Complementarity Between Environment and Development Processes

by

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INTRODUCTION

The complexities of the problems associated with the interrelationships between human population, resources, environment, and development, constitute a subject that is far from new. Ever since the time of Aristotle, and probably even before, there have been speculations as to whether enough resources would be available to ensure continued development for future generations. In 1798 a far-sighted Englishman, the Cambridge don Thomas Malthus, pointed out the seeming contradiction between geometric growth of population and arithmetic growth of food production in his now-famous book *An Essay on the Principle of Population as it Affects the Future Improvement of Society* (Malthus, 1798). Malthus allowed for the likelihood that some technological developments would occur in the future, but he believed that these would be finite, and would quickly be used by a burgeoning population. Like that of other animals, the human population would continue to grow until it was checked by food or other shortages. In his later works, Malthus recommended that 'self-restraint' should be practised, so that such a catastrophic future could be avoided. In recent years, especially after the UN World Population Conference in Bucharest in 1974, it has become almost customary to equate his name with a pessimistic view of the future of Mankind.*

While population–resources–development problems have been analysed and discussed for some time, environment really became a focus of major international concern only in the nineteen-sixties. This of course does not imply that environmental concerns were not raised before the 'sixties, or that they were not important earlier. For example, Hotelling (1931) summarized the neo-Malthusian writings of the time in an article entitled 'The Economics of Exhaustible Resources', which could very well have been written today. He said:

> 'Contemplation of the world's disappearing supplies of minerals, forests, and other exhaustible assets, has led to demands for regulation of their exploitation. The feeling that these products are now too cheap for the good of future generations, that they are being selfishly exploited at too rapid a rate, and that in consequence of their excessive cheapness they are being produced and consumed wastefully, has given rise to the conservation movement.'

DEVELOPMENT DURING THE 'SIXTIES

It would probably be fair to say that, before environmental consequences of economic development became an area of major national concern in many countries during the nineteen-sixties, overriding priority was mostly placed on the first-order effects of technology and economic growth. Consequently, if there was a conflict between having more development projects at the cost of environmental degradation, it would have been resolved in favour of the former in practically all cases and almost as a routine procedure. The secondary effects, such as environmental pollution, would have been taken in stride. To the extent that environmental deterioration was discussed or thought about, it was considered to be a 'price of progress'. It is still, unfortunately, not unusual to find this philosophy lingering on in unenlightened or excessively greedy quarters.

During the late 'sixties, the undesirable side-effects of economic development became highly visible and even pronounced in many industrialized countries. Among the problems encountered were extensive air, water, and noise, pollution, difficulties with solid-waste disposal, lack of land-use planning, and a general deterioration of quality of life in most urban areas. People became concerned with the problems of environmental deterioration and their resultant effects on life-style and health, and expressed that concern articulately. It was being

* In all fairness, however, it should be pointed out that the simplistic aphorisms of Malthus's contention that are now attributed to him, do not do justice to the complex theories which he put forward. As is the case with almost any human being, Malthus's ideas developed with time. Even though he is generally known, and blamed, for the opinions on population which he expressed in his 1798 book, a later work entitled *An Essay on the Principles of Population; or a View of its Past and Present Effects on Human Happiness; with an Inquiry into our Prospects Respecting the Future Removal or Mitigation of the Evils which it Occasions*, is much more scholarly. This book of 610 pages was first published in 1803, and was subsequently revised by Malthus in 1807, 1817, and 1826 (Malthus, 1803).

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increasingly realized that human activities, based on the massive leverage which science and technology has made available to us, have reached a scale and intensity at which they are significantly modifying many of the 'elements' within The Biosphere that are vital to sustaining human life.

Increased consumption of fossil fuels, proliferation of nuclear reactors, accelerated deforestation and loss of productive soils, introduction of more than 1,000 man-made organic chemical compounds every year, loss of genetic diversity, and other similar problems—all have impacts on the natural systems in more ways than one, which we still cannot fully evaluate or even understand. Being aware of the fact that such developments were creating real, and in many cases immediate, problems which often transcended national boundaries, the United Nations convened a world Conference on the Human Environment, which was held in Stockholm, Sweden, in 1972.

The discussions of environmental problems of the late 'sixties and the early 'seventies were very much influenced by the experiences of the industrialized countries. The emphasis was primarily on the physical environment: there was very little analysis or understanding of the underlying socio-economic reasons for environmental deterioration in the less-developed countries. Two aspects generally received increasing attention in the West: constantly increasing use of raw materials and energy in developed countries, and 'population explosion' in the Third World. Many doomsday scenarios were put forward, which unfortunately received extensive attention in the 'mass media'.

On the question of scarcity of resources, two reports came out in 1972. One was by the journal *The Ecologist* and entitled 'Blueprint for Survival', and the other was *The Limits to Growth* (Meadows *et al.*, 1972). Both these reports were based on the fundamental and indisputable fact that exponential growth in a finite environment cannot continue indefinitely. *The Limits to Growth* made a profound impression on many people, and provided a bandwagon for parties who were already more than convinced that mankind was headed straight for disaster unless growth-oriented policies were forsaken (e.g. A.K. Biswas, 1979*a*). Discussions of physical limits to growth became fashionable—without much consideration of social, institutional, and technological, factors that affect such growths and limits.

Similar doomsday scenarios were put forward on the population sector of developing countries. Paul Ehrlich, in his 1968 book *The Population Bomb*, asserted that 'The battle to feed all of humanity is over. In the 1970s the world will undergo famines—hundreds of millions of people are going to starve to death' (cf. Ehrlich, 1971). Similarly William & Paul Paddock (1967), in their book *Famine 1975!*, advocated the policy of 'triage—letting the least fit die in order to save more robust victims of hunger'. They classified the three categories as 'can't-be-saved', 'walking wounded', and 'should receive food'. Their opinion as to the triage classification of sample nations was:

'Haiti	Can't-be-saved
Egypt	Can't-be-saved
Gambia	Walking Wounded
Tunisia	Should Receive Food
Libya	Walking Wounded
India	Can't-be-saved
Pakistan	Should Receive Food'

Even in a later edition of the book, published in 1976, the Paddock brothers claimed that the 'basic facts have not changed'.

Into the 1970s

These types of statements, and clamour for 'no-growth' in the West, did not contribute to mutual understanding of environment and resource problems between developed and undeveloped countries. People in the latter could not comprehend how their impoverished citizens could compete with the substantially more affluent consumers of the industrialized countries in terms of depleting finite global resources. In many cases they were not even aware of the resources available in their own countries, as many regions were practically unexplored. Accordingly, some 'developing' countries felt that the concept of global resources management was an attempt to take from them the national control of resources. Furthermore, as industrialized countries used the lion's share of resources and contributed to most of the resulting industrial pollution, the Third World countries did not see much reason to find and pay for the solutions (UNEP, 1978).

Thus, in 1970, during the preparation of the Stockholm Conference (*see* above), it became evident that many countries, both developed and developing, believed that environment and development are not compatible, even though they came to this conclusion for very different reasons. Accordingly, in June 1971, the Conference Secretariat convened a seminar on 'Environment and Development' at Founex, Switzerland. This seminar clarified several conceptual problems, the most important of which was that environment and development problems are compatible, and that the false dichotomy of 'environment *versus* development' should no longer be recognized, let alone fostered.

The Founex meeting also clarified many environmental problems of Third World countries that originated from underdevelopment—including lack of potable water and sanitation, burgeoning of squatter settlements, and lack of education, employment, and transportation, etc. 'Pollution of poverty' became an important theme at the Stockholm Conference. The concept that environment and development objectives are harmonious and mutually reinforcing, received a further boost at the Symposium on Resource Use, Environment, and Development Strategies, that was jointly convened by UNEP and UNCTAD in 1974 in Cocoyoc, Mexico, and resulted in the Cocoyoc Declaration. This as well as other activities of the UN Environment Programme—under such labels as ecodevelopment, environmental management, and environment and development—have significantly contributed to our understanding of environment–development interrelationships, and indeed it is now widely accepted that environment and development are 'two sides of the same coin' (Tolba, 1982).

Overall Development

In spite of the attempts that have been made by national governments, international organizations, and bilateral aid-agencies, overall developments in Third World countries have not reached the targets established by the First and Second Development Decades of the United Nations. Bradford Morse, Administrator of the UN Development Programme, stated in his annual report of 1979 (Morse, 1980):

> 'From one point of view, the 1970s was a decade of disappointments. Adequate gains were not made against poverty and its life-crushing consequences. The global economy fell short of the sustained expansion necessary for moving with much greater speed and effectiveness in the struggle to substantially ease hunger, disease, illiteracy, unemployment, and lack of adequate housing. The world became joltingly aware that there were limits to its exploitable resources. Perhaps most frustrating of all was the fact that the industrialized and the developing countries did not achieve greater understanding—much less agreement—about how to deal with these problems effectively and equitably'.

Few people will disagree with the above assessment. This is not to imply that there was no progress made during the first two development decades, but rather that the advances were not up to expectations. Accordingly, at the Third General Conference of the UN Industrial Development Organization (UNIDO), held in New Delhi early in 1980, many governments expressed the opinion that the 'two United Nations Development Decades had failed in their objectives' (UNIDO, 1980). The good intentions and objectives of the 1975 Lima Declaration and Plan of Action, that the developing countries should attain a 25% share in total world manufacturing output by the year 2000, appeared (and still appears) to be far from realization. At the present rate of development, their share might not exceed 13% by the end of the present century—a figure that represents only about half of the accepted target. The above UNIDO Conference stated that during the two preceding decades, 'the rich became richer and the poor poorer; more than one-quarter of the world's population was growing steadily poorer'. Further, 'eight hundred million people, or about 40% of the population of the developing countries, continued to live in absolute poverty; roughly a billion people lacked at least one of the basic necessities of food, water, shelter, education, or health-care' (UNIDO, 1980).

In the agricultural sector, the target for the annual average growth-rate for the Second Development Decade was established at 4%, but the real average annual growth-rate was only 2.8%. It should be noted that this was the average growth-rate: it was much less for many of the less-developed countries. If these countries are considered as a whole, certain indicators of agricultural production during the two UN Development Decades will actually be seen to have declined. For example, Third World countries, in aggregate, were net exporters of grain in the 1950s. At the end of the first Development Decade, the surplus situation had turned into a net deficit. Third World countries as a whole imported 42 million tonnes of grain in 1970, and this total increased annually to reach 80 million tonnes in 1979. Estimates of total grain-import needs by the end of the Third Development Decade in 1990 currently range from 125 to 150 million tonnes.

Similarly, if the index of *per caput* food production is considered, the situation is not much better for the 'low-income developing countries', defined by the World Bank (1980) as having a *per caput* income of US $300 or below in 1978. Of the 38 such countries listed in the World Bank's World Development Report of 1980, the index of *per caput* food production declined for 27 countries, remained the same for four, and increased for only 7 countries. The index (1969–71 = 100) declined to a low of 57 for Kampuchea, 71 for Mauritania, and 80 for Togo, while increasing to a high of 114 for Sri Lanka, 108 for Sudan, and 107 for Burundi.

There is no doubt that the progress during the two Development Decades in the agricultural sector has been inadequate. The Executive Director of the World Food Council, Maurice J. Williams, called it twenty years of neglect when describing the results of the two Decades on the agricultural development of the Third World. Many of the developing countries, however, did not give the agricultural sector the necessary priority in their national development plans. This, fortunately, appears to be changing. The recent suggestions of the 'Group of 77' Third-World countries at the United Nations, which is to be considered during the finalization of the strategy for the Third Development Decade, are for 'a distinct and definite bias in favour of agricultural production' and an average annual growth-rate of 4%, while food and nutritional planning should form the core of national development policies (A.K. Biswas, 1980).

In certain other areas, of course, there have been considerable improvements during the two past Development Decades. Thus, the average life-expectancy at birth increased for the low-income countries as a whole from 42 to 50 years during the period 1960 to 1977. The corresponding improvement for the industrialized countries was from 69 to 74 years, and for centrally-planned economies from 58 to 66 years. Similarly, the child death-rate (number of deaths among children from 1 to 4 years of age, per thousand children in the same age-group in a given year) in low-income countries declined from 30 to 19: the corresponding rate for industrialized countries remained constant at 1. Development statistics for selected countries during the Second Development Decade are shown in Table I.

While no one would argue with the urgent necessity of furthering the development process of developing countries, unfortunately still not enough attention is being given to ensure that the strategies which are being developed and implemented are sustainable over the long-term. Unless short-term stategies for the improvement of different sectors can be effectively integrated with long-term policies, there is a very real danger that short-term *ad hoc* strategies could turn out to be not only environmentally unenlightened but also eventually self-defeating. This is what Dr Mostafa Kamal Tolba (1979), Executive Director of the United Nations Environment Programme (UNEP), has termed *development without destruction*. According to Dr Tolba, 'the international community, especially the developing countries, in advocating and

TABLE I

Development Statistics for Selected Countries (Source: World Bank, 1980).

Country	Population (millions) mid-1978	Life Expectancy at Birth 1978	Average Annual Growth-rate (%): GNP per caput 1960–78	Population: Total 1970–78	Population: Urban 1970–80	Agricultural Production 1970–78	Energy Consumption 1974–78	Industrial Production 1970–78	Labour Force 1970–80	Inflation 1970–78
Bangladesh	84.7	47	−0.4	2.7	6.6	1.6	16.5	5.9	2.4	17.9
Brazil	119.5	62	4.9	2.8	4.3	5.3	7.0	10.1	2.8	30.3
Canada	23.5	74	3.5	1.2	1.7	2.7	1.7	3.7	2.0	9.4
China	952.2	70	3.7	1.6	3.1	—	9.0	—	1.9	—
Egypt	39.9	54	3.3	2.2	3.0	3.1	11.7	7.2	2.2	7.0
Ethiopia	31.0	39	1.5	2.5	6.9	0.5	−7.8	0.4	1.8	4.0
Germany (W)	61.3	72	3.3	0.1	0.5	1.6	1.5	2.1	0.7	5.9
India	643.9	51	1.4	2.0	3.3	2.6	5.1	4.5	1.7	8.2
Indonesia	136.0	47	4.1	1.8	3.6	4.0	21.4	11.2	2.1	10.0
Israel	3.7	72	4.2	2.7	3.1	6.6	2.8	5.3	2.4	31.0
Japan	114.9	76	7.6	1.2	2.0	1.1	1.5	6.0	1.3	9.6
Kenya	14.7	53	2.2	3.3	6.8	5.5	−0.6	10.4	2.8	12.0
Korea (S)	36.6	63	6.0	1.9	4.8	4.0	9.6	16.5	2.8	19.3
Mexico	65.4	65	2.7	3.3	4.5	2.1	6.7	6.2	3.3	17.5
Singapore	2.3	70	7.4	1.5	1.5	1.5	9.3	8.5	2.7	6.1
Sweden	8.3	75	2.5	0.4	1.0	−1.6	2.5	1.0	0.3	9.3
Tanzania	16.9	51	2.7	3.0	8.3	4.5	0.5	2.3	2.3	12.3
USSR	261.0	70	4.3	0.9	2.2	—	4.2	—	1.2	—
UK	55.8	73	2.1	0.1	0.3	0.8	0.3	1.3	0.3	14.1
USA	221.9	73	2.4	0.8	1.2	0.9	1.6	2.9	1.5	6.8

designing the much-needed New International Economic Order', should 'not forget that there will be no sustained development or meaningful growth without a clear commitment at the same time to preserve the environment and promote the rational use of natural resources'.

As the example with which the present Authors are particularly familiar, discussion of the environment–development interrelationships of irrigation will occupy most of the rest of this paper.

Irrigation Development and Environment

Water control is essential for agriculture, and if the world food problem is to be solved, the total area under irrigation will have to be increased. The potential benefits to crop production under various degrees of water control, combined with additional material inputs and existing cultural practices, are shown in Table II (FAO, 1978). It shows that, as the degree of overall control increases, the yield increases as well.

Agriculture is the largest user of water, and accounts for nearly 80% of global water consumption (A.K. Biswas, 1979*c*). The total area irrigated in the world in 1975 amounted to 223,000,000 ha, of which 92,000,000 ha were in developing 'market-economy' countries. By 1990, it is estimated that these figures will have risen to 273,000,000 ha and 119,000,000 ha, respectively (FAO, 1978).

It is, however, not enough to increase irrigated areas. What has been developed must be sustained on a long-term basis, and accordingly the effectiveness and efficiency of the supply and distribution systems must be maintained. Current estimates indicate that some 86,000,000 ha of irrigated land throughout the world are now in need of improvement. Similar improvements will be necessary on nearly half the irrigated area of developing market-economy countries by 1990 (FAO, 1978). The estimated cost of such improvement, at 1975 prices, will be more than US $22.5 thousand millions. In addition, another US $12.4 thousand millions will be necessary for drainage improvement and control of salt-balance in the soil. Thus, the total cost of irrigation improvement schemes alone is expected to be US $34.9 thousand millions.

It is most important to ensure that irrigation projects, which contribute to increased crop-yields, should not also create environmental and ecological problems, that reduce the benefits of such developments. The types of environmental and allied problems encountered from past irrigation developments, and hence to be guarded against whenever possible in future, will now be discussed briefly.

Increase of Water-borne Diseases

Among the most serious effects of irrigation is the spreading of water-borne diseases, and the consequent suffering of millions of human beings and domestic animals. In the tropical and semi-tropical regions of the world, irrigation schemes have enhanced and often created favourable ecological environments for parasitic and water-borne diseases such as schistosomiasis, liver-fluke infections, filariasis, and malaria, to flourish. These diseases are not new: for example, schistosomiasis was known during Pharaonic times. But the unprecedented expansion of perennial irrigation systems has introduced such diseases into previously uncontaminated areas (A.K. Biswas, 1979*b*). Table III indicates some of the water-borne diseases that affect Man.

Schistosomiasis is currently endemic in more than 70 countries, and affects more than 200 million people. Prior to the development of the present extensive

Table II
Yields of Paddy Rice with Different Degrees of Water Control.

Degrees of water control	*Material inputs*	*Location*	*Average yield for 1971–74 in tonnes per hectares*
No water control (rain-fed, uncontrolled flooding)	nil	Laos	1.3
Successive introduction of water control			
Elimination of floods	nil	Kampuchea	1.5
Elimination of drought	low fertilizer application	Burma India Thailand	2.0
Improved water control (irrigation and drainage)	low to medium fertilizer application	Pakistan Vietnam Republic Sri Lanka West Malaysia	 3.0 3.0
Sophisticated management practices (mid-season drying)	high fertilizer use + improved seeds and pest control + diversification mechanization	Republic of Korea Japan	5.0 6.0
Experimental conditions		10.0	

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TABLE III
Water-borne Diseases, Selected Examples.

Parasites	*Diseases transmitted*	*Intermediate host*	*Infection route*
Nematoda:			
Onchocerca volvulus	River Blindness (onchocerciasis)	Black-fly (*Simulium*)	Bite
Wuchereira bancrofti	Elephantiasis (filariasis)	Several mosquitoes	Bite
Protozoa:			
Plasmodium spp.	Malaria	*Anopheles* mosquitoes	Bite
Trypanosoma gambiense	African sleeping-sickness	Tsetse-flies (*Glossina* spp.)	
Trematoda:			
Schistosoma haematobium	Urinary schistosomiasis (bilharziasis)	Aquatic snails (*Bulinus* spp.)	Percutaneous
S. mansoni	Intestinal schistosomiasis	Aquatic snails (*Biompholaria* and *Australorbis* spp.)	Percutaneous
S. japonicum	Visceral schistosomiasis	Amphibious snails (*Oncomelania* spp.)	Percutaneous
Viruses:			
Over 30 mosquito-borne viruses are associated with human infections	Encephalitis; dengue	Several mosquitoes	Bite

irrigation networks, and when agriculture depended primarily on seasonal rainfall, the relationship between the snail-host, schistosome parasite, and human host, was relatively stable, and infection rates were low. Snail populations increased during the rainy season, when agriculture was possible, which provided the contact between Man and parasites. During dry periods, however, there was a lull in infection. With the stabilization of water resource systems through the development of reservoirs and perennial irrigation schemes, the habitats for snails were vastly extended, and they also had a prolonged breeding-phase which substantially increased their populations. Furthermore, it provided more human contacts with parasites, which not only raised infection-rates but also greatly increased the worm-load per Man. The incidence and extension of these diseases can be directly related to the proliferation of irrigation schemes, the stabilization of aquatic biotopes, and subsequent ecological changes with disruption of ecosystems.

The habits and habitats of the snails, as described by Malek (1972), are as follows: 'They breed in many different sites, the essential conditions being the presence of water, relatively solid surfaces for egg-deposition, and some source of food. These conditions are met by a large variety of habitats: streams, irrigation canals, ponds, borrow-pits, flooded areas, lakes, water-cress fields, and rice fields. Thus in general they inhabit shallow waters with organic content, moderate light-penetration, little turbidity, a muddy substratum that is rich in organic matter, submergent or emergent aquatic vegetation, and abundant microflora'. Accordingly water-resource developments—especially impoundments for irrigation, hydropower, or the fishing industry—are most likely to favour increased propagation and spread of these snails.

This relationship has been conclusively demonstrated in several countries of the world. In Egypt, the replacement of flooding or simple primitive irrigation by perennial irrigation, has caused a high incidence of both *Schistosoma mansoni* and *S. haematobium*. Where basin irrigation is still practised, the incidence of the disease is much less. Data from the Egyptian Ministry of Health show that, for Asyut, Sohag, and Qena, Governorates some years ago, the overall prevalence-rate for areas with perennial irrigation was 63.9% (Asyut 68.1%, Sohag 61.9%, and Qena 62%), whereas it was only 16.2% (Asyut 18.5%, Sohag 10.4%, and Qena 13%) in the basin-irrigated areas.

In Sudan, with the introduction of perennial irrigation to 900,000 acres (365,000 ha) under the Gezira Scheme, the incidence of blood-flukes rose greatly (Schalie, 1972), while the incidence of flukes in cattle and sheep also increased. In Kenya, Lake Victoria is rife with schistosomiasis and *S. mansoni* infection in schoolchildren is up to 100% in areas that are associated with irrigation schemes (Alves, 1958). In Transvaal, South Africa, in the early 1950s, the *S. mansoni* infection-rate in 'European' farms was 68.5% compared with only 33.5% in the native reserves, because the former had irrigation (Anneche, 1955). Similarly, in the Far East, irrigation has not only led to increases in schistosomiasis, but also in liver-fluke infections, eosinophilic meningitis, and Bancroftian filariasis (Bardach, 1972).

Constant availability of large quantities of water in reservoirs and canals is conducive to the breeding of mosquitoes, which act as the intermediate host for diseases such as malaria, Bancroftian filariasis, yellow fever, and arbovirus encephalitides. It has been estimated in recent years that over 200 million people are infected with malaria in the tropics and subtropics, and another 250 millions are infected with bancroftian filariasis (UNEP, 1977). Similarly, the relatively exuberant plant growths around water-bodies, provide a suitable situation for tsetse-flies to transmit trypanosomiasis to human beings and domestic animals.

In contrast to the diseases discussed above, water developments tend to reduce the incidence of onchocerciasis. The intermediate host, a black-fly of the genus *Simulium*, tends to breed in fast-flowing waters, which are often 'drowned' by the construction of dams. Thus, the construction of the Volta Dam destroyed the breeding-ground of *Simulium* flies that existed upstream. However, adequate measures should be taken to ensure that new breeding-places do not develop, especially in the fast-flowing waters near spillways.

Salinization Problems

Another major problem of irrigated agriculture is secondary salinization and alkalinization, which have turned millions of hectares of productive land into saline or highly-alkaline barren deserts in the absence of proper drainage systems. Ground-water resources of many areas have been steadily depleted because water was constantly extracted for irrigation without considering the rates of natural replenishment. This has happened in Saudi Arabia, Iraq, Israel, South Africa, Texas, Arizona and Southern California, India, and many other regions. The history of most of these regions is very similar: after a short period of increased food-production, the yields were significantly reduced and in some cases farming had to be abandoned (M.R. Biswas, 1979*a*, 1979*b*).

In Egypt, about 2 million acres (816,000 ha, or approximately one-third) of the old land is affected by salinity, and the newly-reclaimed area of one million acres (408,000 ha) has started to suffer to varying degrees from waterlogging and salinization (Gabaly, 1977). Salinity and alkalinity thus constitute a common problem, indeed in many parts of the world. Over 50% of the irrigated land in the Euphrates Valley in Syria and the lower Rafadain Plain of Iraq suffer from salinity and waterlogging. In Iran, salinity, alkalinity, and waterlogging, are a problem in over 15% of the total area of the country. In Pakistan, 27 million acres (*ca* 11 million ha) out of 31 million acres (*ca* 13 million ha) of irrigated land are affected (Gabaly, 1977). At one time, Pakistan was losing 24,300 ha of fertile cropland every year, and already a decade ago nearly 10% of all Peruvian agriculture was affected by land degradation due to salinization (FAO, 1974).

Among other major areas that are seriously affected by salinization are Helmud Valley in Afghanistan, Imperial Valley and Colorado Basin in the United States, Punjab and Indus Valley in the Indian subcontinent, and Mexicalli Valley in northern Mexico. A study of modern irrigation schemes in the Punjab shows that seepage from unlined canals has, in the first 10 years of operation, raised the water-table 7–9 m above the long-term levels recorded since 1835. On a global scale, at least 200–300 thousand ha of irrigated land are 'lost' every year as a result of salinization and waterlogging (Kovda, 1974). Current estimates indicate that 20–25 million ha of land that is saline at present was fertile and productive at one time (Kovda, 1974).

Population Displacement

Displacement of inhabitants prior to inundation is another important problem of irrigation development. The Volta Dam in Ghana has inundated an area of about 3,275 sq. miles (*ca* 8,482 km^2), and the resulting lake has a shoreline of over 4,000 miles (6,200 km). As a result of the development, some 78,000 people and more than 170,000 domestic animals had to be evacuated from over 700 towns and villages of different sizes. Eventually, 52 new settlements were developed to house 69,149 people from 12,789 families. It was a major social problem, as a large number of people, coming from small villages (600 of the 700 original villages had less than 100 people, and only one had a population of over 4,000), and having often different ethnic backgrounds, languages, traditions, religions, social values, and cultures, had to be resettled in only 52 locations. The complex emotional relationships between the different tribes and their lands were not properly understood. There were many who found it very hard to make a clean break with their ancestral roots, which involved *inter alia* leaving their gods, shrines, and graves of ancestors.

The development of a socially cohesive and integrated community, having a viable institutional infrastructure, became hard to achieve in the area affected by the Volta Dam project. The attainment of economic stability among the settlers had to depend on agricultural products from family farming-plots. Unfortunately, land-clearing schemes did not progress on schedule, and in some cases cleared areas were not ready for farming when the settlers arrived. The World Food Programme had to step in to avoid a major catastrophe (A.K. Biswas, 1979*b*).

Similarly, the Kariba Dam on the Zambesi (Zambia and Zimbabwe or Rhodesia) displaced approximately 57,000 Tonga tribesmen and women, who had to pay a major price for this 'progress'. Technology transfer at that level was a major problem, as many of the planners were from outside Africa. The resettlement programme for the Tonga tribesmen left much to be desired; not only did they suffer great cultural shocks when thrust into communities as different from their own as was theirs from that of the United States, but also it took two years to clear sufficient land to meet their subsistence needs. The Government had to step in to avert famine and very serious hardships and, ironically, this well-intentioned step became one of the most destructive parts of the process. The food distribution centres also became transmission sites for the dreaded sleeping-sickness disease.

Water-quality Problems

Adverse effects of irrigation on water quality include increased salinity, turbidity, colour, taste, temperature, nematodes, Bacteria and viruses, and those resulting from the use of pesticides and nutrients. Irrigation return-flows usually show an increase in salinity and hardness, but the relative importance of these changes varies in the manner illustrated by Hotes & Pearson (1977). The increase in total salts resulting from irrigation normally has the effect of increasing the hardness of river water in the downstream direction, while marked salinity also affects taste.

Other Effects of Dams

Dams built for irrigation and other purposes have also contributed to other serious ecological and environmental problems. The Bennett Dam in Canada, until strong counter-measures were taken, created several environmental problems which very quickly contributed to the deterioration of the life-style in the Peace–Athabasca Delta. Ecological effects on the fish and mammal populations of the area soon reverberated on the people who lived in that area—primarily Treaty Indians and Metis. Their income was substantially reduced, and the social and economic dislocation effects were considerable.

It may be useful at this stage to consider the environment–development costs of the Aswan Dam on the River Nile in Egypt. The Dam was completed in 1968, and is one of the largest dams in the world. Let us consider the environmental costs first.

The Aswan Dam has lowered the fertility of the Nile Valley because of the lack of sediments, and artificial fertilizer has currently to be applied in many areas (A.K. Biswas, 1979*b*). Before the Dam was constructed, large amounts of silt were either deposited on the floor of the Nile Valley or else carried all the way to the Nile Delta and the Mediterranean Sea. The sediments are now being trapped in the reservoir created by the Dam, and clean water is flowing downstream of the Dam and causing erosion to the River's bed and banks.

Another effect of the siltation in the reservoir is the erosion of the Nile Delta, some 1,000 km away. Prior to the construction of the Dam, the Delta used to be built up during the flood season, with the silt carried by the River to the vicinity of the Mediterranean. This situation in the Delta compensated for the erosion that resulted from the winter waves of the preceding year. Without enough siltation, erosion of the Delta has become a major problem, and studies are now being carried on in the hope of finding a suitable solution.

Loss of silt has further affected the productive capacity of the Nile Valley, which used to get regular deposits of sediments every year. Currently, studies are being undertaken to assess the actual nutritive value of the silt, and the trace-elements present therein, so that this loss can be compensated for by using chemical fertilizers.

Lack of sediments downstream of the Dam has contributed to the significant reduction of plankton and organic carbon, and has, in turn, reduced the sardine, scombroid fishes, and crustacean, populations of the area. Loss of sardines in the eastern Mediterranean has created economic problems for the fishermen who used to depend on the catch for their livelihood. Furthermore, there was a thriving small-scale industry of making bricks from the silt dredged from the canals. In the absence of such silt, resort has been had to using the topsoil near the canals to make bricks, thus contributing further to the loss of productive soil in the country. Egyptian research workers have now succeeded in making bricks out of sand, but it will be some time before the local industry can be persuaded to change to it from using topsoil. On the positive side, however, lack of silt has reduced the cost of dredging canals.

The construction of the Aswan High Dam and canal system for irrigation has tended to raise the water-table in many parts of Egypt. Such developments and the tendency to over-irrigate are contributing to an increase in the soil salinization problem, requiring expensive and extensive construction of drainage systems. With the disappearance of the annual Nile floods, the upper limit of ground-water has tended to become stabilized at a higher level than formerly. The salinity in the irrigation canals is increasing, and some of the reclaimed lands are already facing a salinization problem. For example, on a mechanized farm in the West Nubariya sector, the ground-water level rose from 16.2 metres below the surface in October 1969 to only 1.3 metres below the surface in January 1974—an average of 0.94 cm per day (Fig. 1). The salinity of the drainage water increased from 950 ppm in May 1973 to 5,050 ppm in October 1975—an average of 4.81 ppm per day—while the salinity of the irrigation water increased from 1,150 ppm in May 1973 to 3,200 ppm in October 1975—an average of 2.40 ppm per day (Fig. 2).

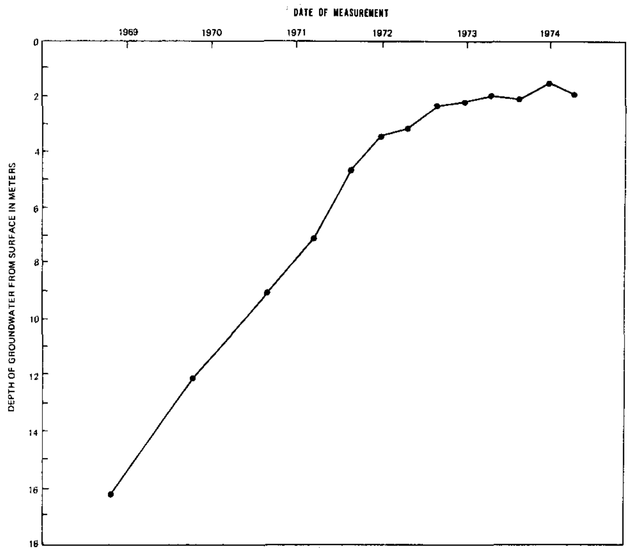

FIG. 1. *Change in ground-water level on an irrigated farm in West Nabariya, Egypt, October 1969–January 1974.*

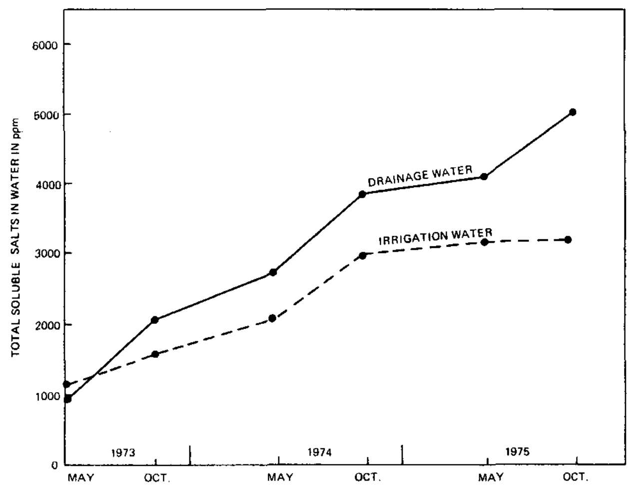

FIG. 2. *Graphs showing increases of drainage (continuous line) and irrigation (broken line) waters on the same irrigated farm in West Nabariya, Egypt, during 1973–5.*

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While much has been written on the negative side about the Aswan Dam, there is no doubt that its contributions to Egypt's economic development have been great. It has provided irrigation for some 400,000 hectares of new agricultural land that was formerly desert. Another 300,000 hectares of land in Upper Egypt, which was under basin irrigation and produced only one crop every year, now produces two or three crops per year with the help of perennial irrigation. Moreover, the productivity of the formerly cultivated land has improved (Abul-Ata, 1979). Navigation on the Nile and its tributaries, from the Aswan Dam to the Mediterranean Sea, has improved substantially. The project can now produce 10,000 million kWh/yr of electrical energy, which is equivalent to the saving of 2 million tonnes of oil per year.

The total cost of the project was Egyptian £450,000,000,* including subsidiary projects and extension of transmission lines. This was recovered in less than two years, at the rate of E £255,000,000 per year. The annual return to the national economy is computed as follows: E £140,000,000 from agricultural development, E £100,000,000 from hydroelectric power generation, E £10,000,000 from flood-control benefits, and E £5,000,000 from navigation improvements. In terms of return on investments, this is very high inded. Thus the real question is not whether the Aswan Dam should have been developed but, rather, what measures should have been taken to reduce the environmental costs to a minimum—to ensure that the benefits accruing from the project are not only maximized but also are sustainable over the long-run.

Conclusion and Summary

Environmental consequences of economic growth and development became an area of major national concern primarily in industrialized countries during the nineteen-sixties. Undesirable side-effects of development became highly visible in terms of air, water, land, and noise, pollution, and people in such countries became concerned with the continuing environmental degradation and impacts on their health and life-style. The emphasis, however, was primarily on the physical environment.

Two problems received much attention: the constantly increasing resource-use in the developed countries, and population explosion in the less-developed countries. Many doomsday scenarios were put forward, and there was a clamour for 'no-growth' in the West. This created much apprehension in the less-developed countries, because development was urgently needed to improve the living-standards of their citizens. Thus, 'pollution of poverty' became an important issue at the UN Conference on the Human Environment, which was held at Stockholm in 1972.

During the early nineteen-seventies, it was gradually accepted that environment and development processes are compatible, and that they are 'the two sides of the same coin'. The complementarity of environment and development processes are discussed in this paper by using irrigation development as a case-study—especially the Aswan High Dam in Egypt. The Dam has contributed to many environmental problems such as increases in water-borne diseases and salinization, erosion of the Nile's delta, reduction of the fish catch in the eastern Mediterranean, and displacement of a large number of people. On the other hand the development benefits were enormous. The investment costs were recovered in only two years. Hence, the real question should be: not whether the Aswan Dam should have been built, but rather what should have been done to reduce the environmental costs which resulted from it.

Development strategies must be sustainable over a long term, and in order for this to happen, Man must work with Nature and not against her, *inter alia* retaining a large range of natural ecosystems as nearly as possible unscathed.

* 1 Egyptian £ = US $1.20 in March 1984.—Ed.

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