

# WORLD•WATCH

VISION FOR A SUSTAINABLE WORLD

## Population AND ITS DISCONTENTS

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One of 12 features in this special issue

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# World Population, Agriculture, and Malnutrition

Increases in food production, per hectare of land, have not kept pace with increases in population, and the planet has virtually no more arable land or fresh water to spare. As a result, per-capita cropland has fallen by more than half since 1960, and per-capita production of grains, the basic food, has been falling worldwide for 20 years.

**E**ntering the new millennium, stark contrasts are apparent between the availability of natural resources and the demands of billions of humans who require them for their survival. According to the Population Reference Bureau, each day almost a quarter-million people are added to the roughly 6.4 billion who already exist. Yet the stocks of natural resources that support human life—food, fresh water, quality soil, energy, and biodiversity—are being polluted, degraded, and depleted.

Global population has doubled during the last 45 years. If the present growth rate of 1.3 percent per year persists, the population will double again within a mere 50 years. Growth rates vary from one country or region to another. For example, China's present population of 1.4 billion, despite the governmental policy of permitting only one child per couple, is still growing at an annual rate of 0.6 percent. Although China recognizes its serious overpopulation problem and recently passed legislation strengthening the policy, its young age structure means that the number of Chinese will continue to increase for another 50 years. India, with nearly 1.1 billion people (living on approximately one-third the land of either of the United States or China), has a current population growth rate of 1.7 percent per year. This translates to a doubling time of 41 years. Taken together, the populations of China and India constitute more than one-third of the total world population. In Africa, despite the AIDS epidemic, the populations of most countries also are expanding. The populations of Chad and Ethiopia, for example, are projected to double in 21 and 23 years, respectively.

But the problem is hardly confined to the developing world. The U.S. population—among the most heavily

consuming in the world—is growing rapidly. Now standing at nearly 300 million, it has doubled during the past 60 years. The U.S. Bureau of the Census reported in 2003 that sustaining the current growth rate of about 1.1 percent per year will double the population to 600 million in less than 70 years.

Current United Nations estimates of population stabilization at about 9 billion people by 2050 are questionable, mainly because of the very young age structure of the current world population and the momentum it fosters. A large share of the population is concentrated within the 15-to-40 range, where reproductive rates are high. Even if all the people in the world adopted a policy of only two children per couple, it would take approximately 70 years before the world population would finally stabilize at about 12 billion, twice the current level.

## Land

Many human beings already suffer from hunger and/or malnourishment. The United Nations Food and Agricultural Organization (FAO) reports that the quantity of food produced per capita has been declining since 1984, based on available cereal grains, which make up about 80 percent of the world's food supply. Although grain yields per hectare in both developed and developing countries are still increasing, the rate of increase is slowing. According to the U.S. Department of Agriculture, U.S. grain yields increased at about 3 percent per year between 1950 and 1980, but since then the annual rate of increase for corn and other major other grains has been only about 1 percent. Yet the World Health Organization estimates that more than 3 billion people are malnourished (deficient in intake of calories, protein, iron, iodine, and/or vitamins A, B, C, and D). This is the largest number and proportion of malnourished people ever reported.

At the same time, cropland resources are under severe strain. FAO Food Balance Sheets show that more than 99.7 percent of human food (calories) comes from the terrestrial environment, while less than 0.3 percent comes from the oceans and other aquatic ecosystems. Of the total of 13 billion hectares of land area on Earth,

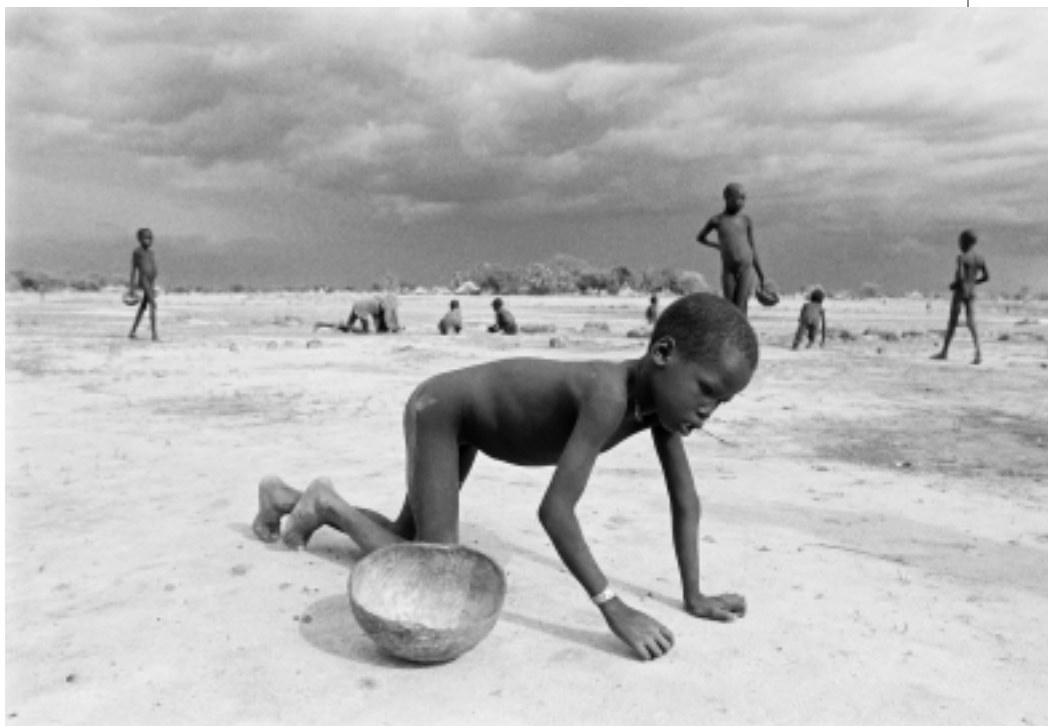
cropland accounts for 11 percent, pastureland 27 percent, forested land 32 percent, and urban lands 9 percent. Most of the remaining 21 percent is unsuitable for crops, pasture, and/or forests because the soil is too infertile or shallow to support plant growth, or the climate and region are too cold, dry, steep, stony, or wet.

In 1960, when the world population numbered only 3 billion, approximately 0.5 hectare of cropland per capita was available, the minimum area considered essential for the production of a diverse, healthy, nutritious diet of plant and animal products like that enjoyed widely in the United States and Europe. But as the human population continues to increase and expand its economic activity and related artifacts, including transport systems and urban structures, vital cropland is being covered and lost from production. Globally, available per-capita cropland is now about 0.23 hectare. In the United States, there is already about 0.4 hectare (1 acre) of land per person tied up in urban buildings and highways and the available cropland per capita has shrunk over the last 30 years or so to 0.5 hectare. In China, per-capita cropland has declined to 0.08 hectare from 0.11 hectare 25 years ago, due to continued population growth as well as extreme soil erosion and degradation. This relatively small amount of cropland provides the Chinese people a primarily vegetarian diet.

The United States produces 1,481 kilograms per year of agricultural products for each American, while the Chinese food supply averages only 785 kilograms per year per capita (mostly grains in both cases). Lester Brown of the Earth Policy Institute has suggested that by all available measurements the Chinese have reached or exceeded the limits of their agricultural system. The Chinese reliance on large inputs of fossil fuel-based fertilizers to compensate for shortages of arable land and severely eroded soils, combined with their limited fresh water supply, suggests severe problems looming ahead. Even now, China imports large amounts of grain from the United States (which also relies heavily on fossil inputs for agriculture) and other nations, and is expected to increase imports of grains in the near future.

The decline of per-capita cropland is aggravated by the degradation of soils. Throughout the world, cur-

rent erosion rates are higher than ever. According to a study for the International Food Policy Research Institute, each year an estimated 10 million hectares of cropland worldwide are abandoned due to soil erosion and diminished production caused by erosion. Another 10 million hectares are critically damaged each year by salinization, in large part as a result of irrigation and/or improper drainage methods. This loss amounts to more than 1.3 percent of total cropland annually. Most of the additional cropland needed to replace yearly losses comes from the world's forest



H. Schwarzbach/UNEP/Peter Arnold

#### Hunting in Africa: Starving children look for ants in famine-stricken Sudan.

areas. The urgent need to increase crop production accounts for more than 60 percent of the massive deforestation now occurring worldwide.

Erosion losses are critical because topsoil renewal is extremely slow. It takes about 500 years for 2.5 centimeters (1 inch) of topsoil to reform under agricultural conditions. Soil erosion rates on cropland range from about 10 metric tons per hectare per year (t/ha/yr) in the United States to 40 t/ha/yr in China. During the past 30 years, the rate of soil loss throughout Africa has increased 20-fold. A 1996 study in India found that as much as 5,600 t/ha/yr of soil were lost under some arid and windy conditions.

Some crops can be grown under artificial conditions using hydroponic techniques, but the cost (in energy

and dollars) is approximately 10 times that of conventional agriculture. Such systems are neither affordable nor sustainable for the future.

## Water

The availability of adequate supplies of fresh water for human direct use and agriculture is already critical in many regions, especially the Middle East and parts of North Africa where low rainfall is endemic. Surface waters, for instance, are often poorly managed, resulting in water shortages and pollution, both of which

year, while in Tianjin, China, it is dropping 4.4 meters per year. In the United States, groundwater overdraft is high, averaging 25 percent greater than replacement rates. The capacity of the Ogallala aquifer, which underlies parts of Nebraska, South Dakota, Colorado, Kansas, Oklahoma, New Mexico, and Texas, has decreased by 33 percent since about 1950. Withdrawal from the Ogallala is three times faster than its recharge rate. Aquifers in some parts of Arizona are being overpumped more than 10 times faster than the recharge rate.

Irrigation enables crop production in arid regions, provided there is an adequate source of fresh water and enough energy (generally fossil in origin) to pump and move the water. About 70 percent of the water removed from all sources worldwide is used solely for irrigation. Of this amount, about two-thirds is consumed by growing plants and is non-recoverable, i.e., lost to the hydrologic cycle via evapotranspiration. Irrigation is less water-efficient than rainfed watering of crops, and the limitations of surface and ground water resources for irrigation, its high economic costs, and the large energy inputs required will tend to limit future agricultural irrigation, especially in developing nations that cannot afford such expenditures.

Pollution is a major threat to maintaining ample fresh water resources. Although considerable water pollution has been documented in developed nations like the United States, the problem is of greatest concern in countries where water regulations are not rigorously enforced or do not exist. This is common in most developing countries, which (according

to the World Health Organization) discharge 95 percent of untreated urban sewage directly into surface waters. For instance, of India's 3,119 towns and cities, only 209 have even partial sewage treatment facilities, and a mere eight possess full facilities. Downstream, the polluted water is used for drinking, bathing, and washing.

## Energy

Humans have relied on various sources of power for centuries, beginning of course with solar energy—fundamental to nearly all natural ecosystems—and their own muscle power. Other sources have included animals, wind, tides, water, wood, coal, gas, oil, and nuclear energy. Since about 1700, increasingly abundant fossil fuel energy supplies have made it possible to augment agricultural production to feed an increasing number of humans, as well as improve the general



Jinda Uthaipanumas/UNEP/Peter Arnold

**Labor-intensive irrigation in Thailand. Increasing agricultural output often means irrigating crops, yet water supplies are under increasing strain.**

threaten humans and aquatic biota. Groundwater—rainfall lying in underground aquifers—is another vital source of water for agriculture; it too is often used profligately. Aquifers recharge very slowly, usually at rates of 0.1 to 0.3 percent per year, according to the UN Environment Programme. At these rates, groundwater resources must be carefully managed to prevent overuse and depletion, but this wisdom is often ignored. For example, in Tamil Nadu, India, groundwater levels dropped 25 to 30 meters during the 1970s because of excessive pumping for irrigation. In Beijing, China, the groundwater level is falling at a rate of about 1 meter per

quality of human life in many ways.

Since the fossil era began, the rate of energy use from all sources has grown even faster than world population. From 1970 to 1995, energy use increased at a rate of 2.5 percent per year (doubling every 30 years), compared with worldwide population growth of 1.7 percent per year (doubling about every 40 years). During the next 20 years, energy use is projected to increase by 4.5 percent per year (doubling every 16 years) and population by 1.3 percent per year (doubling every 54 years).

Although about half of all the solar energy captured by worldwide photosynthesis is used by humans, this amount is still inadequate to meet all human needs for food and other purposes. To make up for this shortfall, the world consumes a lot of fossil energy: about 345 quadrillion British thermal units ( $3.64 \times 10^{20}$  joules) of it in 2001, with the United States alone accounting for 83 quadrillion Btu of fossil energy consumption that year. (Each year, in fact, the U.S. population uses twice as much fossil energy as all the solar energy captured by harvested U.S. crops, forest products, and other vegetation.) A great deal of this supplemental energy goes into agriculture. In China, for instance, while most fossil energy is used by industry, about one-quarter is used for agriculture and the food production system. Like some other developing nations with high rates of population growth, China is increasing fossil fuel use to augment agricultural production of food and fiber. Since 1955 Chinese agriculture has boosted energy use 100-fold for fertilizers, pesticides, and irrigation.

In general, however, in what may be a harbinger of an approaching crunch, the International Fertilizer Organization reports that fertilizer production has declined by more than 17 percent since 1989, especially in the developing countries, because of fossil fuel shortages and resulting high prices. In fact, the projected global availability of fossil energy resources for fertilizers, not to mention all other purposes, is discouraging.

British Petroleum and other authorities have estimated that the world supply of oil would last approximately 50 years at current production rates. Perhaps somewhat optimistically, the global natural gas supply is considered adequate for about 50 years and coal supplies for at least 100 years. However, demand is not static, but rising dramatically. Moreover, even adequate production in one place may not translate into adequate supply elsewhere; natural gas supplies are already in short supply in the United States and U.S. reserves may be depleted in as little as 20 years, yet transporting natural gas in liquid form to the United States from places where it is abundant poses serious technical and financial challenges.

An even more sobering prospect is that of the imminent peak in production of oil and natural gas. The experience of the United States may portend the fate

of global oil and gas production. Walter Youngquist, formerly an oil geologist with Exxon, reports that current oil and gas exploration drilling data have not borne out some of the earlier optimistic estimates of these resources yet to be found in the United States. U.S. oil production peaked around 1970 and has been declining ever since. Youngquist estimates that about 90 percent of U.S. oil resources already have been mined. A key consequence is that U.S. net imports of oil rose to about 53 percent of total consumption in 2002 and are still going up, placing the economy at risk from fluctuating oil prices and difficult political situations.

This scenario is likely to repeat globally. Predictions for the peak year of global oil production, for instance, range from 2005 to 2035, but in our view the most plausible of these estimates are those in the 2005–2010 range. Whenever the peak occurs, the impacts of rising energy prices on the economies of most nations will be profound. Modern agriculture, no less than other sectors of the economy, depends on large quantities of oil and natural gas (used in nitrogen fertilizer production) and higher energy prices are already having an impact on agricultural production.

## Wild Facts

These facts speak for themselves. They starkly signal a rapidly approaching time of grave challenge for the agricultural system. During the 20th century, increased food production—supporting a period of unprecedented growth in the world population—depended on the availability of cheap fossil energy, primarily oil and natural gas. The consequent expansion of human needs and activities has been depleting the land, water, and biological resources that are essential for sustainable agricultural production. Already, more than 3 billion people in the world are malnourished, yet per-capita production of cereal grains, basic world foods, has continued to decline for the past 20 years, despite all the new biotechnologies.

As the world population continues to expand, all vital natural resources will have to be divided among increasing numbers of people and per-capita availability will decline to low levels. When this occurs, we believe that it will become quite difficult to maintain prosperity, a quality life, and even personal freedoms for those who already enjoy them, much less secure those benefits for the billions currently living without. Meeting this challenge will test humanity's resourcefulness and goodwill to the utmost.

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