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Environment and Water Development in Third World

By Asit K. Biswas, M. ASCE[1]

Introduction

Water is not only essential for man's survival on earth but also is an essential component for the improvement of quality of life of the people living in developing countries. Provision of clean water will undoubtedly contribute to the improvement of health, irrigation will increase food production, electricity can be generated with water, and all industrial products need water to manufacture. Thus, our available water resources has to be used more efficiently and rationally for the benefit of all people.

Water resources development projects, like any other project, have social and environmental impacts, some of which are beneficial and some adverse. The interaction of social and environmental factors are often so complex that it is not always possible to predict the future results accurately.

This paper analyzes the social and environmental effects of water development in the third world under three major categories—physical, biological, and human.

Physical Subsystem

Water development projects invariably change river and ecosystem regimes, and thus the real question is not whether such developments will affect the environment, but how much change is acceptable to society as a whole, and what countermeasures should be taken to keep the adverse changes to a minimum, at a reasonable economic cost, within that acceptable range. The Aswan Dam in Egypt, one of the largest dams of the world that was completed in 1968,

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[1] Dir., Biswas & Assocs., Ottawa, Canada, Pres., International Society for Ecological Modeling; and Vice-Pres., International Water Resources Assoc., Oxford, England.

has received its share of criticisms for contributing to environmental disruptions. The scheme, built primarily for generating hydropower, has produced many environmental problems. A detailed analysis of the benefits and the costs of the Aswan Dam has yet to be made, but many of these effects can now be perceived and are summarized in the following.

First is the question of silt. Before the dam was constructed, large amounts of silt either used to be deposited on the Nile valley or carried all the way to the delta and the sea. These sediments are now being trapped in the reservoir created by the dam. Before the dam was built, suspended matter in the River Nile, passing the Aswan, ranged between 100,000,000 tons/yr–150,000,000 tons/yr. Observations made during the first few years after the completion of the dam indicate that the reservoir is losing about 60,000,000 m^3 of storage/yr due to siltation. At this rate, the dead storage capacity of 30 km^3 will be filled in about 500 yr.

As a result of the siltation in the reservoir, clean water is now flowing downstream of the dam causing erosion to the river bed and banks. One possibility now being considered is to construct a number of barrages to reduce the velocity and force of the clear water. These barrages can also be utilized for power generation. The other possibility is to spill the water into Toshka Depression located to the west of the lake (14).

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 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 out to find a suitable solution.

Loss of silt has further affected the productive capacity of the Nile Valley which used to get regular deposit 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 by using chemical fertilizers. Before the dam was constructed, the silt load carried by the Nile was estimated at 134,000,000 tons/yr (based on 30 yr of available data), of which 125,000,000 tons was accounted for by the flood season. Only 12% of this amount, 16,000,000 tons, was deposited on land, and the rest used to flow with the water to the sea. After the dam was constructed, suspended sediment now being deposited on land is estimated at 4,000,000 tons, thus providing a short-fall of 12,000,000 tons/yr. It has been suggested that the loss of nitrogenous component of silt can be counterbalanced in the cultivated lands by some 13,000 tons of lime nitrate (1).

Lack of sediments downstream of the dam has contributed to the significant reduction of planktons and organic carbons. It has, in turn, reduced the sardine, scombroid and crustacean population of the area. Loss of sardine along 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 on making bricks from the silt dredged from the canals. In the absence of such silts, many such industries have now resorted to using the topsoil near the canals to make bricks, thus contributing further to the loss of productive soil in the country. Egyptian researchers have now succeeded in making bricks out of sand, but it will be some time before the local industry can be persuaded to change from using topsoil to sand. On the positive side, however, lack of silt has reduced the cost of dredging canals.

Besides siltation, other environmental problems created by the Aswan Dam that could be included within the physical subsystem, are change of terrestrial system to aquatic system, hydrometeorological effects, and changes in soil and water quality. The High Dam created a vast reservoir, having a shore-line length of 9,250 km, surface area of 6,216 km^2 and volume of 156.9 km^3 at a 180-m elevation. It changed 500 km of the River Nile from a riverine to lacustrine system. Though much of the land inundated was thinly populated, it contained areas rich in historical monuments, foremost of which was the Abu Simbel temple. Thus, the temples of Abu Simbel and Philae (near Aswan) had to be dismantled and moved to higher locations. The huge man-made reservoir also changed the microclimate of the area. It was calculated that the raising of the water level by 20 km, from 160 m–180 m, more than doubled the lake surface from 2,950 km^2–6,118 km^2, which increased the total annual evaporation from 6 km^3–10 km^3.

The construction of the High Dam and Canal system for irrigation has tended to increase the water table in many parts of Egypt. Such developments and the tendency to over-irrigate is 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 ground-water level has rather stabilized at a higher level. The salinity in the irrigation canals is increasing and some of the reclaimed lands are already facing a salinization problem.

With regard to water quality of the lake, thermal stratification occurs in the summer. This, however, is to be expected since the maximum and mean depths at 180 m elevation are 130.0 m and 25.5 m, respectively. It means that the stagnant water layer at the bottom of the lake is losing dissolved oxygen which cannot be replenished, due to decomposition of organic matters. Consequently, anaerobic biological population is taking over, which reduces nitrates to nitrites and ammonia. It is followed by sulfate reduction. Such anaerobic biosynthesis is contributing to the formation of gases like methane and hydrogen sulfide, which may interfere with water use.

The examination of the preceding environmental effects of the Aswan High Dam is not meant to be a total condemnation of the structure, nor does it imply that it should never have been built. The benefits of the dam are many, and like in any other project, the benefits and costs should be compared. Increase in population and loss of productive soil has steadily decreased per capita cultivated land in Egypt from 0.41 acres in 1930 to 0.18 acres in 1975 (2). The population of Egypt has increased from 20,000,000 in 1952–38,000,000 in 1976 and is expected to reach 100,000,000 by the year 2000. Without the Aswan Dam, the situation would certainly have been far worse.

There is no doubt that the construction of the Aswan High Dam has contributed to much social and environmental costs, but its benefits should not be underestimated. It has not only provided much-needed irrigation water for agricultural expansion in new areas exceeding 2,500,000 feddans, but also has facilitated cultivation of two to three crops annually instead of one in Upper Egypt due to changes from basin to perennial irrigation. It is providing protection against high floods, which means that much of the millions of pounds that were being spent previously for flood control projects can now be diverted to other purposes. The generation of hydroelectric power saves Egypt the equivalent of 2,000,000 tons of oil/yr, which is an important consideration in terms of her chronic balance of payment deficit problems. It has improved the efficiency of the Old Aswan hydropower station. The navigation along the Nile has now been improved. According to Abul Atta (2) the cost of the Aswan Dam and ancillary works, including electrical transmission lines, amounted to 450,000,000 Egyptian pounds. The benefits are now estimated at 255,000,000 Egyptian pounds/yr, which means that the cost of the project is paid for in less than 2 yr—which indeed is a very high return on the investment.

There are cases where water development projects to increase irrigated agriculture have also contributed to problems which eventually reduced total food production. Among such problems are deterioration of soil fertility and eventual loss of good arable land, due to progressive development of salinity or alkalinity. For example, at one time Pakistan alone was losing 24,280 ha of fertile cropland every year, and currently, nearly 10% of the total Peruvian agricultural area is affected by land degradation due to salinization. Among other major areas affected by salinization are the Helmud Valley in Afghanistan, the Punjab and Indus Valleys in the Indian subcontinent, Mexcali Valley in Northern Mexico, Imperial Valley in California, and the Euphrates and Tigris basins in Syria and Iraq. A study of major modern irrigation schemes in the Punjab shows that seepage from unlined canals has in the first 10 yr of operation, raised the water table 7 m–9 m above the long-term levels recorded since 1835 (10).

Water is also responsible for soil erosion, and thus it is no surprise to find that the dominant forms of soil erosion in countries like the United States is due to runoff which carries away fine sediments. Nearly 4 billion tons of sediments are carried every year to the streams in the 48 contiguous states, nearly 75% of which come from agricultural lands (10). One-quarter of the water-borne sediments eventually end up in the oceans, but the rest remain in lakes, reservoirs and rivers, creating environmental problems. The economic cost of siltation to the United States is quite significant. Currently some 450,000,000 yd^3 of sediment are dredged every year from water bodies at a cost of about $250,000,000. Sediments also continually reduce the economic lives of man-made lakes which costs the nation a further $50,000,000 annually. These, plus other damages, are estimated at approx $500,000,000/yr. The total cost of soil erosion due to water is obviously much higher since the damages estimated do not include the cost of agricultural products that might have been raised, had the soil degradation not taken place. Such damages run to about 2% of the total economic value of agricultural products raised every year.

Studies carried out in Kenya during the period 1948–1965, show great variations in erosion and sedimentation in different parts of the country. Highest rates of soil erosion occurred in an area of very steep slopes on the eastern sides of Mount Kenya, where land is cultivated on the steep valley slopes of the upper part of the basin, and cultivation and grazing being the dominant form of land use along the gentler but drier hillslopes of the lower parts. Thus, the annual rate of soil loss in the catchment area of the Tana River varied from 1,550 ton/sq km, between Kindaruma and Grandfalls (agriculture/grazing), to about 320 ton/sq km above Kamburu Dam (agriculture/forestry) (19). In contrast, soil erosion in undisturbed forest, in areas of steep slopes, is extremely low. For example, in the Sagana Drainage Basin, the annual rate of soil loss is approx 4 ton/sq km. Soil loss tends to increase under agricultural conditions and is much greater in pastoral semi-arid parts of the country.

On a global scale approx 20,000,000 km^2 of soil has been destroyed or degraded, which is nearly 35% more than the 14,000,000 km^2–15,000,000 km^2 of arable land currently being used for agriculture. Currently 46% of the total degradation of the earth's surface due to different hazards can be directly related to water. These hazards can be roughly estimated as follows: water erosion, 22%; waterlogging and flood damage, 8%; salinity and alkalinity, 5%; and frost, 11%.

Finally, the possibility of inducing earthquakes by construction of large dams is another environmental problem that has not received adequate attention so far. The 1967 Koyna Dam disaster in the Indian peninsula, which resulted in a heavy loss of lives and considerable property damage, was due to an earthquake whose epicenter coincided with the dam itself. Several recent studies indicate that the observed seismic activity can be attributed directly to the creation of dams and storage reservoirs. Some of the tremors thus caused can reach magnitudes of up to six in the Richter scale and thus contribute to considerable damage. In general, the seismic distirbances can be traced to the existence of inactive faults and it seems likely that the effect of the added forces contributed by the dam and reservoir liberate orogenic tensions of much greater strength. Studies at the Kariba Dam sites appear to confirm this theory. It also appears that the height of the water column is a more important parameter in inducing earthquakes than the total volume of the reservoir. The seismic activity tends to become more pronounced once the depth exceeds 100 m (20).

Biological Subsystem

Water resources development can affect biological subsystem in many different ways, and the effects can be either beneficial or adverse. Since the quality of water is of prime importance to human health, the availability of potable water to much of mankind is literally a matter of life and death. The World Health Organization (WHO) carried out a survey in 1976 on the availability of potable water in developing countries to the end of 1975. Based on the survey questionnaire that was returned by 67 developing countries, the following seems to be the current situation. In urban communities, 57% of the population have house connections and another 18% have access to stand-pipes, making a total of 75% (390,000,000 people) that have access to potable water. The situation, as might be expected, is far worse for the rural sector, where only 20% (248,000,000) have reasonable access to safe water. If both rural and urban populations are considered, only 35% (638,000,000) are adequately served.

These, of course, are average figures, and hide the tremendous disparity that exists even within the developing countries. The range of this disparity can be easily seen by considering community water supply situation in the African continent. At the upper range are several countries where more than 90% of the urban population are served by potable water. These are Botswana, Lesotho, Liberia (all 100%); Mauritius, Senegal (98%); Gambia, Guinea, Ivory Coast, Kenya, Togo, Zambia (97%); Benin, Egypt (94%); Morocco and Tunisia (91%). At the bottom end of the scale are the rural populations of several countries, where even 5% do not have access to safe water. These are Burundi, Gabon, Madagascar, Sierra Leone (1% or less); Kenya (2%); Gambia (3%); Togo and Zaire (5%). In addition, there are several other countries where data on rural sectors are not available, but they are virtually certain to be less than 5%. These are Central African Republic, Ethiopia, Guinea and Lesotho (22).

Universal availability of potable water will undoubtedly reduce health hazards like cholera, typhoid, infectious hepatitis, amoebiasis, enterovirus diarrheas, and bacillary dysentery. It would further reduce human contacts with vectors of water-borne or water-based diseases like schistosomiasis, trypanosomiasis,

TABLE 1.—Water-Borne Diseases, Selected Examples

Parasites (1)	Diseases transmitted (2)	Intermediate host (3)	Infection route (4)
Nematoda			
Onchocerca volvulus	River blindness (onchocerciasis)	Black fly (Simulium)	Bite
Wuchereira bancrofti	Elephantiasis (filariasis)	Several mosquitoes	Bite
Protozoa			
Plasmodium spp.	Malaria	Anopheles mosquito	Bite
Trypanosoma gambiense	African sleeping sickness	Tsetse fly (Glossina p.)	Bite
Trematoda			
Schistosoma haematobium	Urinary schistosomiasis (bilharziasis)	Aquatic smail (Bulinus)	Percutaneous
Schistosoma mansoni	Intestinal schistosomiasis	Aquatic snails (Biompholaria; Australorbis)	Percutaneous
Schistosoma japonicum	Visceral schistosomiasis	Amphibious snail (Oncomelania)	Percutaneous
Viruses			
Over 30 mosquito-borne viruses are associated with human infections	Encephalitis; dengue	Several mosquitoes	Bite

or guinea worm (*Dracunculus Medinensis*). Schistosomiasis will be considered later. With regard to trypanosomiasis, some have estimated that the Gambian sleeping sickness, *Trypanosoma gambiense*, can be reduced by 80% by good water supply schemes (11). While this figure may be somewhat optimistic, there is no doubt that the provision of potable water will reduce the incidence of the dreaded sleeping sickness disease by reducing the exposure of human beings to Tsetse flies during the water collection journey. Similarly, guinea worm infection, which currently affects some 48,000,000 people, chiefly in India and West Africa (17) can also be reduced. Maximum infection occurs during dry periods, when people rely on ponds and other shallow sources. Infection rates of over 50% have been observed in India and Nigeria, and incidences of around 20%–30% are commonly reported (13). The health and economic costs to the communities can be substantially reduced by rational water resources development and management. It would further reduce or eliminate the time necessary for the water collection journey, which will be examined later in the section on Human Subsystems.

Water resources developments, however, do not only bring unmitigated benefits: they also often are responsible for unanticipated social costs. Thus, one of the most serious impacts of irrigation developments in the tropical and semi-tropical regions is the secondary effect of spreading water-borne diseases, and the consequent suffering of millions of human beings and animals. Irrigation schemes have often enhanced or created favorable ecological environments for parasitic and water-borne diseases such as schistosomiasis, dengue plus dengue hemorrhagic fever, liver fluke infections, bancroftian filariasis, and malaria to flourish. These diseases are not new: for example, schistosomiasis was known during the Pharaonic times. But unprecedented expansion of perennial irrigation systems has introduced such diseases into previously uncontaminated areas. Table 1 shows some of the water-borne diseases that affect man.

Schistosomiasis is currently endemic in over 70 countries, and affects over 200,000,000 people. Prior to the development of the present extensive irrigation networks, and when agriculture depended primarily on seasonal rainfall, the relationship between snail host, schistosome parasite and human host was somewhat stabilized, 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 population. Furthermore, it provided more human contacts with parasites, which not only raised infection rates but also greatly increased worm load per man. The incidence and extension of these diseases can be directly related to the proliferation of irrigation schemes, the stabilization of the aquatic biotope and subsequent ecological changes.

Malek (18) described the characteristics of snail habitats:

> 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 rich in organic matter, submergent or emergent aquatic vegetation, and abundant micro-flora.

Thus, water resources developments, especially improvements for hydropower, irrigation or fishing industry, are most likely to favor increased propagation and spread of these snails (26).

The relationship between water developments and increase in schistosomiasis has been conclusively demonstrated in several countries of the world. In Egypt, the replacement of simple primitive irrigation with perennial irrigation has caused a high incidence of both *S. mansoni* and *S. haematobium*. Where basin irrigation is still practiced, the incidence is much less. Infection rates in four selected areas, within 3 yr of introduction of perennial irrigation, rose from 10%–44%, 7%–50%, 11%–64%, and 2%–75%. The life expectancy of males and females in heavily infected areas is estimated to be 27 yr and 25 yr respectively. In Sudan, with the introduction of perennial irrigation to 900,000 acres under the Gezira Scheme, the incidence of blood fluke rose greatly. It also increased the incidence of flukes in cattle and sheep. In Kenya, the Lake Victoria is hyperendemic for schistosomiasis. *S. mansoni* infection in school children is up to 100% in areas associated with irrigation schemes. In Transvaal, South Africa, the *S. mansoni* infection rate in European farms was 68.5% compared with only 33.5% in the reserves, because the former had irrigation. Similarly, in the Far East, irrigation has not only increased schistosomiasis, but also diseases like liver fluke infections, eosinophilic meningitis, and bancroftian filariasis (5).

Constant availability of large quantity of water in reservoirs and canals is also conducive to the breeding of mosquitoes, which act as intermediate host for diseases like malaria, bancroftian filariasis, yellow fever or arbovirus encephalitides. Currently it is estimated that over 200,000,000 people are infected with malaria in the tropics and subtropics and another 250,000,000 are infected with bancroftian filariasis (23). Similarly, plant growths around water bodies provide a suitable habitat for the tsetse fly to transmit trypanosomiasis to human beings and domestic animals.

In contrast to the diseases previously mentioned, water developments tend to reduce the incidence of onchocerciasis. The intermediate host, simulum fly, 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 simulum fly 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.

Many cases can be cited in developing countries of Africa, Asia, and Latin America where society has had to pay heavy prices for water development schemes in terms of the overall health of the region as well as through ecological deterioration. Thus, irrigation developments do not automatically and necessarily bring unmitigated benefits to mankind: they can, and do, extract high costs as well. What is necessary is a determined attempt to minimize the costs and maximize the benefits of such developments on a long-term sustaining basis. This can only be done if ecological and environmental principles are explicitly considered in the overall planning process right from the very beginning.

Aquatic weeds also can be the result of water resources development, especially in the tropics and semitropics. Serious problems of weed growth have been observed at Aswan, Kariba (Zambia and Rhodesia), Nam Pong (Thailand), and Brokopondo (Surinam). Unless adequate preventive measures are taken, growth of aquatic weed can be very fast. Thus, *Eichhornia crassipes*, commonly known as water hyacinth, covered an area of about 50 sq km in the Lake Brokopondo within the short period of February–December, 1964. In little over 2 yr, by April 1966, it had covered more than 50% of the surface of the reservoir, an area of about 410 sq km. Similarly, in Egypt, weeds were not a problem till 1964. However, in 1965, water hyacinth started to spread prolifically in the majority of drains and many canals in Middle Egypt and the Delta area. By the beginning of the spring of 1975, various types of aquatic weeds, sometimes mixed with dense algae, had invaded more than 80% of all the watercourses and a great part of the Nile itself (16). Experience in the Congo Basin has been somewhat similar. Between 1952, when the weeds were first observed, and 1955, they spread a distance of some 1,600 km, covering large areas of the Congo River.

In terms of water availability, and efficiency of water use, weeds are a great nuisance. Loss of water occurs due to two principal reasons. Firstly, a large amount of water is necessary in the canals for flow augmentation in order to ensure adequate quantity of water is available in the lower reaches. Secondly, water losses are greatly enhanced by evapotranspiration process of the weeds. These two factors often account for a tremendous amount of water loss. Thus, at Aswan, it has been estimated that 2,875,000,000 m^3 of water is lost per year due to the preceding two factors alone. A better perspective can be obtained, if it is considered that at present prices, 2,875,000,000 m^3 of annual over-year storage on the upper reaches of the Nile at Aswan will cost some $216,000,000 which is not an insignificant figure (16). In addition to water loss, there are other direct benefits which accrue from the control of aquatic weeds. Among these are: (1) Significant increase in the efficiency of operation of drainage networks; (2) improvement of water quality; (3) lowering of the level of the watertable, and thus less drainage requirements; (4) improvement of navigation; (5) reduction in dredging and excavation; (6) reduction of incidence of malaria and schistosomiasis since weeds tend to support invertebrates such as mosquitoes and aquatic snails, which are vectors and intermediate hosts for disease-causing agents; (7) less problems with the operation and maintenance of pumping and hydroelectric stations; and (8) reduction in competition with fish for space and nutrients.

Control of aquatic weeds in the tropics and semitropics, especially after invasion, is a difficult and expensive task. Mechanized or manual clearing of weeds, especially in shallow waters, has been quite successful, but in deep waters it is not a very viable alternative. Weeds thus removed can be used to produce animal feed, biogas or manure. In certain countries like China, aquatic plants are specially cultivated as animal feed.

Chemical herbicides have been extensively used to control weeds. Thus, Egypt has a major program for spraying 2,4-D using motor launches and boats in the River Nile and the northern lakes (16). Chemical control is not very effective for submerged weeds. In addition, herbicides often pose a major environmental hazard to aquatic organisms, deteriorate water quality and their long-term effects on aquatic ecosystem and human health are little understood.

The third type of control is biological, wherein fish, snails or aquatic grasshoppers are introduced to control weeds. There is still much to be learned on the use of biological controls. Naturally, the three control measures are not mutually exclusive; often they are used in various combinations for optimal weed control. The type of control measures to be used depends on various local situations such as the type of weed, density of infestation, depth and width of the channel, time of application, water use pattern, proximity of crop area sensitive to herbicides, availability of material from local or foreign sources, and availability of skilled manpower.

Human Subsystem

The impacts of water developments on human subsystem could be direct or indirect, stemming from direct effects on physical and biological subsystems. These impacts can either be beneficial or adverse.

Provision of potable water to the rural or urban population is undoubtedly a major benefit of water developments. It immediately reduces the health hazards significantly, and further contributes to other major direct and indirect benefits. Thus, it is not surprising that the UN Conference on Human Settlements considered the availability of potable water to all the population of the world a priority item, and recommended that such a development should be complete by 1990 (7). The recently convened UN Water Conference further reendorsed the importance of this step (9).

TABLE 2.—Time Spent for Water Collection in Africa

Distance between water source and consumer, in miles (1)	Time spent in collecting water, in hours (2)	Time spent in collecting water to average daily working time, as a percentage (3)
0.25	0.166	2.8
0.50	0.333	5.5
1.00	0.667	11.1
2.00	1.333	22.2
3.00	2.000	33.3
4.00	2.667	44.4
5.00	3.333	55.5
6.00	4.000	66.6
7.00	4.667	77.7
8.00	5.333	88.8
9.00	6.000	100.0

A major beneficiary of the availability of potable water will be the women of the developing world, who currently spend considerable time in carrying water and collecting firewood. According to the Economic Commission for Africa of the United Nations, 90% of all water and fuel is collected by women: men only contribute to 10% of this task (21). Thus, rational water resources development and management will reduce the water collection journey, mainly of women and children, who currently spend up to 5 hr every day collecting the family water requirements (25). Table 2 shows that time spent in carrying water is a function of the distance of the source from the consumer, and also how it affects the total daily working time of water carriers (24). It shows that if the water source is about 4-1/2 miles away, a woman would spend at least 3 hr a day carrying water or 50% of her daily working time. If this time can be freed by providing water closer to the residences, it can be used for learning productive work.

Time and inconvenience are not the only disadvantages of long water collection journey for the women of the developing countries: it extolls other costs as well. It has been estimated that it takes up to 12% of daytime calorie needs of most carriers in nondry areas and in drier areas and in mountainous regions, energy spent in collecting water and firewood may take up to 25% or more of the daytime calories (12). Women are not traditionally the most well-nourished member of the family: the most nutritious food being normally reserved for the men, the breadwinners of the family (9). Thus, elimination of water collection journey for women, by providing potable water closer to home, has not only important implications in terms of reduced disease propagation (since contacts with disease vectors during long water collection journey will be eliminated) but also in terms of nutrition, a fact often overlooked by planners and politicians.

All impacts on the human subsystem due to water developments, however, are not beneficial: there are many adverse impacts as well (5). Many of the effects mentioned earlier under the sections on physical and biological subsystems do also have impacts on the human subsystem. However, distinction could be made that such developments initially contribute to environmental and ecological changes, which in turn affect the human subsystem. Under the present section, only direct impacts on the human subsystem will be considered.

Many of the major water development projects have also created other human problems, especially in terms of displacement of local inhabitants. Thus, the Volta Dam in Ghana has inundated an area of about 3,275 sq miles, and the resulting lake has a shoreline of over 4,000 miles. 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 (15). It was a major social problem since 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 different ethnic backgrounds, languages, traditions, religions, social values, and cultures, had to be resettled into 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, by 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.

The economic stability of the settlers depended 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 Program had to step in to avoid a major catastrophe (4).

Similarly, the Kariba Dam on the Zambesi (Zambia and Rhodesia) displaced approx 57,000 Tonga tribesmen, who had to pay a major price for this progress. Technology transfer at that level was a major problem, since many of the planners were from outside Africa. The resettlement program for the Tonga tribesmen left much to be desired; not only did they suffer great cultural shocks when being thrust into communities as different from their own as theirs from Great Britain, but also it took 2 yr 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. However, there is no doubt that many of these development projects have contributed to unanticipated adverse secondary effects, some of which could have been eliminated and others reduced in magnitude by appropriate planning process. Furthermore, there appears to be a considerable difference of opinions on criteria and techniques by which successes or failures of projects can be judged. Thus, it is not exactly unusual to find a major water development project hailed as a technological triumph by engineers, welcomed as a success in terms of economic efficiency and regional income distribution by economists, but seriously questioned as to its desirability by environmentalists and sociologists. Such an anomalous situation often indicates the lack of adequate interdisciplinary interactions during the planning process, which means the objective functions that are being maximized by different groups are not the same. Lack of public participation during the planning and construction phases further complicates the situation.

The addition of environmental quality in recent years to the other two traditionally accepted objectives of water resources development—economic efficiency and regional income redistribution—has made the planning process more complex than ever before. Inclusion of environmental quality as an objective of development recognizes the fact that the welfare of the society has other dimensions besides economics, and thus the real question is not whether environmental quality should be considered as a planning objective, but rather how should it be incorporated objectively within the planning framework. Existing analytical techniques available for making planning decisions cannot effectively cope with the social, ecological and environmental concerns. To give just one example, economic analyses in terms of marginal benefit-cost consideration cannot handle these types of complex problems. Damages to the environment caused by the construction of a dam, whether to the beauty of a canyon or the countryside, or to the overall ecology, cannot be analyzed by the fine tuning of marginalism. Neither can this approach be successfully used where benefits are short-run and quantifiable while the costs are long-run and often unknown and unquantifiable (10). Such analyses often involve the question of value judgement. The cost upgrading the quality of water, air or land is measurable, but the benefits accrued by improving an additional unit of water, air or land quality is immeasurable, and thus in the realm of values. Such situations, however, are not unique: like many other social choices, decisions and value judgements have to be made through the political process.

Finally, planning is for the people, and planners must give adequate emphasis to the social and environmental consequences stemming from water development projects. Technical and economic feasibility studies are needed, but equally necessary are social and environmental feasibility studies. Without such analyses, public understanding and acceptance of the program, an important parameter to judge the success of water development projects may not be complete. Planners and engineers must learn from past mistakes committed, and should not make similar mistakes all over again. The planning process should become more sensitive to social and environmental problems, since long-term sustaining developments can only take place within the framework of appropriate environmental guidelines: otherwise, the overall strategy of development will be self-defeating. Harmony can come only with integrated planning but discord is comparatively easy to produce.

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15295 ENVIRONMENT AND DEVELOPMENT IN THIRD WORLD

KEY WORDS: **Dams; Developing countries;** Diseases; **Egypt;** Environmental factors; Resettlement; **Rural areas; Water demand; Water supply**

ABSTRACT: Water resources development is an essential component for further improvement in the life style of the people of the third world. Community water supply is a basic necessity, but water is necessary to improve agricultural yields, increase hydroelectric power generation and for further industrial development. Water resources projects invariably change river and ecosystems regimes, some of which are adverse. Hence, the real question is not whether such changes will have social and environmental impacts, but rather how much changes is acceptable to society and how can the adverse change be kept to a minimum. The changes can be broadly divided into three major subsystems—physical, biological and human. Within this general framework, environmental implications of water developments in the developing countries are considered, with concrete examples of such changes from different parts of the world. Special mention is made of the Aswan Dam on the Nile.

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