State of the Environment and Its Implications to Resource Policy Development

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A quantum jump is necessary in our efforts toward a comprehensive understanding of the state of the environment, on both global and regional bases. Such an understanding is indispensable to rational environmental management because it enables us to comprehend the environment's resilience to man's action and the maximum potential it may offer for sustained development of mankind. Such an understanding will also enable us to predict better the interrelated effects of some of the major challenges facing the world today, such as those of population changes, economic development, availability of adequate food, energy, and raw materials, development of new technology, high inflation rates, and shortage of investment capital. All these factors have significant impact on the environment, some beneficial and some adverse, and the environment, in its turn, affects development in those areas.

PROBLEMS OF FORECASTING ENVIRONMENTAL TRENDS

The difficulties of forecasting environmental trends are many, and a perceptive and objective study of the present state of the environment is a difficult one in the best of circumstances. Objectivity is a relative term, and even the most rational and dispassionate analysis of the present state of the environment has to be based on certain ideas and assumptions. Any analysis of the relationship between man and his environment or the future of mankind can only be done by implicit or explicit assumptions of society's overall goals and the possibilities of attaining them. There are also problems of establishing parameters and making accurate descriptions of parameter interrelationships. Often much of the analysis may have to be based on incomplete or inaccurate data.

In addition, there are the problems of forecasting future political and technological developments and the difficulty, often near impossibility, of predicting the secondary and tertiary effects precipitated by these developments. For example, very few scientists predicted the effectiveness of the Arab boycott of oil, and even fewer foresaw its effects on the price and availability of fertilizers and the resulting food shortages in several developing countries. The process is further complicated by the fact that there is generally a time lag between an action and the development of secondary effects, and the side effects of a proposed action are seldom totally anticipated at the time action is taken. The combined effects of those secondary developments could even be worse than the original wrong the action was intended to correct. Thus, it is important to realize the necessity of long-term planning for environmental management, because during the present era of rapid social, economic, political, technological, and institutional changes, short-term forecasts are likely to be very deceptive and could even be diametrically opposite to the long-term development goals of mankind.

Man is part of nature, and the quality of life and the material level man can expect to enjoy depend on the resources nature has made available; the rate at which and the techniques by which they are exploited and used; the level, distribution, and growth rate of the population; and the nature of the demands man makes on resources. Man is clearly the central element in this complex equation, and his activities have made significant changes in some of its closely interrelated key parameters which have led to our present crises. His effect on the physical environment stems entirely from his economic and social behavior and the resulting impact on man himself, experienced in economic and social terms. His increasing awareness of physical constraints will become manifest in accelerating pressures on his political and social systems, the value and behavior patterns they reflect, and the institution through which he seeks to manage his affairs. Good management of the environment is, therefore, indispensable to the achievement of socioeconomic objectives and goals.

The problems we currently face are not simple extensions of old ones which can be resolved by further fine tuning of traditional responses. They are of a wholly new character and require not only better understanding and development of new attitudes and perceptions but also new kinds of management responses. The consequences of our collective actions within a nation, region, or global perspective can neither be anticipated nor controlled in terms of a single parameter, problem, interest, and discipline, or through the medium of any single institution. They can be understood and dealt with only in the whole system of cause and effect relationships within which they take place.

Even though the outlined problems are interdependent and global in nature, their magnitude and extent vary widely from region to region. Although one part of the globe may consider itself to be overpopulated, there are other parts which will claim to be vastly underpopulated. Thus, two of the most important factors to consider in any environmental management process are the diversity of circumstances and the vastly differing magnitude of problems to be found around the world. In

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addition, it is clear that the nation state is, and will continue to be, the central repository of power and responsibility for the action that must be taken to deal with these issues. International cooperation is necessary to establish the global frameworks required, but if the action taken by nations is to be effective, only the exercise of national sovereignty and acceptance of national responsibility can provide the basis for such action. Then the action will reflect the nation's relative priorities as well as the complex interaction of each society's own social, economic, cultural, political, institutional, and religious motivations and goals.

The major problems we are now facing are urgent and complex and, if appropriate action is not taken immediately, they are bound to proliferate, making conditions still worse. Since these problems are often multidimensional, no nation however powerful can cope with them individually and unilaterally. Many go far beyond the capacity of even small groups of the more powerful nations to solve. Action taken to combat these types of problems must be well planned and coordinated, otherwise steps taken to alleviate the problems in one part of the globe could create negative reverberations in another. The so-called "energy crisis," "food crisis," and "raw materials crisis" dramatize the finiteness of our earth, a sober reality that should be accommodated in our social, economic, political, and institutional problems.

RECENT DEVELOPMENTS

Faced with these types of serious problems, a series of major world gatherings has been held or will be held under the auspices of the United Nations. Among these are the Conference on the Human Environment at Stockholm, Special Session of the General Assembly on Raw Materials and Development, Law of the Sea Conference at Caracas, World Population Conference at Bucharest, World Food Conference in Rome, the Special Session of the General Assembly on Development and International Cooperation, Conference/Exposition on Human Settlements (Vancouver, 1976), World Water Conference (Buenos Aires, 1977), and World Desertification Conference (1977). All of these conferences deal with particular aspects of the complex issues affecting the human environment and the quality of life.

The Special Session of the General Assembly on Raw Materials and Development recommended the development of a new international economic order, with better distribution of resources all around the globe. The Caracas conference was a collective approach to bring a new ocean settlement to no less than 70% of the earth's surface under a new rule of law. Effective international cooperation for the care and management of the oceans and their inert and living resources is not only desirable but also essential for world peace and order. There is an urgent need for universal acceptance of the concept that resources beyond national boundaries are the common heritage of all people. Equally important is a universal commitment to cooperation in assuring that the resources of the global "commons" are in fact used and cared for in the interests of all mankind.

There was general agreement at Bucharest that the population growth cannot continue at the present rate forever in a finite world. There was considerable debate and disagreement, however, on (a) the number of people that can be sustained at a minimum standard of living on a long-term basis; (b) the process or processes by which such growth will eventually decline and cease; (c) the time horizon within which this change is to occur; and (d) the need for efforts directed specifically toward population growth in contrast with general economic and social development (Biswas and Biswas 1975a).

The World Food Conference at Rome discussed the urgent necessity of increasing the food production of developing countries from a recorded 2.6% rate over the last 20 years to at least 3.6% over the next 12 years. If this minimum increase is not made possible, the developing countries might well face annual deficits of 85 million tons in normal years and over 100 million tons in bad years. Strategies to increase food production were discussed, as well as the development of a fertilizer pool and availability of adequate buffer stocks in lean years (Biswas and Biswas 1975b).

POPULATION AND ENVIRONMENT

If we start with only two dozen individuals 100,000 years ago and assume an average increase of slightly less than 0.02% per year, we can easily account for the present population. The present rate of population growth is nearly 100 times the above rate (nearly 2%), and the highest rates of growth have been continually sustained in the modern period. The rate of growth between 1950 and 1970 was more than twice that experienced during the first half of the 20th century (Biswas and Biswas 1974).

The world population has now reached nearly 3.8 billion people. Barring an unforeseen catastrophic disaster, we are destined to reach at least 6.5 billion by the end of this century, with more to come (UNESCO Courier 1974).

The population issue should be viewed not only in its global perspective but also in terms of regional concentration. Although some parts of the globe are underpopulated, other parts are overpopulated in relation to the present levels of available resources and development. In a world, much of which lives in the "Poverty Belt" of Asia, Africa, and Latin America, increasing population has aggravated the lack of some of the basic necessities and amenities of life, which was already serious to begin with. There is an inadequate food supply (in terms of both calories and protein), poor housing conditions, lack of potable water supply and basic sanitary facilities, nonavailability of medical and health services, chaotic transportation facilities, and very little per capita availability of energy, raw materials, and other basic amenities. Illiteracy, unemployment, malnutrition, and abject poverty are what seem to be abundant. Records of recent decades indicate that the gap between the rich and the poor nations of the world has continued to grow, an unhealthy feature from the environmental viewpoint because poverty degenerates the quality of life and may be considered to be a major source of environmental pollution.

Environmental problems of this order are being aggravated by the present large-scale transition from rural to urban societies. During the 1950's, the urban population of the world was estimated to be growing at 3.4% per annum, but in developing countries the rate was 4.7% (UN Economic and Social Council 1973). Urban regions are now growing at close to twice the rate of overall population growth. By the year 2000, more than half the world population will be living in urban regions rather than rural areas for the first time in history (Carrillo-Flores 1974). In 1950, there were some 75 cities of more than a million inhabitants; by the year 2000, there will be nearly 275 (UN World Food Conference 1974). Approximately 80% of the people in developed countries and 40% in less developed countries will live in urban areas. In absolute numbers, this means that within the course of only one generation there is going to be an increase of nearly 2,000 million in the number of city dwellers, about 450 million in developed and 1,500 million in developing countries (UN Economic and Social Council 1973, Chapter XV).

The urban growth rates in developing countries will far surpass anything ever experienced in more industrialized countries. The fastest growing cities of the world will be in the developing countries, whereas the major cities of the industrialized countries will just about hold their own. During only a 15-year period from 1970 to 1985, Bandung is expected to grow by 242%, Lagos by 186%, Karachi by 163%, Bogota by 146%, and Baghdad by 145%. Such growth rates, without immediate emergency countermeasures, may outstrip even the basic minimum resources and services required to maintain them.

But each nation has the right to determine its own optimum population level based on its own aspirations. Equally important, however, is the need for each nation to accept the corollary—the responsibility to ensure that the demands of its population on resources and environment do not impair the rights and interests of the world as a whole. Indeed, the key to the global population issue is the acceptance by each nation of the responsibility for sound national population policies based on its carrying capacity, whereby the level, growth, and distribution of its population are related to its available resources, its capacity to develop these resources, and to the kind of life to which its people aspire.

FOOD AND ENVIRONMENT

The year 1972 graphically illustrated the vulnerability of the world food situation. In spite of the significant increase in food production due to the "Green Revolution" in the 1960's, the food problem in recent years has become aggravated and more persistent. At present well over 450 million people are hungry and lack the capacity for living a normal life (UN World Food Conference 1974), conservatively estimated, and their number is increasing daily. The majority of them live in rural areas, and at least 40% of them are children (UN World Food Conference 1974).

Population has certainly been the major historical factor in the increasing demand for food. Rising affluence, however, is becoming a major new claimant, and approximately 20% of the food consumed last year is attributable to this new factor (UN World Population Conference 1974a). This can be demonstrated by considering the grain requirements of different societies. The per capita availability of grain in developing countries averages 180 kg per year, most of which is consumed directly and very little in the form of animal protein. In contrast, the per capita grain consumption in developed countries is about one ton per year and only 70 kg of it is consumed directly, the remainder being consumed indirectly in the form of meat, milk, and eggs. Affluence has also reshaped the world trade in food. The major food importers are no longer developing countries like India and Pakistan but rather the rich countries like Japan and the USSR.

The task of more than doubling world food production by the end of the century will be a much more difficult one than is generally realized. The demand for food in developing countries is likely to expand at about 3.6% per year during the period 1972 to 1985. This compares with the actual average production increase of about 2.6% in the past 12 years (Biswas 1975). Under the conditions of present world economic instability and the energy-intensiveness of the "Green Revolution" type of agriculture, such an increase in food production would be a formidable task. Even more difficult than doubling food production within a generation will be the task of ensuring that those who need the food will have access to it, because much of the potential for increased production exists in areas like North America or Australia and not in the developing countries of high population density and growth.

Some of the basic ingredients for increasing food production, such as fertilizer and pesticide, are already scarce and expensive. Some of the traditional exporters of fertilizers are banning exports until home needs have been met. The high price of fertilizer is also accenting the gap between the rich and poor nations. Since grain prices are high, farmers in rich countries can afford to pay even higher prices for the world's increasingly scarce supply of fertilizer. Poor countries, then, have to import grain from rich countries, a fact which helps to keep grain prices high. It is indeed a vicious circle. It would make far better sense to send another 250,000 tons of fertilizer to India, which will grow an additional 2.5m tons of grain, than to send the same amount to Europe to grow only an extra 1.5m tons of grain.

Food production and distribution is becoming more and more energy intensive. Currently nearly 13% of the North American energy budget is used for this sector (Pimentel et al. 1973). If we compare calorie input and output as a convenient way of computing energy subsidy for the agricultural sector, it would indicate that the number of calories of energy supplied to produce one calorie of food for actual consumption has steadily gone up in the last few decades. The input-output ratio was 1:1 around 1910 for the U.S. system; at present it is 8:1. It is rather appalling that this trend does not appear to be leveling off (Steinhart and Steinhart 1974).

The increase in the yield of agricultural products has been made possible by ever-increasing inputs of energy and other ingredients and a mild climate. For example, the corn yield in the United States has increased from 1 ton in 1945 to 2.2 in 1970. During the same 25-year period, energy inputs increased as follows: machinery (180×10^3 to 420×10^3 Kcal), fertilizers (nitrogen 3 to 50 kg, phosphorus 3 to 14 kg, potassium 2 to 27 kg), insecticides (0 to 0.50 kg), herbicides (0 to 0.50 kg), irrigation (19×10^3 to 34×10^3 Kcal), drying (10×10^3 to 120×10^3 Kcal), electricity (32×10^3 to 310×10^3 Kcal) and transportation (20×10^3 to 70×10^3 Kcal) (Biswas and Biswas 1974). Thus, the "Green Revolution" has only been made possible by increasingly higher inputs of energy.

The task of increasing food production faces another constraint in the impact to environment and to health that can result from the continuing increases in the use of chemical pesticides and fertilizers to intensify yields from existing acreage. Current studies indicate that only 15 parts per billion of phosphorus are necessary to support algal blooms (Brubecker 1972). Thus, even a 1% loss of P_2O_5 in runoff from a field treated with 18 kg of phosphorus would support algal blooms in 6,200 m^3 of water.

This is just one example of the growing risks man faces from the substances he is introducing to the environment. Currently we are introducing more than 1,000 new substances a year, many of which, for all practical purposes, never existed before. Some of these are highly stable and, therefore, persistent. Once they enter the ecological system, they are destined to stay there for a very long time. The distribution process is irreversible, and we know very little about their synergistic effects or their accumulation in the atmosphere, land, water, and food chains.

Land and water are essential requirements for food production. As the need to increase food production becomes more urgent, man is faced with continued loss of productive soil through desertification, erosion, salination, and other forms of destructive development. Intensifying pressures on the land are making the problems more difficult to solve. It is estimated that already man's activities have despoiled some 10% of the world's arable land. In addition, good agricultural land is coming under intense pressure, in both developed and developing countries, from urban uses. There is still land available which can be brought under cultivation, but as larger and larger areas are given over to farming, the unexploited tracts available to serve as reservoirs of species diversity and to carry out "public service" functions of natural ecosystems become smaller and smaller.

Pressure to expand the area under agriculture is leading to destructive attempts to cultivate land that is actually unsuitable for cultivation with the technologies currently available. Thus, the expansion of agriculture to steep hillsides has led to serious erosion in Indonesia, the increasing pressure of slash-and-burn techniques is destroying tropical forests in the Philippines, and attempts to apply the techniques of temperate zone agriculture to the tropical soils of Brazil and southern Sudan have led to laterization and erosion loss of nutrients. Overlogging of tropical forests has similar effects.

There are many instances of environmental and ecological costs of expanding food production due to lack of good management practices. In fact, these could be ecologically disruptive and can actually undermine the food production system. After two decades of rapid expansion, the total world fish catch during the past several years has decreased. Overfishing, pollution, and natural fluctuations have negated the total production of this high quality protein. The need to feed an expanding population in the drought-plagued Sahel has led to overgrazing, deforestation, and southward march of the desert. Deforestation in the Himalayas is probably contributing to an increase in the frequency and severity of flooding in Pakistan, India, and Bangladesh (UN World Population Conference 1974b).

Water for irrigation is an important requirement to increase food production. The health costs of irrigation due to the spread of water-borne diseases, especially in the tropical countries, can no longer be ignored. The trade-off between the benefits of extra food production and the costs of additional misery due to health hazards had to be carefully considered (Biswas 1974a).

The quest for high yields has led also to the replacement of a wide variety of traditional crop varieties all over the world with a few, specially bred, high-yield strains. Unprecedented areas are now planted to a single variety of wheat or rice. This enormous expansion of monoculture has increased the probability and the potential magnitude of epidemic crop failure from insects or diseases.

On the average, plants currently use less than 1% of the solar energy for photosynthesis. The efficiency of this process may be affected by adverse environmental developments. Equally important, it may be possible to increase the photosynthetic efficiency of plants under certain ideal environmental conditions and thus increase world food production.

Finally, all ecological systems have experienced traumas and shocks over the period of their existence. The ones that have survived have explicitly been those that have been able to absorb these changes. They have developed an internal resilience that gives them a domain of stability. So long as the resilience is great, unexpected consequences of an intervention of man can be absorbed without profound effects. But with each such intervention, the price often paid is a contraction of the domain of stability until an additional incremental change can transform the system to another state. In a development scheme, it would generate certain kinds of unexpected consequences: a freeway that changes the morphology of a city so that the urban core erodes; a pesticide that destroys an ecosystem structure and produces new pest species. Man now seems to be faced with problems that have emerged simply because he has used up so much of the resilience of the ecosystems. Up to now the resilience of the systems has enabled us to operate on the presumption of knowledge with the consequences of our ignorance being absorbed. Now that the resilience has contracted, traditional approaches to planning might well generate unexpected consequences that are more frequent, more profound, and more global.

It is urgent that we substantially increase our existing food production, but this increase must be on a sustained basis. The steps taken to increase food production must be ecologically and environmentally sound, otherwise it will be self-defeating strategy on a long-term basis.

ENERGY AND THE ENVIRONMENT

Energy has long been viewed as an essential ingredient to stimulate and support economic development. Traditionally and historically, as countries have advanced economically and technologically, their energy and resources consumptions have increased as well. Thus, the developed countries use more energy per capita than developing countries. However, a transition in the distribution of world energy consumption is slowly taking place. For example, North America's share of global energy fell from as high as 50% in the mid-20's to nearly one-third in 1968. During the same period, the Soviet Union's energy consumption increased from a little less than 2% to 15% (Biswas and Biswas 1974). The average annual growth for the developing countries during the 1950 to 1968 period was 7.5% compared to 5% for developed countries. In spite of the significant population increase in developing countries, their average per capita energy consumption increased at a much faster rate (4.8%) compared to those of developed nations (2.8%). However, the gap between the two is still immense, and with unaltered trends it will take nearly 300 years to close it (Biswas and Biswas 1974).

The major long-term potential environmental hazards from our energy development and consumption practices are thermal pollution, the possibility of climatic changes due to constantly increasing levels of heat fluxes, carbon dioxide and particulates, and the problems of management of highly radioactive nuclear and other toxic wastes (Biswas 1974b, c). To this should be added the environmental problems caused by rapid deforestation in developing countries due to their heavy dependence on wood as the main source of fuel.

As a rule hydropower and gas turbine plants do not add significant amounts of heat to the environment. An efficient conventional fossil-fuelled plant converts nearly 40% of heat energy of combustion to electricity; 45% of the remainder is discharged to the cooling water and 15% to the atmosphere. The worst offenders, nuclear power plants, discharge about 40 to 50% more heat into cooling waters than a modern fossil-fuel plant (Biswas and Cook 1974). From a heat rejection point of view, hydro is the cleanest form of energy, and its percentage share of energy generated is expected to be reduced; nuclear power is the least desirable, and its share of the market will increase substantially; thus, the thermal pollution problem will greatly multiply in the future (Biswas and Cook 1974).

The release of heat to the atmosphere, either directly or through heated water, is increasingly becoming a cause for concern. The heat-island effect has been clearly identified in many cities. As the population concentrates more and more on urban regions, the heat rejection rate could become equivalent to nearly 50% of the heat received from solar radiation in winter. If the existing trends in power consumption continue, heat introduced into the atmosphere could become climatically significant at some point in the next century.

Consumption of fossil fuels has increased the concentration of carbon dioxide in the atmosphere from 290 ppm in 1860 to about 320 ppm at present. There are several hypotheses that increasing levels of heat fluxes and concentrations of carbon dioxide and particulates in the atmosphere are already changing the world climate (Bryson 1973). Some present studies indicate that these factors have contributed to the movement of subtropical highs toward the equator, causing decline in rainfall in subtropical semiarid regions. The results of these types of climatic changes on mankind, including food production, are horrendous. A particularly troublesome issue, it must be the focus of far greater collaborative international research efforts than have been devoted to it thus far.

The third major potential environmental problem is the management of highly radioactive nuclear wastes like plutonium, one of the most dangerous substances known to man, which has to be completely isolated from the biosphere for some 200,000 to 240,000 years—a period much longer than the history of modern man. Since nuclear industry is only a few decades old, its capability to design an almost eternal fail-safe system has to be highly suspect. Generally unknown to the public, the nuclear industry has already made a commitment for our entire society with an implicit assurance that from now to perpetuity our social institutions will retain sufficient stability to guarantee the continued existence of a cadre that will take care of these highly radioactive toxic wastes. A glimpse at man's past history over only the last 3,000 years indicates that this may very well turn out to be an impossible assumption. Finally, as nuclear stations proliferate in the future, it will become increasingly difficult to keep plutonium out of the hands of irresponsible persons, who might decide to hold society at ransom. Equally difficult may be the spread of materials that could be used for weapons of mass destruction. These are highly moral and ethical questions of a nature that man has never faced before, and the final decisions should be made not by the nuclear lobby but by a fully informed public (Biswas 1974b, c).

The developing countries present a different type of environmental problem because of their marked dependence on wood as a major source of fuel. The per capita consumption of wood-fuel in these countries is just over 1 ton per year, and if we consider all the developing countries, the wood-fuel usage rate is around 80% (Biswas and Biswas 1974). Thus, their forests are coming under increasing pressure. Deforestation is creating serious soil erosion problems, more intense flooding like the recent floods in India, and increasing the pace of the march of the deserts like those of Sahara in Africa and Rajasthan in India (Biswas 1975).

The "energy crisis" and the high cost of oil have forced many countries to prepare future energy plans that rely heavily on nuclear power to become "electrical societies" by the year 2000. Assuming that these countries do go that route, we have not yet even cursorily analyzed what the combined effects will be on resource industries like steel and copper, on land-use planning, or the cumulative effect on the environment. This type of incremental ad-hoc planning will ensure that we will replace "energy crisis" with another crisis.

Increasing energy requirements and the recent increase in energy prices have affected the developed nations badly, but the predicament of the developing nations is even worse. Current estimates indicate that added petroleum energy costs, both direct and indirect, to the developing countries will be on the order of $10 to $15 billion in 1974, compared to about $4 billion previously. The sudden increase in the price of raw materials and agricultural products during the last two to three years has seriously aggravated the balance-of-payments deficit for developing countries, which have trebled in recent years (Biswas and Biswas 1974). Inflation is outrunning aid measures at an ever-increasing speed, and during the last year it more than totally used up the entire development aid available. This means a significant amount of precious foreign exchange earned by the developing countries has to be used for payment of oil import bills (50% in the case of India). This means budgets earmarked for other priority sectors like education, housing, health care, industrialization, etc., have to be severely cut, an event which is going to set back the development plans of these nations by many years. Thus, the energy crisis has hit developing countries very harshly (harsh because price increases have been very swift and very great), and the economies of these nations are not resilient enough to absorb these types of hefty price increases without major perturbations or serious breakdown of their existing social and economic systems.

RAW MATERIALS AND ENVIRONMENT

Increases in population and per capita use of resources mean that total resources requirements for the globe as a whole are increasing very rapidly. On a global basis, however, it is unlikely that man will run out of raw materials: he is more apt to run into other barriers to growth. Traditionally, raw materials are classified as nonrenewable resources. This term, however, is somewhat of a misnomer and needs some clarification. Some raw materials, strictly speaking, are renewable so far as man's use is concerned. Thus, we have so much iron or copper in the world today, as we had 1,000 years ago, and as much as we will have 1,000 years from today. These materials can be used again and again by recycling processes. What has changed is their easy availability in terms of their original concentration in ores. These may be termed as "nonlosable" resources.

The other major consideration is that exploitation of any raw materials is a direct function of our technological knowledge. With the improvement of technological capability over time, man has been able to use lower concentrations and mine in more and more regions of the world. The average grade of copper mined in the United States has steadily declined from 1.6% in 1936, to 1.22 in 1941, 0.98 in 1946, 0.97 in 1951, 0.84 in 1956, 0.82 in 1961, 0.79 in 1966, and 0.65 in 1971 (Biswas and Biswas 1974).

Before concluding that there will be enough raw materials for future generations, one must note several qualifications. Firstly, as the world scrambles for more resources and resorts to ever-lower grade ores, more materials have to be reprocessed for each unit of the end product. Hence, generation of residuals from processing will grow even faster than total consumption. Secondly, ever-increasing energy must be applied to mine, refine, transport, and use minerals from ores of lower concentration. Thirdly, in the case of strip mining, more and more land has to be disturbed to mine lower grade ores. The investment necessary to reclaim those areas for other uses could be substantial, especially in arid zones. Finally, the transitory nature of mining operations could mean greater rates of migration and social disruption resulting from greater rates of exploitation.

CONSIDERATION OF OUTER LIMITS

Perhaps less acute and immediate, but in the long run no less important, is the evidence that all mankind shares the risks to its collective survival from those human activities which may impinge upon the "outer limits" on which human life depends. There are broadly two different kinds of limits or barriers to human development and progress. First, there are what might be called ultimate, or natural, limits to material growth; growth within a finite space cannot continue forever. Scientific and technological advances can postpone the time and moderate the way these limits are reached, but it cannot repeal fundamental laws of nature. Ultimately, therefore, all countries must choose how they want population and material economic growth to cease, through the operation of natural forces or in a manner and at a time chosen by man. Secondly, there are proximate, or man-made, barriers to growth and human development. These are the insitutional, political, and international conditions that restrict the ability of individual countries and some groups within countries to take full advantage of the available resource base. The unequal distribution of income and power in the world, both between and within countries, bears stark testimony to the presence and seriousness of these barriers.

Even though there is unanimity among scientists about these proximate barriers, there is considerable disagreement about the ultimate limits (Biswas and Biswas 1974). If the world, or major portions of it, were approaching such limits within perhaps the next 100 years, it would be imperative that population and material economic growth be stopped, or at least significantly slowed, in the near future. Given the enormous momentum involved in demographic and socioeconomic processes, there would be no time to lose. But if humanity is still several centuries away from the ultimate limits, the policy implications would be much different. There would still be reason for concern about the speed with which population, resource consumption, and environmental disruption increase because high rates of change in these variables could create problems faster than solutions could be found, could force mankind to live with greater uncertainty and risk, and could make the elimination of the proximate barriers more difficult. And approaching toward the ultimate limits of population (or of any other kind) forecloses most other alternatives, many of which are highly related to quality of life as envisioned by those within the affected cultures.

The problem is ignorance of the factors determining such ultimate limits. The mineral and energy reserves ultimately available to man are unknown. Also unknown are how much new land can be made suitable for agriculture, the extent to which additional fresh water supplies can be developed, the seriousness of the disruptions to ecosystems caused by man's efforts to acquire these resources, or the timing of technological advances required to extend present limits. Most public attention has been focused on the direct effects, and within this category on acute rather than chronic manifestations. Far too little is known about what small amounts of persistent substances such as chlorinated hydrocarbons, radiation, mercury, lead, and DDT might do to the human body when accumulated over 20- to 30-year periods. Nor is much known about behavioral responses likely to result from growing resource and environmental pressures. Far more serious efforts must be devoted to overcoming these areas of ignorance. Until they are overcome, mankind must search for some strategy that takes appropriate account of the uncertainties and risks involved.

In spite of these uncertainties, fewer things are becoming increasingly evident. Man's activities, based on the massive leverage which science and technology has made available to him, have reached a scale and intensity at which they are significantly modifying many of the elements within the biosphere vital to sustaining human life. Increased consumption of fossil fuels, proliferation of nuclear reactors, introduction into the environment of more than 1,000 man-made organic chemical compounds every year, vast man-made changes in the surface of the earth (its plant and animal life)—all have impacts on the natural systems in ways in which we still cannot fully evaluate and understand. But there is increasing evidence that they are giving rise to serious risks in such areas as possible climatic change, marine pollution, contamination of the food chain, polluted water supplies, and damage to human health.

One area causing increasing concern is the possibility that important changes are occurring, or have already occurred, in the climatic bases of certain regions. For example, monsoon rains over the south Sahara extended well to the north from the 1920's to 1960's. This favorable trend has now been reversed over the past six years, with seasonal rainfalls considerably below the previously recorded averages (Biswas 1975). Since 1971, the world snow and ice cover has increased by at least 10% (Kukla and Kukla 1974). The cumulative effects of the climatic anomalies that occurred in 1972 had catastrophic results on world food production. One cannot be sure about the precise causes of these events.

Effects of these types of climatic changes on food production in marginal areas have been quite severe, and mankind can no longer afford to be complacent about the effects that such changes can precipitate (Biswas 1975).

CONCLUSION

All of these major issues form a complex system of cause and effect relationships in which the dynamics of our future will be shaped. They increase by many orders of magnitude both the potential for conflict and the need for cooperation. It is not in any one of them, but in their interaction, that the future of mankind will be decided. Increase in population and provision of basic human necessities to each individual mean more food, energy, and raw materials; intensifying the supply of food means more land, water, energy, and fertilizers; the energy crisis and higher oil prices mean less energy available to increase food production and to alleviate fertilizer shortages; and the common denominator in virtually all responses to these problems must include more capital, more technology, and more cooperation. It is here that these concerns inevitably merge with the important issues of war and peace, monetary and trade relations. Each affects and is affected by the others. This system of relationships is global in scale. That is not to say that all global problems can be met with global solutions; there are few global solutions. But they can only be understood and dealt with in a global framework, within which there can be a wide variety of national and regional responses.

It is equally important to be aware of the vast number of "public services" rendered by the natural environment. Almost all potential plant pests are controlled by natural ecosystems, only those of crops being controlled by man. Insects pollinate most of the vegetables, fruits, and flowers. Natural vegetation reduces floods, prevents erosion, and beautifies the landscape. As the size of human populations and economic activities increases, man's potential for disrupting such systems grows. With the world's population doubling in the next 30 to 40 years and economic activities at least tripling during this period, man's impact on these systems can no longer be ignored.

What is necessary is integrated environmental management rather than incremental ad hoc steps taken for environmental protection, and the realization that the ultimate self-interest of all nations is inevitably merged in the inescapable web of interdependencies. An integrated cooperative approach is needed for managing the interacting relationships between resources (their development, distribution, and use), technology (its orientation and use), and the minimal needs for sustaining decent standards of human life and protecting the environment on which that life depends. These interlocking subjects must be foremost on the world's agenda for consideration and action. Only through the understanding of these intricate interrelationships will it be possible to solve the mammoth problems facing all mankind and the creation of a New International Economic Order as envisioned by the United Nations.

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