FEATURES

Human Population and Environmental Stresses in the Twenty-first Century

by Richard E. Benedick

Abstract: Human populations have put pressure on their natural surroundings throughout history. Yet the world is now facing truly global environmental challenges and rapid population growth in the final half of the twentieth century is a critical component to understanding these phenomena. In his article, Ambassador Richard Benedick examines a host of population dynamics and their complex interlinkages with three representative environmental issue areas: forests, freshwater resources, and climate change. These connections raise the importance of meeting the commitments made at the 1994 Cairo International Conference on Population and Development. Benedick maintains that investments in measures to slow the rate of population growth-and thereby to reach a stable population earlier, and at lower levels, than under current trends-would significantly reinforce efforts to address the environmental challenges of the century ahead, and considerably lower the cost of such efforts.

Introduction: People and Their Environment

When historians in the far distant future look back upon the tumultuous twentieth century, they will likely judge the most outstanding feature to be the extraordinary increase in human numbers that has occurred during this relatively short time period. It took the entire history of humanity—tens of thousands of years—for the world's population to reach one billion, which is now estimated to have occurred around 1804. It was more than a century later that the second billion was reached. But, it took only twelve years—from 1987 to 1999—for the most recent billion, the sixth, to be added. The world has never seen anything like the steep population growth of the twentieth century, with most of it concentrated during the last fifty years.

That human populations can exert strains upon their natural surrounding is nothing new. However, from the dawn of history until about thirty years ago, the impacts of human activities were primarily localized. Early regional civilizations—Mesopotamia in the Near East, Mohenjo Daro in Southwest Asia, the Mayans of Central America, and possibly the Anasazi in the southwest of what is now the United States—collapsed due to a likely combination

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of overpopulation and scarcity or depletion of arable land and water supply. In some places, archaeologists have found evidence of adverse environmental effects caused by deforestation and by gradual salinization of irrigated land. The final blow may have been a regional climate change: a succession of unusual dry years, probably ascribed by local spiritual leaders to angry or capricious gods. Many centuries before the Aswan High Dam, Herodotus wrote of salinization in the Nile Delta. Much later, rapid industrialization in Europe and North America was accompanied by severe local pollution of air and water.

Environmental stress has thus been a continuing factor throughout human history. It is fair to say, however, that at the close of the twentieth century, the six billion inhabitants of planet Earth find themselves threatened by environmental dangers that would have been unimaginable to our 1.65 billion forefathers at the beginning of the century. The industrial, agricultural, and energy policies that produced enormous improvements in standards of living during the last half-century are now beginning to have profound environmental impacts that can adversely affect the interactive natural planetary cycles upon which all life depends. For the first time, we confront a new generation of environmental problems that are global in nature such as:

- *Changing climate* that could bring both drought and flooding, altered rainfall patterns and loss of agricultural land, sea-level rise, severe storms, and the spread of disease;
- *Depletion of the stratospheric ozone layer* that protects humans, plants, and animals from potentially fatal ultraviolet radiation;
- *Loss of biological diversity* due to mass extinctions of animal and plant species that represent an irreplaceable genetic library;
- *Spread of arid lands, desertification, and soil erosion* on a global scale, affecting the livelihood of hundreds of millions of already poor people;
- *Pollution of marine and freshwaters* that combine with overfishing to imperil a vital food source;
- *Destruction of forests* at a rate never experienced in the history of the planet; and,
- *Worldwide diffusion of hazardous substances*, including the persistent organic pollutants that may, even in minute quantities and over long time periods, adversely affect the metabolism of humans and animals.

These new environmental issues are not the premonitions of modern Cassandras. They are to a significant extent already upon us, measured and tracked by scientists. And, these environmental issues come in an era when human numbers are moving rapidly upward into uncharted territory.

All of these global environmental trends are, in some ways, touched by demographic dynamics: population size, population growth rates, population densities, and migration of peoples. Some environmental problems are influenced more directly by population, some less—even acknowledging that there are such mediating factors as income levels, consumption patterns, technological structure, and economic and political institutions. Because of these intervening parameters, it is often difficult to establish with scientific precision clear correlations between population pressures and environmental degradation. Nevertheless, it is hard to disagree with the conclusion of a recent study that "the *least* likely theory is that there are no relationships at all."[1]

Many scientists are beginning to express concern about the extent of the planet's capacity, as reflected in the functioning of its natural cycles and ecosystems, to support the unprecedented numbers of people and their growing demands.[2] Can enough food and energy be provided—not to mention jobs, education, health care, and waste disposal—to accommodate these billions without causing some irreversible ecological collapse that could imperil the whole human experiment?

As one example, the fragile layer of ozone molecules scattered throughout the stratosphere is vital to the survival of life on Earth. The example of Antarctica offers us a sobering lesson: the sudden and totally unexpected depletion of the stratospheric ozone layer over the southern continent (the so-called "ozone hole") demonstrates that when the atmosphere is perturbed, nature may not provide convenient early warning signals to moderate our activities in time. About twenty-five years ago, the cumulating effects of man-made chlorofluorocarbons (CFCs)—an "ideal" chemical whose usefulness in thousands of products and processes made it almost synonymous with modern standards of living—began slowly to lift the quantity of chlorine in the atmosphere from its natural level of 0.6 parts per billion (ppb). Concentrations increased gradually, to 0.9, 1.4, then 1.9 ppb—yet the ozone layer remained unaffected. Only when chlorine concentrations passed the minute but unforeseen threshold of two parts per billion did the ozone layer over Antarctica suddenly collapse, to the surprise and alarm of the scientific community. Notwithstanding the successful global controls imposed by the 1987 Montreal Protocol and its subsequent revisions, the long atmospheric lifetime of CFCs means that it will take about seventy years for the ozone layer world-

wide to recover to natural levels.[3]

By their very nature, the risks of other environmental thresholds are not quantifiable. But they are not zero.

In this article, I would like to explore population-environment interlinkages in three representative areas: forests, freshwater, and climate change. Following this, I will examine the most recent comprehensive effort by the international community to address population issues, as manifested in the twenty-year Cairo Programme of Action negotiated at the 1994 International Conference on Population and Development (ICPD). But before this, I will look more closely in the following section at some dimensions of the population nexus.

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The Population Century

Some time during October 1999, the world's population passed six billion souls. Since the middle of the century, when there had been 2.5 billion people, the number of human beings on planet Earth had grown by an additional 3.5 billion. Within the previous two decades alone, the increase was equivalent to the entire population of the world at the beginning of the twentieth century. Never in human history have populations grown so rapidly and in such dimensions.[4] To be sure, the annual growth rate peaked at two percent in 1965-70, and the annual increments reached a height of nearly ninety million in 1985-90. Global population growth is currently estimated at 1.3 percent, representing an annual addition of just under eighty million.

Using sophisticated demographic tools and assumptions about the continuing rate of fertility decline, the United Nations currently estimates that in fifty more years, by 2050, the world's population will probably lie within a range of 7.3 billion (low variant) to 10.7 billion (high variant), with the 8.9 billion medium variant considered as "most likely." The difference between the low and high variants depends largely on the degree to which families in developing countries freely decide to reduce their number of pregnancies.

Looking only thirty years into the future, the ranges are closer, and the estimates more accurate, because tomorrow's parents have already been born. The low variant is 7.4 billion, the high variant 8.8 billion. (Note that under the low variant assumptions, population is peaking and will begin a slow decline to eventual stabilization around seven billion.) The most likely global population in 2030 is 8.1 billion—over two billion more people than at present.

There are three aspects of these demographic developments that I would like to highlight because of their relevance to the environment. First, population growth has been, and will continue to be, strongly skewed. Over ninety percent of the population increase during the last half-century occurred in the poorer regions of the world. The pace accelerated to ninety-seven percent in the 1990s, and for the coming fifty years, it will be virtually 100 percent. Just the *additions* to India's population in the last five years—eighty million people—was equivalent to the total population of Germany.

This phenomenon has brought about a significant redistribution of the Earth's population. Between 1950 and 2000, the populations in developing regions grew by well over three billion (which was equivalent to *total* world population in 1960). Whereas in 1950, the industrialized countries accounted for about one-third of the total, their proportion dropped below twenty percent by century's end. According to the most likely U.N. estimate, by 2050 the developing nations will comprise eighty percent of the global population. Most of these countries already face problems of health and deteriorating environments, with large numbers living in ecologically fragile areas (e.g., drylands, hillsides, savannas, low-lying deltas), and now confronting combined environmental impacts brought about by both poverty and by the early stages of industrialization.

Within the developing world itself there are also significant differences in growth patterns. While Asia's growth rates are slowing, it was and will remain the largest region in total numbers, with about sixty percent of the global population. The fastest growing—and poorest—region is Africa, with its proportion projected to grow from less than nine percent in 1950 to nearly 20 percent of the much larger world total in 2050. In 1950, there were fewer than half as many Africans as Europeans; now, despite the AIDS epidemic, there are nearly three times as many. Most industrialized countries currently have stable, or even declining populations, the main exceptions being the United States and Canada

due to immigration and higher growth rates.

A surprising note on aging: while there has been much written about the increase in numbers of older people in the industrialized world, looking ahead, the prospect is quite different. Currently, the over-sixty population in the South amounts to about 170 million, or only forty-three percent of this age category worldwide. However, during the next fifty years, the number is projected to surge more than nine-fold, to 1.6 billion, which will then comprise eighty percent of the world's total elderly population. For industrialized countries, the expected growth is from 226 million in 2000 to 376 million in 2050.

A second outstanding demographic development of our era is the accelerated concentration of populations in urban areas. In 1950, just over one third of the world's population were city dwellers, a total of 860 million. By the close of the century, this number had grown to just under three billion, forty-eight percent of total population. But in just the coming *fifteen* years, it is expected that four billion people will live in cities, or fifty-five percent of the global population.

Again, most of this growth in urbanization will occur in the South, with masses fleeing rural poverty brought about by scarcity of arable land and water, growing land degradation, and aridity. By 2015, nearly three billion city dwellers in the poorer countries will constitute three-fourths of the world's urban population. Perhaps the most striking aspect of the urbanization trend is the rise of "megacities," agglomerations of over ten million people—a phenomenon new to the planet. In 1950, there was only one megacity, New York City. By 2015, it is anticipated that there will be twenty-six, of which twenty-two will be in the South. It is difficult to conceive of Lagos holding nearly twenty-five million inhabitants, or Dhaka with over nineteen million.

Such urban concentrations have significant environmental implications. In many cases, cities will encroach on farmland or ecologically sensitive wetlands or watersheds. Increased overcrowding will bring greater health problems and higher vulnerability to epidemics and natural disasters such as earthquakes, volcanic eruptions, storms, and flooding. Issues of waste disposal—air and water pollution and solid wastes—will assume gigantic proportions. It is also worth mentioning that city dwellers consume more energy and natural resources per capita than their country cousins.

The third and final dimension of the population picture is the phenomenon of *demographic momentum*. In developing nations, an unusually large proportion of the population is under fifteen years of age—in dozens of countries they exceed forty percent of the total. This means that even if future families have fewer children, there is a continuing growth factor because the number of people that are entering into their reproductive years (new parents) is greater than the number that are leaving those years. Thus, populations continue to grow significantly for many decades even after fertility rates begin to decline. Hence, there is a built-in growth momentum.

> "The industrial, agricultural, and energy policies that produced enormous improvements in standards of living during the last half-century are now beginning to have profound environmental impacts that can adversely affect the interactive natural planetary cycles upon which all life depends."

The current total fertility rate (TFR, or average number of children per female) in most of Africa and the Middle East is well over five, which, combined with high proportions of young people, explains the continuing rapid population growth projected for these areas. In contrast, some developing countries with slow growth now have reached TFRs of under three (e.g., Mexico, Brazil, and Indonesia), or even less than two (e.g., China, Thailand). However, as long as TFR exceeds 2.1 (representing one female child per woman, with allowance for some deaths before the female children themselves, reach reproductive age), a nation's population will continue to grow.[5]

Because of the factor of demographic momentum, *for most developing countries, the greatest increase in numbers actually lies ahead, not in the past.* The following figures are based on the current U.N. medium variant ("most likely") estimates published in 1999. Only if the fertility decline is steeper than is considered most prob-

able based on recent experience, or if mortality rates and/or emigration are higher than expected, will the numbers for 2050 turn out to be below the current medium variant estimate.

With the exceptions of China, India, and Indonesia (which are shown here because of their size), in all of these countries and in many more, the greatest growth in numbers will probably occur in the coming fifty years. This is so, despite the fact that they have all witnessed a doubling, tripling, or even quadrupling of their numbers within the previous fifty years. By 2050, the number of Afghans (and Sudanese, and Yemenis) will each exceed the number of Frenchmen; there will be more Tanzanians than Germans.

In other words, the largest increases are still to come. Most of these countries are already in political and/or ecologically precarious situations. Yet political leaders, North and South, do not act as if they are aware of what lies ahead demographically. Against this background, I will now examine three specific environmental issues in terms of their relationship to population dynamics.

Dwindling Forests in the Developing World

The forests of our planet have been basic to the development of human civilization. They are a resource that is unique in its combination of multifaceted utility and easy renewability, through planting. Wood products are a major element in the global economy, fundamental for human settlements in housing, furnishings, fuel, paper and packaging, and for such non-wood products as berries, nuts, and medicinal herbs. For example, nine of the ten most-prescribed pharmaceuticals in the United States derive from forest plants and animals. Although wood has been replaced for many traditional uses by coal, oil, steel, and plastics, wood and wood products still rank third in value among the world's commodities, trailing only behind oil and natural gas.[6]

Complementing their direct economic benefits are the irreplaceable ecological functions of the world's forests. Forests are essential for biological diversity. Tropical forests alone shelter at least half of the world's known

Chart 1. Population Growth: Past, Present, and Projected Future

(population in millions)

	1950	2000	2050 (est.)
Trouble Spots			
Afghanistan	9	23	61
Angola	4	13	37
Dem. Rep. Congo	12	52	160
Iraq	5	20	55
Water scarce			
Ethiopia	18	63	169
Saudi Arabia	3	22	54
Sudan	9	29	59
Yemen	4	18	59
Tropical			
Colombia	13	42	72
Guatemala	3	11	27
Philippines	21	76	131
Tanzania	8	34	81
Giants			
China	555	1278	1478
India	368	1014	1529
Indonesia	80	212	312
Nigeria	31	112	244
Pakistan	40	156	345

Source: U.N. Population Division, 1999.

species.[7] Through the evapotranspiration cycle between soil, trees, and atmosphere, forests are a major determinant of local climate and their diminution could bring on drought. An estimated seventy-five to ninety-five percent of rainfall in the Congo River basin is recycled through forests.[8] Forests protect and enrich soils and watersheds, providing erosion control against landslides and flooding, enhancing water quality, and regulating the quantity of water. As a major sink for carbon dioxide, the world's forests help to offset anthropogenic emissions from burning fossil fuel, and thereby mitigate potential climate change. Not to be ignored are the recreational, esthetic, and spiritual aspects of forests.

More forests have been cleared since 1850 than in all of previous history, and the rates of destruction have been highest in recent decades. Although forest cover in the industrialized world is now expanding, this has been more than offset by destruction of forests in the developing nations. Asia and Africa, regions with the greatest population growth, have lost an estimated sixty-five to seventy percent of their original forest cover.[9]

Global wood consumption has tripled during the twentieth century—roughly paralleling growth in human numbers. But interestingly, forest loss is not a problem caused by profligate consumers in the North. Industrialized countries, largely with managed forests and reforestation programs, produce seventy-five percent of the total industrial hardwood, while tropical forests account for only fifteen percent. Thus, the North produces eighty percent of the world's wood used for paper and pulp. In contrast, developing countries produce ninety percent of wood used for household consumption as fuel and charcoal. In the ten developing nations that lost the most forest in the period 1990-1995, all but two consumed over ninety percent of their output domestically, including Brazil, Congo, Indonesia, Mexico, Sudan, and Thailand. Rising demand for wood, especially for fuel, in Bangladesh, China, India, Nepal, Pakistan, Sri Lanka, Thailand, and Vietnam, poses increasing dangers to the viability of their forests.[10]

Because of the complexities involved in human use of forests, it has been difficult to provide definitive proof of the link between population growth and forest destruction. Nevertheless, a recent study of 111 countries by an international research consortium concluded that approximately half of the deforestation over the course of human history could be explained by changes in population. The World Bank has noted that Central Africa, during the 1980s, experienced the world's second highest rate of deforestation while having the lowest per capita income and the highest population growth rate. Haiti, the most severely deforested nation in Central America, is also the poorest and most densely populated. In South Asia, the U.N. Food and Agriculture Organization warned that conservation efforts "will be nullified and in places reversed, unless...accompanied by a reduction in the rate of growth of population."[11]

Many analysts are convinced that the greatest future threat to forests stems from the imperative to provide food for the immense numbers of people on the horizon. Judging from the recent half-century, there will be pressures to clear more forests to provide land for crops and/or livestock. When dams are constructed to furnish needed water for irrigation, forests are often flooded and farmers are displaced to highlands, where the destruction cycle continues in order to make room for agricultural land. Forests have also fallen victim to government resettlement programs in response to local population pressures (e.g., in Indonesia, Brazil, and the Philippines). Poverty and inequitable land tenure force landless workers to seek a livelihood by clearing forest lands.

It has been estimated that by 1995, 1.7 billion people in forty countries already were, because of inadequate forest cover, vulnerable to shortages of fuel wood and to growing impacts of flooding and erosion. In just thirty years, by 2025, this number is projected to rise to 4.6 billion people in fifty-three countries. In many areas, including Egypt, Kenya, and Pakistan, it is anticipated that severe forest loss will combine with increased water scarcity over this period to compound the threats to the well-being of hundreds of millions of people.[12]

Growing Water Scarcity

Water gives an illusion of abundance since it covers about two thirds of our planet's surface. The reality, however, is that only 2.5 percent consists of the freshwater needed by human beings. Of this fraction, sixty-nine percent is locked into permanent snow cover or glaciers. A further thirty percent consists of fresh groundwater, much of which is inaccessible, unusable, or only obtained at great expense of energy. Only three-tenths of one percent of total freshwater can truly be considered as renewable: the water from rainfall, seeping into the soils to nourish plant and tree growth and replenish underground aquifers, collecting in rivers and lakes, flowing into the oceans, and evaporating into the atmosphere in a natural hydrological cycle that will produce more rain.[13]

Humanity uses freshwater for drinking and hygiene, for carrying away wastes (e.g., from urban areas), for industrial purposes, but most of all—more than two-

thirds—for irrigating land to satisfy the world's growing demand for food. In the past half-century, there has been a virtual explosion of large-scale irrigation projects, mostly concentrated in the developing world. The number of large dams (defined as over fifteen meters in height) grew from 5,000 in 1950 to approximately 40,000 today.[14] Most of the expansion in irrigation has been concentrated in Asia. China, India, Indonesia, and Pakistan, for example, depend on irrigated land for more than half of their domestic food harvest.[15]

Current trends in water usage are disturbing. Growth in irrigated land in recent decades has not kept pace with population growth. The watersheds of some of the largest Asian rivers—the Indus, Ganges, Yangtze, and Yellow rivers—have been damaged by deforestation.[16] Many of the world's major rivers—including, in addition to the above-mentioned, the Nile, Colorado, Chao Phraya (Thailand), and Amu Darya (Central Asia), are overused to such a degree that little or none of their flow ever reaches the sea. Indeed the Yellow River has run dry in every year throughout the 1990s.[17]

Worldwide, cropland is being lost to cities, industry, erosion, flooding, and to salinization—the slowly cumulating curse that accompanies big irrigation schemes, described as "one of the gravest threats to irrigated agriculture and food security."[18] Increasing reliance on nonrenewable groundwater is resulting in falling water tables being recorded on every continent, including in the United States. It is estimated that India's water withdrawals are already twice the rate of natural groundwater recharging—and a half-billion more Indians are on the way.[19]

Poor quality drinking water affects the health of hundreds of millions of people in the developing world and is a major factor in infant and child mortality. The number of people without access to safe drinking water has risen by the end of the twentieth century to over 1.2 billion, roughly one person in four in the poorer countries.[20] The growth in the developing world of large cities with over one million inhabitants—from thirty-four in 1950 to an estimated 400 by 2015—imposes added strains on water supplies and leads to rainwater being flushed away rather than recharging underground aquifers by natural seepage through the soil.

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Beyond the strictly utilitarian demands on freshwater, scientists and environmentalists make a strong case for a holistic concept of freshwater as part of a network of interconnected ecological systems. Although economists cannot assign a market price, freshwater ecosystems perform numerous vital functions: carrying nutrients into the sea that sustain marine life; providing habitats and spawning grounds for a diversity of animal and plant species; replenishing soil fertility; and diluting wastes. And, as with forests, the waters possess aesthetic and inspirational qualities that have enriched the human experience.

A symbol of the conflict between preserving an ecosystem and conventional economic development is the Okavango Delta in Botswana, the largest in the world. The Okavango nourishes Africa's biggest oasis, a watering ground for millions of animals fleeing the Kalahari Valley during the dry season. About 100,000 local fishers and herders also derive their livelihood from the Okavango. Development planners, advising neighboring Namibia, proposed a system of dams and dredging to divert the river for multiple purposes, including irrigation, a rapidly growing metropolis, and diamond mine operations. A consortium of conservationists and local villagers was able to block the project and ecotourism has been promoted as an alternative revenue source. But the demands, here and elsewhere, will inevitably grow.[21]

Looking into the coming century, it should be possible to meet the growing water needs for personal use, for municipalities, and for industries, assuming there is more intensive conservation measures, more realistic water pricing, and some luck with technological innovation. However, there will be growing competition with the needs of agriculture, which could lead to loss of food production.

The population-food-land equation is compounded by humans seeking ever greater supplies of water—under the U.N.'s most likely variant, two billion additional people in the next thirty years. Because of the sheer volume of water required for irrigation, population growth is the critical factor, translated into demand for food, which in turn implies more irrigated land. It is clear that the risks are growing that more people will face the prospect of water scarcity and, therefore, food scarcity. As a leading water resource scholar recently observed:

"Water scarcity is now the single biggest threat to food production."[22]

The poor are particularly vulnerable. Researchers have noted that approximately 470 million people in the developing world were affected by water stress or scarcity in 1995. They estimate that this number could rise more than six-fold in only thirty years, to over three billion by 2025—nearly forty percent of the world's population.[23] People in affected countries would be subject to chronic shortages as not enough water would be available to satisfy all the needs of cities, industries, and irrigated agriculture.

With water scarcity affecting harvests, poor countries will need to import increased quantities of grain. Egypt, for example, which used to be self-sufficient, now depends on imports for forty percent of its grain consumption. If the situation worsens, economic development will be set back and serious environmental degradation may occur. The combination of hunger, rising prices for imported grain, and large urban populations has the potential to destabilize societies in many parts of the world.

As recently as twenty to thirty years ago, shortages of water were only occasional, scattered occurrences. Now, the problem is becoming pervasive. Water scarcity on such a large scale, affecting hundreds of millions of people, is a uniquely modern phenomenon. Security concerns mount as nations compete for increasingly scarce water to meet the needs of their people. Many of the great river systems provide water to countries with rapidly rising populations, and in most cases the greatest numbers are, as we have seen above (*see Chart 1*), still to come, such as with the Tigris-Euphrates River (Turkey, Syria, and Iraq); the Ganges River (India and Bangladesh); and the Nile River (Sudan, Ethiopia, and Egypt). In 1985, Boutros Boutros-Ghali, at that time, Foreign Minister of Egypt, warned that "the next war in our region will be over the waters of the Nile, not politics."[24]

Many agricultural specialists believe that the future of the Green Revolution will depend on irrigation, since only an assured water supply will justify farmers' large investments in seeds, fertilizers, pesticides, and technologies to increase land productivity. But, how will this happen? Most potential major dam sites have already been exploited, at great social and economic cost. In any event, the long-term viability of such massive projects is questionable. Rising costs (including compensation for displaced persons), greater awareness of ecological consequences, siltation, and waterlogging and salinity are diminishing the returns from mammoth irrigation schemes.[25]

The future will need to see different and more efficient management of the planet's scarce freshwater resources, combined with greater sensitivity to the interconnected ecological systems—water, land, and forests—that provide the context for our civilization and well-being. The productivity of irrigation water could be enhanced by greater conservation and by various technical improvements. Measures could include drip irrigation and high efficiency sprinklers; rational pricing and water allocation planning; crop selectivity and better cultivation practices; more accurate weather forecasting linked to water distribution; and recycling of urban water for irrigation use. If not discouraged by political or emotional considerations, further advances in biogenetics could create food crop varieties that are resistant to drought, salts, and pests. Desalinization of seawater might provide unlimited supplies if problems of cost, energy, and transport can be solved.

If population growth could be slowed to the low variant path of the UN estimates, with only one billion additional people, the task of marshalling water resources to meet rising demands while preserving the planet's associated ecosystems would be considerably more manageable. But clouding the future of water supply is the wild card of climate change, which itself will be influenced by population. Potential climate change can greatly complicate issues of planning, timing, and location of long-term investments in water management.

Global Climate Change

Sophisticated models based on paleological evidence, and on theories of physical, chemical, and biological interactions, predict that continued unchecked emissions of greenhouse gases from anthropogenic sources (chiefly carbon dioxide from fossil fuel combustion and destruction of forests, but also methane and other gases) could precipitate a global change in the climate that has accompanied the history of human habitation. In actuality, concentrations of carbon dioxide in the atmosphere have increased by about a third since the start of the Industrial Revolution, and (like population numbers) they are moving up into uncharted territory. There is scientific consensus that this growth cannot continue indefinitely without throwing the Earth's climate out of the equilibrium that has prevailed for millennia – notably, since the dawn of agriculture.[26]

Great uncertainties, however, surround the issue of climate change. Since there is no prior experience with this phenomenon, the prospective consequences are largely conjectural. There is no indication as to what

level of concentration of greenhouse gases in the atmosphere could prove dangerous, nor how severe or differentiated the possible impacts might be in different regions of the planet. For example, intensified hurricanes and storms are expected, and rainfall and monsoon patterns would almost surely shift. In some regions there could be more rainfall, in others less. Presently unproductive areas (e.g., Siberia) might become more suitable for agriculture. Elsewhere, there could be flooding, erosion, drought, and the spread of arid lands. Rivers might change their courses. More carbon dioxide could prove conducive to higher crop yields and the expansion of agriculture. On the other hand, there might be an increase in weeds, disease, and pests. Higher sea levels and resultant salinization of coastal farmlands and ecosystems are among the most probable consequences. For all of these possible impacts, however, the extent and timing are unclear.

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The continuing growth in anthropogenic greenhouse gas emissions might be mitigated to some degree, although not indefinitely, by offsetting natural forces such as greater carbon absorption in the oceans or increasing cloud cover. But because the gases have such long atmospheric lifetimes, any major change in the great planetary forces that determine long-term climate—stratospheric windstreams, ocean currents, polar ice cover, or the hydrological cycle—could have portentous and potentially irreversible results. Crossing an invisible and unpredictable threshold would be dangerous.

The links between population and climate change are subtle. Historically, most carbon dioxide emissions stem from the great economic expansion of the industrialized nations of the North, fueled largely by energy from coal and oil during the last century. These nations have relatively small populations and, at present, virtually no population growth. But, they also have very high per capita emissions. However, climate change is decidedly not—as an Indian diplomat once remarked to me in the context of the ozone negotiations— "rich man's problem: rich man's solution."

Demographic trends in the developing world can affect greenhouse gas emissions in several ways. More energy will be consumed by large and growing populations to enhance their standard of living. Even now, two billion people in the South are yet to be supplied with electricity, quite apart from the greater numbers that lie ahead. Unprecedented urbanization, combined with an aging population (more households) will further contribute to higher per capita energy consumption. Intensive industrialization in the currently less developed nations will also add to total energy demand. Carbon dioxide emissions will rise as additional land is cleared for agriculture and fuelwood, and more methane will be released from rice paddies and other forms of agricultural production, as well as from expanding livestock herds.

It is true that per capita emissions of carbon dioxide from fossil fuel combustion in the currently less developed nations average only about one-fifth that of the North. However, emissions of total greenhouse gases from the South are augmented by the massive clearing of forests and savannas to acquire ever more firewood and land for crops and settlements, a factor as yet difficult to measure but nevertheless significant. Some estimates place them at about one-fourth of all anthropogenic emissions.[27] Moreover, developing countries' understandable priority for economic growth, means that their future per capita emissions will increase *even as their population growth begins to taper off.*[28]

In fact, developing nations' emissions are already rapidly overtaking those of the North. Even considering only carbon dioxide emissions from fossil fuel combustion (and ignoring those from deforestation and biomass burning), the South's portion of the global total has jumped in only twelve years from twenty-nine percent in 1985 to forty-two percent in 1997. China's emissions are already second only to the United States, and the ground under 1.3 billion Chinese contains one third of the world's known coal reserves. India's emissions have surged nearly fifty percent since 1990 and are now higher than Germany's. South Korea has surpassed Italy, and Mexico's emissions are almost as large as those of France.[29] Propelled by rapid population growth and expanding industrialization, the South's emissions will probably exceed those of the North in two to three decades.

Unfortunately, efforts under the United Nations to curb rising worldwide emissions of greenhouse gases have met with little success to date. Beginning at Chantilly,

Virginia, in early 1991, 180 nations have been negotiating in vain to establish a realistic approach to the problem of climate change. The U.N. Framework Convention on Climate Change was signed in June 1992 at the U.N. Conference on Environment and Development in Rio de Janeiro and entered into force two-and-a-half years later. This was followed by the Kyoto Protocol, agreed upon in Japan in December 1997. The protocol, however, has thus far, only been ratified by nineteen small developing countries and none of the major emitting countries. Its prospects for entering into force are questionable given continuing deep differences among the negotiating parties on the modalities for achieving emissions reductions.[30]

During the negotiations for both of these treaties, population was an unwelcome guest. There was no overt discussion of the linkages. Because of the inability of industrialized countries to undertake effective steps to cut emissions, key developing nations have refused to even consider commitments to rein in their own rapidly rising emissions. Unfortunately, the populations of the South, most already living in ecologically fragile areas, are also the most vulnerable to possible impacts of climate change, especially altered monsoon patterns, flooding, drought, aridity, sea-level rise, and severe storms.

Climate change and population growth share the characteristic of being long-term in their effects. Halting population growth will not by itself prevent climate change. Especially in the near term, a slower rise in population will barely affect total emissions, which will be largely influenced by the nature of industrialization, energy use, and consumption patterns in the South. Still less, will it affect the level of atmospheric carbon dioxide concentrations during the coming century, as it is mainly a product of previous emissions of the long-lived gases?

However, in the longer term, the effects of slowing population growth—and of an earlier stabilization of global population—would cumulate and significantly improve the chances of mitigating climate change. The further into the future one looks, the greater the difference between smaller (low variant) and larger (high variant) population sizes could make in the ability of growing economies to achieve the substantial future cutbacks in carbon dioxide emissions that are necessary in order to avoid dangerous levels of atmospheric concentrations. Slower population growth would also relieve pressures on fragile ecosystems—freshwater, forests, highlands, watersheds, and arid regions—and thus, improve the chances for adaptation to long-term climate changes.[31]

Containing Population Growth: The Cairo Solution

H.L. Mencken, the satirical American social commentator of the 1930s, has been quoted as stating that for every difficult problem, there is a simple solution—and it is usually wrong. The phenomenon of population growth, as we have witnessed it in the twentieth century, is surely one of the most difficult and complex of problems.

Birth rates in most countries of the South have begun to decline during the past decade. But, in the face of the United Nations' medium variant projection for 2050, the "most likely" outcome, are they declining rapidly enough? Is nearly nine billion people in the next fifty years—and still rising, possibly to eleven or twelve billion desirable? Is it inevitable?

Can we lower birth rates sufficiently to achieve the 7.3 billion low variant—which, incidentally, would imply a future stabilization of global population at somewhat below this level, just a billion or so more than at present? Is "development the best contraceptive," as propagandists for the South trumpeted for many years as an argument for more, and ever more, foreign aid? Will the free market and less government interference provide the solution? Is "democratization" the key? Is it simply a matter of inundating the South with condoms and contraceptive pills? As the experience of population programs over the last thirty years has demonstrated, there are no simple answers. We will have to do many things simultaneously.

At Rio de Janeiro in 1992, the U.N. Conference on Environment and Development, the largest world summit in history, culminated over two years of negotiations on an agenda for the future. Among the many important documents, resolutions, declarations, and aspirations at this monumental conference, one historic feature stands out. The leaders of nearly all the world's nations established for the first time the political legitimacy of the concept, *sustainable development*: to conserve and manage the planet's resources in a manner that can improve the conditions of today's populations without foreclosing options for the well-being of the generations still to come.

A logical follow-up to the rather profound and many-faceted implications of the Rio conference was the convening in Cairo, two years later, of the 1994 International Conference on Population and Development (ICPD). Again, following two years of preparatory negotiations, the world's governments at Cairo affirmed that early stabilization of the Earth's human population would be crucial for attaining sustainable development.

In particular, they agreed on a "Cairo Programme of Action."[32]

This carefully negotiated document, a twenty-year program to the year 2015, was both more specific and more practical than the voluminous 800-page "Agenda 21" that was adopted at Rio to encourage long-term actions to promote sustainable development. Under the Cairo Programme, governments accepted specific quantitative and qualitative twenty-year targets which, if achieved, might enable the world to achieve population stabilization at just over seven billion, rather than facing in mid-century a still-growing population of nine billion or even eleven billion.

> "[T]he populations of the South, most already living in ecologically fragile areas, are also the most vulnerable to possible impacts of climate change, especially altered monsoon patterns, flooding, drought, aridity, sea-level rise, and severe storms.

The ICPD deliberations were influenced by three decades of international experience that clearly demonstrated that family planning programs could succeed in countries widely differing in their cultures, political and economic systems, and levels of development—from Cuba to Tunisia, from Iran to Vietnam, and from Sri Lanka to Brazil. The key to significant lowering of birth rates was the presence of certain enabling conditions: when girls and women enjoyed decent health care and access to family planning methods and advice; when most girls received at least a primary education; when women had better economic opportunities and social status; when infant mortality was low; when adolescent child-bearing declined; when marriage was delayed to a later age; and, when births were spaced more widely. Each of these factors reinforces the others, in a cumulative effect. Perhaps most important, experience worldwide showed that most women, if given the choice and the means, would have fewer children than their mothers did.

For over twenty years, since the first world conference on population in 1974 in Bucharest, governments had largely paid lip service (and then only after strenuous negotiations) to the concept that all couples and individuals have a basic right to decide freely and responsibly the number, spacing, and timing of their children—and to have the information, education, and means to do so. But, despite two decades of noble rhetoric, the realities were different as the century drew to a close. About one third of women of reproductive age in developing nations—approximately 350 million—have no access to family planning information and services. Existing health programs were strained to meet the needs of the increasing numbers of women entering their reproductive years. There are approximately one billion adolescents—more than ever before in history—who, largely because of religious and cultural mores, are hypocritically kept uneducated about these subjects, even though most are sexually active. Thus, they are particularly susceptible to sexually transmitted diseases and unwanted early pregnancies, which are inimical to the health of both the young mothers and their infants. And, finally, in most countries social equity for women remains a cruel fiction, and they are still denied equal access to education, health care, and job opportunities.

Against this background, high-level representatives of 179 governments at Cairo, under the sensitive leadership of the conference secretary general Dr. Nafis Sadik, Executive Director of the United Nations Population Fund, agreed on several quantitative targets to be achieved in the ensuing two decades.[33] These targets included:

- universal access by 2015 to the full range of "reproductive health" services, covering family planning, maternal health, and prevention and treatment of sexually transmitted diseases, including HIV/AIDS;
- universal primary education by 2015 for all girls and boys;
- specified, significant reductions by 2015 in mortality rates for infants, children, and mothers; and,
- financial targets.

In addition, the Cairo Programme of Action iterated qualitative goals, or aspirations, which were just as carefully negotiated as the quantitative targets. These included: increased access by young women to higher education (beyond primary school); greater attention to adolescents' reproductive health needs; the elimination

of violence against women; broad-based measures to ensure gender equity and equality; and the empowerment of women in the job market and in the development process.

The ICPD did not adopt or recommend demographic targets, such as specific reductions in birth rates or family size, since experience in some countries, notably India and China, had shown that such targets could lead to human rights abuses by overzealous administrators. Instead, a consistent theme throughout the Cairo Programme of Action was the emphasis on personal choice and on the quality of reproductive health and family planning services.

Underlying the ICPD approach is the assumption that creating suitable conditions will lead women—and their menfolk—to make the "right" choices in terms of birth spacing and family size. As discussed above, experience has showed that birth rates can indeed decline under certain circumstances. What remains an open question after Cairo, however, is whether they can fall fast enough and far enough to make a difference, or whether the total fertility rate might stall at three or even 2.5 children per woman. Were this to occur at anything above a TFR of 2.1 (the "replacement level of fertility"), population numbers would continue to climb to new heights, albeit more slowly.

Unfortunately, follow-up negotiations during 1999, to evaluate progress under the program, revealed backsliding by some governments and sadly familiar controversies over issues of cultural and religious sensitivity, ranging from acknowledgment of adolescent sexuality and ensuring safe abortion (where legal) to the status and rights of women in general. Five years after Cairo, the trends were not encouraging: continued discrimination and violence against girls and women; hundreds of millions of couples still lacking access to family planning services; HIV/AIDS spreading more rapidly than anticipated; tens of thousands of women still dying due to unsafe abortions; and, only limited progress in reducing infant, child, and maternal mortality.[34]

Equally discouraging was the failure of governments to come up with the financial resources that had been estimated at Cairo as essential to implement the program. The ICPD, after hard negotiation, had calculated that a total of $17.5 billion would be required by the year 2000, and $21.7 billion by 2015, to achieve the quantitative targets enumerated above. It was agreed that two-thirds of these amounts would be raised by the developing countries themselves, while the donor community would furnish the remaining one-third.

The latest available data, however, revealed that the foreign donors, in particular, were far behind the needed pace. In 1997, only $1.7 billion had been raised, making it highly unlikely that the donors would reach their $5.7 billion target for 2000.[35] With the exception of a handful of nations (Denmark, Finland, Netherlands, Norway, and Sweden), aid-malaise appears to have taken its toll on the health, education, and women's programs recommended by the ICPD. To place the sums in perspective, the $17.5 billion global target for 2000 amounts to less than one week of the world's expenditures on armaments.[36]

Conclusion: Uncertainties Ahead

It is clear that in the course of the new century, the human population will move into a zone—eight to twelve billion—which many analysts predict could exceed the Earth's supportive capacity.[37] The difference between the 7.3 billion United Nations low variant and the 10.7 billion high variant for 2050 is equivalent to the *total* population of the world as recently as 1966. That is quite a difference.

There is no question that improving standards of living for the current poor of the world, plus providing for the billions still to come, will increase global demand for food, water, energy, wood, housing, sanitation, and disposal of wastes. Even if the interrelationships between population and the ecological support systems of the planet are not yet established with statistical certainty, it behooves us to act with prudence: to err on the side of caution in both our population and our environmental policies.

Investments in measures to slow the rate of population growth—and thereby to reach a stable population earlier, and at lower levels, than under current trends—would significantly reinforce efforts to address the environmental challenges of the century ahead, and considerably lower the cost of such efforts. We need to proceed on several fronts simultaneously, including:

- achieving the health, education, and gender equity goals of the ICPD Programme of Action;
- reducing wasteful life-styles and consumption;
- investing in technology to facilitate new energy forms and less resource-intensive industrial and agricultural production; and,
- adapting our political and economic institutions to the future, making them more responsive, more humane, and more focused on the long-term perspective rather than on tomorrow's stock market results or next year's elections.

Seven years ago, the officers of fifty-eight national academies of science met at a worldwide "Science Summit" in New Delhi. They issued a warning that is relevant to our current concerns. The scientific leaders

> "... expressed a sense of urgent concern about the expansion of the world's population and concluded that if current predictions of population growth prove accurate and patterns of human activity on the planet remain unchanged, science and technology may not be able to prevent irreversible degradation of the natural environment and continued poverty for much of the world. ...
>
> The academies believe that ultimate success in dealing with global social, economic, and environmental problems cannot be achieved without a stable world population. The goal should be to reach zero population growth within the lifetime of our children."[38]

The stable population goal of the national academies is equivalent to the U.N. low variant estimate for 2050, which is also the objective of the ICPD's Cairo Programme of Action. We are, clearly, not on that path. The interactions between human activities and the Earth's natural systems in the century ahead will determine the future of our species. It is not merely a technical problem of feeding the teeming billions. We must define our vision of the future: an Earth of humans and wheat (or edible seaweed) without the wilderness, without the great animals? Decisions made now will be critical. The central issue is the quality of life: how men and women of the future will be able to live, their options and their trade-offs. Will it be a life of dignity, security, and beauty?

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NOTES

[1] O'Neill *et.al.*, 1998, emphasis added.
[2] Cohen 1995, Watson, *et.al.* 1998.
[3] Benedick 1998.
[4] Demographic data throughout this article come from: United Nations Population Division 1999 and, for urban data, *ibid.*, 1998.
[5] United Nations 1999:70-72.
[6] Gardner-Outlaw and Engelman 1999:18-19.
[7] Ibid, 22.
[8] Ibid, 19.
[9] Ibid, 25-27.
[10] Ibid, 9,34-37.
[11] Ibid, 32-33,56.
[12] Ibid, 9,49-51.
[13] Shiklomanov 1993.
[14] Postel 1999:81.
[15] Ibid, 41.
[16] Gardner-Outlaw and Engelman 1999:21.
[17] Postel 1999:65-73.
[18] Ibid, 109.
[19] Ibid,73-80; United Nations 1999:28.
[20] Watson, *et.al.* 1998.
[21] Gardner-Outlaw and Engelman 1997; Postel 1997.
[22] Postel 1999:6.
[23] Ibid,128-132; Gardner-Outlaw and Engelman 1997.
[24] Gleick 1994.
[25] Postel 1999:60-64.
[26] Benedick 1997; 2000.
[27] Gardner-Outlaw and Engelman 1999:23.
[28] Meyerson 1998.
[29] CDIAC 1999.
[30] Benedick 2000.
[31] Meyerson 1998; Bongaarts *et.al.* 1997; O'Neill *et.al.* 1998.
[32] Ashford 1995; UNFPA 1999.
[33] UNFPA 1999.
[34] Ibid.
[35] Ibid.
[36] UNFPA 1997.
[37] Cohen 1995.
[38] National Academy of Sciences 1993.

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