population size and densities;*

2) *Length of time people have been in an area* (tenure); and

3) *Level of technology and affluence*, which determines the degree to which humans can utilize the environment to extract resources.

  

As population size and density increase, the degree to which humans modify the natural/physical landscape increases. When population size is small and densities are low, humans are less apt to alter the natural flow of energy and matter through the Earth's natural/physical environmental systems and the natural patterns tend to persist. Existing energy and matter processes are more likely to be altered when more people in greater densities extract resources from the environment. Human modification of the processes in the environmental system results in a cascading myriad of interrelated environmental changes, which, in turn, alter environmental patterns. Many of these changes may not be immediately evident.

Holding the variables of population density/size and level of technology constant, areas that have been occupied for longer periods of time tend to have undergone greater cultural modification than areas occupied for shorter periods. Areas of early cultural development, inhabited for thousands of years, are greatly different from the pristine landscapes that once existed.

Technology and affluence also influence the extent to which people modify the environmental resource base. Technology can be defined as the ideas and tools that allow a group of people to alter the flow of energy and matter through the Earth's environmental system to achieve some *perceived* good for those possessing the technology. As affluence increases people consume more, which requires more resource extraction. High levels of technology on the part of affluent people make it possible for a relatively small group of people to drastically alter the existing flow of energy and matter through the Earth system and culturally modify the environment in a short period of time.

Today, few areas remain untouched by cultural modification. Remaining wilderness areas are under siege because they often contain a wealth of resources that can be exploited for subsistence survival, economic development, and/or profit. Every day, regional and global reserves of unprotected wilderness are irreversibly diminished. Access to energy and the level of technology possessed by a culture appear to be one of the single most important variables in determining the degree to which a culture can overcome the limitations of the environment and, at the same time, modify or destroy the environment.

## CULTURAL LANDSCAPES

As humans modify a natural/physical landscape the creation of cultural landscape features results. When a landscape is largely the product of human activity it is called a *cultural landscape*. Los Angeles, California, and Austin, Texas; wheat and cotton fields in Texas; strip mines in Colorado; the National Mall in Washington, D.C.—all are cultural landscapes. They are landscapes created by humans. Globally, the trend is toward decreasing natural/physical landscapes and increasing cultural landscapes. In fact, it is difficult to find a landscape that is totally free of human imprints today.

  

Cultures with low levels of technology have less control over the environment and their local cultural landscapes are expected to be more reflective of the expected natural environments than the landscapes of high-technology cultures. For example, low-technology cultures build structures out of naturally occurring, locally available materials such as sod, logs, stones, skins, or ice. High-technology cultures, on the other hand, create urban cultural landscapes out of many kinds of material, which often originated from distant locations and perhaps required sophisticated manufacturing techniques. Imagine how different the American cultural landscape would be if it had been constructed only of naturally occurring materials found within a 50-mile radius of where they were used!

Up until a mere 10,000 years ago (a small fraction of the time it is believed humankind has been on this planet) it appears that all humans possessed low levels of technology and were essentially dependent upon hunting and gathering for their survival. People lived in small groups, often occupied abundant habitats, and extracted most of what they needed from the local natural environment. They migrated throughout their territory in a manner that reflected an understanding of the natural cycles of availability of resources in the natural landscape. These migrants are called *optimum foragers*, because they knew when and where fruit or nuts would be available in a given location, when certain animals, birds, or fish would be most abundant or easiest to obtain, and so forth.

Interestingly, it is also believed that these small societies were egalitarian with no rigid class structure. All men did all male jobs and all women did female jobs. Perhaps surprising to some, it is also believed that these people lived a life of relative abundance and ease. Some anthropologists estimate that it took only 16 hours a week for hunters and gatherers to meet their needs in the abundant habitats that they once occupied.

Small human populations living a low technology, low-energy migratory existence meant that these ancestors of ours did little to modify or damage the landscape of the planet. An exception to this might have been the use of fire to expand grasslands and savannas at the expense of marginal forests in drier areas, but even this may not have had a negative impact on the environment.

## THE TURNING POINT IN THE HUMAN-ENVIRONMENT RELATIONSHIP

Around 10,000 years ago the quiet and unceremonious rumblings of change emerged in the form of the simple technologies of horticulture, agriculture, and animal husbandry. Development of these technologies is believed to have been very slow. Gradually, however, people became increasingly dependent upon agricultural technologies and less dependent upon hunting and gathering. Food supplies became more abundant and reliable. Population growth began to slowly accelerate.

Migratory existence was eventually traded for permanent housing. Villages emerged over time. Later, cities appeared in the most favorable locations. Increasing numbers of people created a need for public administration and division of labor. Rigid social class orders emerged. At the top were small elite classes who controlled access and distribution of wealth and resources. These societies believed that the workings of the universe, hence their well-being, were orchestrated by the whims of deities, a "Thou," so to speak. In order to maintain a favorable relationship with the "Thou"-driven environment, rigid and complex religious infrastructures evolved to address the issues of crops, natural hazards, warfare, and virtually every other aspect of life. Great power accrued to these religious leaders.

  

Either through local innovation, or adoption through spatial diffusion, technologies such as writing, standardized weights and measures, coinage, codified laws, metallurgy, transportation improvements, and irrigation allowed some of the early *cultural hearths* to grow. This usually resulted in a need or desire for additional resources, which, in turn, prompted an expansion of borders to control larger portions of the Earth's surface and the resources found therein. This often occurred at the expense of nearby, less technologically developed societies of hunters and gatherers or agriculturalists. Undoubtedly, possession of a universalizing religion also greatly enhanced the probability of spatial expansion of a group of people.

One outcome of the expansion of these early technological societies was that cultural features became more evident and widespread in the landscapes in which the cultures interacted. Urban centers expanded, fields and managed pastures increased, dams and canals, roads, bridges, and other components of the emerging cultural infrastructure came to dominate in many areas. Forests and woods were diminished, soil under cultivation eroded away and, in many instances, became increasingly salty as a result of irrigation. At each step of cultural expansion, the natural/physical landscapes were increasingly modified and the imprint of culture and the resultant cultural landscape became increasingly evident.

## TECHNOLOGICAL ACCELERATION OF THE HUMAN IMPACT ON THE ENVIRONMENT

Gradually the *agricultural revolution* led to the cultural reorganization of most of the Earth's surface that was arable or contained some perceived resource. Hunters and gatherers were increasingly restricted to remote areas where agricultural societies had not yet arrived. Nearly 10,000 years later a second major technological breakthrough occurred in the form of the *industrial revolution*. In the simplest terms, the *industrial revolution* represented a transition from a reliance on animate energy (the energy of muscles of humans and animals) to inanimate energy. A major event in the industrial revolution was the refinement of the steam engine, which made it possible to extract the chemically bonded energy stored in wood and coal to do work. Once the limitations of animate energy were overcome it became much easier to extract resources from the environment. Mechanical innovations rapidly appeared to take advantage of the new energy, and humankind began to accelerate its efforts to obtain more resources and, thus, increasingly modify the landscape. Because this new energy could be located virtually anywhere, the spatial impacts on the landscape expanded rapidly.

New technological innovations and sources of energy led to dramatic improvements in transportation and communication, as well. This in turn accelerated the level to which humans could control certain aspects of the environment. The outcome was an increase in the availability of goods and services. *Carrying capacity* refers to the maximum number of a particular organism that an environment can support in a sustainable manner. The carrying capacity of humans on the planet has increased dramatically due to technological advances, which have made resources more abundant and reliably available. Over time technological improvements in sanitation, housing, nutrition, and more recently medical technology have reduced death rates. Increased resources and decreased death rates lead to unparalleled global population growth.

  

## HISTORIC SCENARIO OF POPULATION GROWTH

Growth of global population can best be understood by looking first at the year A.D. 1. It is estimated that about 250 to 300 million people inhabited the planet. Thousands of years had been required to reach this number. From the year A.D. 1 it took until 1650, well after the Pilgrims had made their way to New England, for global population to double to 500 million (1/2 billion). In 1830, only 180 years later, population had doubled again, reaching one billion. In little more than a century it doubled again, reaching 2 billion by about 1930. Population doubled again by 1974, reaching 4 billion. If current trends persist, it is expected to reach at least 9 to 10 billion by the year 2050!

The first doubling since the time of Jesus of Nazareth took 1,650 years; the second took 180 years; the third only 100 years; and the fourth only 44 years! At the present rate of growth, it is expected that it might only take about 50 to 60 years for the population to double again. How old will you be when the population doubles, to more than 12 billion? How old will your children be? All of these people will want food, clothing, housing, clean drinking water, medical care, an education, jobs, and even perhaps parking spaces! How many people can the world support? The maximum carrying capacity of the planet is unknown. It will be determined by the ability of technology to increase resource availability and by the standard of living at which people aspire to live.

## WHAT DOES THE FUTURE HOLD?

Although the carrying capacity of the planet is unknown, one thing is certain: There will never be one more person on the planet than the planet can support. Think about that! Obviously, with the aid of technology and energy subsidies the planet can support many more people today than it could have supported 500 or 1,000 years ago. We are, however, dependent upon maintaining or increasing the present levels of technology and massive energy subsidies to support the present and future levels of population.

A potential problem, unfortunately, is that population is continuing to increase rapidly while many vital resources such as energy, soil, and clean, safe water are diminishing. Every year large amounts of agriculturally productive land deteriorate to a state of nonproductivity or the land is allocated to nonagricultural uses such as subdivisions and interstate highways. Attempts to compensate for this loss of soil by increasing agricultural intensity, often accompanied by increased subsidies of energy, are accelerating soil erosion and compounding the problem by reducing yields even further in some of the poorer regions of the world. Forests are being cut down and deserts are expanding at alarming rates, either directly because of hunger or indirectly because of ill-fated attempts to service debt and/or develop the economies of poorer countries. At the same time, other vital resources such as water supplies are being depleted or polluted. Not only is the atmosphere being poisoned, but chemical modification threatens to alter the existing climatic distributions of the planet, which could dramatically reduce the food-producing capability of the Earth.

  

All three factors that influence cultural modification of the natural/physical environmental system (number and density of people, tenure, and technology/affluence) are increasing. Humans may be destroying the very life support system that has nurtured them and their ancestors for eons. There is preliminary evidence that suggests we might be changing the nurturing relationship we have with our environment into something more akin to being imprisoned on a planet that is dying by the acts of our own hands.

Natural/physical processes and the underlying spatial patterns of environmental distribution are what support the present density and distributions of population on this planet. They are the result of the existing paths along which energy and matter flow and interact. As we disrupt, detour, or otherwise realign those paths in the name of "development," we can expect the system to continue to change. Alteration of the system might be comparable to tearing threads from a net that supports us from falling off a great precipice into catastrophe. Perhaps humankind is already approaching the upward limits of a sustainable population while maintaining some degree of quality of life.

There is a view, however, that argues that human intelligence and creativity are sufficient to resolve any problems that face us. This is known as the ***technological fix***, or economic solution. Proponents, known as *resource optimists*, argue that it was technology that permitted population to reach its present level. They argue this is a crowning achievement because never before have so many people lived so well. They point out that the availability of goods and services has never been as high as it is today; they are optimistic that there is no problem on the horizon.

Opponents to the technological fix, or resource optimism, argue that shortsighted technology is responsible for the perceived problems facing humankind today. The very existence and increasing severity of these problems, they argue, confirms that technology is not capable of resolving the emerging problems. They further argue that if human technology cannot even accurately forecast the weather one day in advance, or control hurricanes or tornadoes, or find acceptable solutions to solid waste disposal, it is not credible to believe that technology could stop or control widespread global climatic change. This perspective takes a conservation view, suggesting that we should use resources cautiously since they are finite and future generations are dependent upon them. This view is said to be one of ***resource pessimism***, in which resources are seen to be finite and using less, reusing, and recycling more resources are key ingredients in any plan to improve the future of resource availability.

Another argument against the technological fix is that in a market economy technology is directed toward meeting the needs of those who can afford to purchase whatever is developed. For example, the development of Internet-capable cell phones was driven by the hope that enough people would purchase the product to generate a profit. Unfortunately, in a world exceeding six billion people, the people with the most immediate and serious problems are the poor. They do not constitute a potential market or command enough economic clout to attract sufficient investment of technology and money to resolve their problems.

  

## HOW WILL IT TURN OUT?

Will technology permit the planet to grow large amounts of food with decreasing soil or water in order to feed the increasing masses? Will safe, new, and inexpensive sources of energy be discovered? Will technology resolve the myriad of human-enhanced environmental problems that may threaten human existence, as we know it? Perhaps. The verdict is not in yet. One thing is certain: Whatever happens will be in part the result of our decisions. We, and our heirs, must live—or die as the case may be—with the outcome. The geographical perspective has a lot to offer in our observation and analysis of the world around us and the pursuit of solutions to perceived problems.

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