HEALTH, ENVIRONMENT AND WATER DEVELOPMENT: AN UNDERSTANDING OF THE INTERRELATIONSHIPS

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ABSTRACT. Our understanding of the interrelationships between people, resources, environment and development has advanced significantly during the past decade. This paper reviews the close interrelationships among health, environment and water development — both small and large scale — and points out that changes in one area are likely to have repercussions in other areas. Some of these changes could be beneficial while others could be adverse. Examples of such changes are given from different parts of the world. It is argued that without proper understanding of these interrelationships, it is unlikely that water development projects can be sustained over the long term or continue to produce optimal benefits.

INTRODUCTION

A seminal event in the history of the environmental movement was the United Nations Conference on the Human Environment held in Stockholm in June 1972. An analysis of the report of this Conference will indicate that though there was reasonable understanding at that time of the the interrelationships between population resources, environment and development, the approaches adopted in the resolutions were basically sectoral (Biswas and Biswas, 1982). Since that time, our understanding of the development processes has advanced significantly, and to a great extent it was facilitated by the work of the United Nations Environment Programme (UNEP). Of particular help was the personal interest of its Executive Director, Dr. Mostafa Kamal Tolba (1982). Currently it is better recognised that development is a multi-dimensional concept which encompasses not only economic and social activities, but also those related to population, the use of natural resources, and their resulting impacts on the environment (Biswas and Biswas, 1985).

While the concept of interrelationships is not novel, the need for rapid development and technological advancement has meant that, very often, whatever knowledge of interrelationships was available tended to be disregarded. However, attempts to solve seemingly technical problems such as desertification, loss of productive soil, water development or deforestation have indicated that emphasis should be placed not only on such physical factors as climate, soil type, modes of cultivation or land-use patterns, but also on diverse factors including demographic trends, types of technology used, levels and distribution of income among the population, consumption patterns, cultural habits and educational levels of the inhabitants.

Without such a holistic approach, actions taken to solve specific problems may give rise to several other unintended side effects, the sum total of which could even be worse than the problems initially addressed. To some extent this is due to the fact that the nature of beneficiaries often tends

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to be different. Much of the benefits of the original action tend to accrue to a more educated and powerful section of the population, whereas the adverse side-effects, to a large extent, are borne by people who do not have a power base and as such are not in a position to influence the socio-economic decisions which affect their own lives and lifestyles.

ISSUES INVOLVED

The study of interrelationships among people, resources, environment and development is important for three major and interlinked reasons. First, it is increasingly evident that development efforts, at all stages of growth and in countries having different social, economic and cultural backgrounds, institutional infrastructures and availability of natural resources, tend to produce systemic effects at national, regional and global levels that have a cumulative impact on the overall productive process and the attainment of long-term development objectives. Secondly, it is also increasingly evident that such systemic effects result from strong interactions between economic, social, demographic and physical factors. Thirdly, since the exact causal links between these interactions are at present unknown, there is considerable uncertainty with regard to the likely long-term impact of such systemic effects; consequently, attention has largely focused on the risks of negative impacts, even though the probability of positive impacts is perhaps equally high.

Taken together, these three considerations suggest the need for a more constructive approach, emphasising that the study of the interrelationships should clarify causal linkages and identify points of leverage. Appropriate integrated policies and programmes can then be adopted; this would start a cycle of positive impacts in terms of attaining both developmental and environmental objectives, and ensuring that development can be sustainable over a long-term basis.

The critical issues are not so much the rate of population growth and the insufficiency or the unavailability of natural resources, but rather the uneven geographical distribution of population relative to the carrying capacity of land and the inefficient and irrational use of natural resources. Consideration of these fundamental issues broadens the scope of discussion from resource depletion, environmental degradation and population growth to include resource redistribution and transfer, environmental management that encourages more rational use of resources, development of appropriate technologies, and population movement.

Environmental management of this kind would require better understanding and cooperation among, as well as within, nations, since ultimately, the interrelationships between the four areas frequently extend beyond national boundaries. In the final analysis, study of the interrelationships becomes a collective responsibility of the entire international community.

Many of the conceptual issues associated with the interrelationships among people, resources, environment and development were clarified during the 1970s and are better understood and more widely recognized at present than they were at the time of the Stockholm Conference. Understanding of the interrelationships is still incomplete, however. Much work remains to be done during the next decade to analyse the underlying complexities, identify their policy implications and use the resultant knowledge successfully in operational contexts.

The development process can then benefit from an integrated approach, rather than the sectoral approach which is all too common at present. Techniques and means will have to be developed not only for devising intersectoral policies and programmes at national, regional and global levels, but also for ensuring their effective implementation. Such developments should finally lead to rational resources management and effective environmental protection.

It is not possible to analyse the interrelationship concept comprehensively here because of space constraints. Accordingly, only one aspect — the interrelationship between the health of people, environment, and water resource development — will be examined below.

HEALTH, ENVIRONMENT AND WATER DEVELOPMENT

Health of the people, environment and water development are closely interrelated. One affects the other, and in turn is affected by the others.

There are three important ways by which the impacts of water development on health and the environment can be examined. These are:

- drinking-water supply
- large-scale water development
- agricultural and/or rural development, of which water development is an integral part

DRINKING WATER SUPPLY

No sane person would argue with the statement that access to safe drinking water and hygienic disposal of wastes should be an important social goal of every nation. From experience in advanced industrialized countries, we know that water-related communicable diseases are now very rare due to running water in all homes, coupled with satisfactory sewage and waste disposal facilities. In addition, however, these are reinforced by the availability and knowledge of health care.

It is not possible at present to define precisely

the relationship between quality of water and public health. Other broad and diverse elements like housing, comprehensive health services, availability of nutritious food, energy, education and transportation are also important. Many of the health and other related benefits most people now expect from the provision of clean water to rural communities in developing countries are unlikely to accrue unless rural water supply and sanitation are considered within the overall context of integrated rural development. The necessity for such an integrated approach is becoming evident as many projects in developing countries are now unable to deliver all the benefits expected.

Clean Water Is Part of the Answer

Here are two brief examples. One is a disease that can indeed be eliminated by providing clean water, with minimal added steps. But for the second disease — in fact, for a whole range of waterborne diseases — clean water is only part of the answer.

First is guinea worm disease, currently prevalent in developing countries of Asia and West Africa. It can be eliminated by the provision of clean water and improved education. The disease is transmitted by drinking water containing a crustacean water flea — Cyclops — which carries the larvae. The larvae develop in the walls of human digestive systems, from which the adult female worm migrates toward the skin. It then grows and causes sores. After about a year it emerges, usually through the victim's legs or skin. When the victim comes in contact with fresh water, the larvae are released, which are then eaten by Cyclops. When another person drinks the water, the cycle starts again.

The mature worm can reach up to four feet in length. The only well-known but highly unsatisfactory treatment is to wind the worm around a stick and pull it out slowly day by day. If it breaks, a severe abscess results. Guinea worm infection seldom kills, but it does cause disabilities due to painful abscesses and ulcers — usually in legs and feet. About 5% of the victims become permanently disabled. In some areas, epidemics have incapacitated 30% to 50% of the inhabitants.

Current estimates of those infected range from 10 to 48 million every year; 20 million infections per year is a likely average. In some places, like Andhra Pradesh in India, many people become infected 50 to 100 times during their lifetime, and some have suffered for 20 to 30 years at a stretch.

Provision of piped water has already reduced guinea worm infections from 60% to zero in some towns in Nigeria. By educating the people about the intermediate host — Cyclops — and by simply filtering the contaminated water through a double-thickness cotton cloth, the incidences can be eliminated. Similarly, by enclosing the step-wells (so called because one has to step in to draw water) by a brick wall and thus forcing people to draw water by a rope, the transmission cycle can be easily broken. Such measures successfully eradicated the disease in Tashkent and Samarkand in the Soviet Union some 40 years ago, and have already reduced its incidence in the Indian provinces of Andhra Pradesh and Rajastan (Biswas, 1981a).

Contrasting Case

The second example is the incidence of diarrheal disease. Studies in Bangladesh (Levine et al., 1976), Guatemala (Gordon et al., 1984), Lesotho (Feachem et al.,1978), and the United States (Schliessmann et al., 1958) have failed to demonstrate that improvements in water quality had any marked impact on the diarrheal disease. The reasons for such findings are complex, but a brief discussion is in order.

Unfortunately, water is not the only means through which fecal-oral diseases like cholera, typhoid, diarrheas, dysenteries or hepatitis are transmitted. Unless it is clearly known that diarrheal disease is almost exclusively waterborne in a specific community, improvement of water quality alone is unlikely to change the incidence of the disease significantly.

Quality of Water

Moreover, improving water quality via standpipes does not automatically improve personal hygiene practices which have developed over centuries. In very few instances where potable rural water supply schemes have been developed have provisions also been made for bathing and laundry facilities. People thus continue to use contaminated sources for such purposes, and these continue to remain a source of infection. House connections or communal washing and laundry facilities need to be provided before a marked decrease in such water-related diseases can be expected.

Thus the importance of educating the public about good hygienic practices cannot be overemphasized. At present, such services in rural areas are mostly nonexistent, even for those households which are looking for information.

As the examples just given suggest, quality of water alone is unlikely to bring all the benefits expected. Especially for the key objective of better health, two other factors need to be considered: quantity of water used and education.

Quantity of Water

From the empirical studies available so far, it is becoming increasingly evident that quantity of water used has an important impact on health.

How much water do we need per person per day? There are no simple answers. Even the needs for basic survival depend on body size, climate, type of work being performed, etc. Normally, the basic survival requirement per person is about 5 liters a day.

But survival needs are very different from health needs, which are significantly greater. Information on the minimum amount of water consumption needed to maintain adequate health is scarce, but some indication can be obtained from a 10-year study carried out in Singapore from 1960 to 1970. This study attempts to correlate domestic water use in relation to waterborne diseases reported in Singapore hospitals. Predictably, it indicates that as domestic use goes up, disease goes down. However, there did not seem to be much improvement beyond 90 litres per capita per day of high quality use. Hence, it could be concluded that this amount represents a "social minimum" for that area.

Unfortunately, other studies of this kind are not available to enable us to draw firm conclusions. For example, we do know that as the standard of living increases, so does water consumption. Accordingly, for the Singapore study, it is highly likely that some socioeconomic indicators changed as well when per capita water consumption increased, which means that the reduction in incidence of diseases cannot be solely attributed to the increase in water use.

Currently, most water consumption figures in developing countries are arbitrarily fixed at around 15-25 litres per capita per day. This seems well below any reasonable health minimum, although it may also understate the amounts actually consumed once community supplies are available. On the other hand, the simple provision of standpipes does not appear to increase water use patterns in the villages; the change really occurs when taps are available in individual houses. Once a household has a tap and bathing facilities, water use increases and health improvements are appreciable. But, plainly, an enormous effort still needs to be made not only to provide facilities but to persuade people to make full use of them.

Health Education

This leads to the next issue: the importance of education. With rural people, some of the basic points of personal hygiene must be instilled: i.e., discontinuing the use of contaminated water for drinking, cooking, washing and bathing; boiling contaminated water if it is to be used; storage of water; and basic sanitation requirements in handling food products and disposing of waste products. The effectiveness of education will ultimately decide whether all the benefits of community water supply programmes are realized. Unfortunately, this simple lesson has still not been fully grasped by most national and international agencies dealing with community water supply.

A brief illustration is provided by my hometown in India, Balasore, where standpipes and some house connections have been installed in recent years.

- People have no information on how to store water, so that contamination takes place at home.
- Although they may have safe water at home, people think nothing of drinking from the nearest water source, regardless of its condition, when they are away from home and thirsty.
- Small children, who normally have the highest incidence of diarrheal diseases, often are not taught to use the improved water supply.
- In most instances, there is no provision for drainage of spilled water at the standpipes, with the result that pools of stagnant water (a common sight in most developing countries) become breeding grounds for mosquitoes and other insects. Balasore now has more malaria than before, and has, in effect, traded waterborne for mosquito-borne disease!
- When the system breaks down, as it does frequently, people resort to contaminated sources — and are now more vulnerable to infection after having used clean water for a time.
- Provision of standpipes has not increased the volume of water-use per capita.

In short, providing quality is only the beginning in terms of the ultimate goal of improved health. There must be enough water, and people must be educated in its use. While these aspects of the problem must be primarily the responsibility of national and local authorities, they affect the plans of international agencies as well.

LARGE-SCALE WATER DEVELOPMENT

Conceptually, the health implications of water resources development projects can be divided into two broad categories: short-term and long-term problems. Short-term health impacts occur during the planning, construction and immediate post-construction phases when filling the reservoirs (Biswas, 1984; Biswas, 1982; Biswas 1980a). Longer-term health impacts stem from the presence of large man-made lakes, development of perennial irrigation instead of seasonal irrigation, alteration in the ecosystem of the area, and the changing socio-economic situation.

Short-term Health Impacts

Since water resources development projects require major constructions such as dams, spillways, and diversion works, they create new employment opportunities, and new workers of different cate-

gories move into the areas near construction sites in large numbers. Since dams are often built in remote, undeveloped regions, they lack suitable housing, sanitation and other infrastructural facilities. Even when they are not in remote regions, host communities are seldom able to absorb large numbers of immigrant workers without encountering serious social problems.

In developing countries, labour-intensive technology is often used to construct such large structures, and this invariably means that a large number of unskilled and uneducated labourers arrive at construction sites in search of employment. It is often not possible to satisfy labour requirements locally. For example, during the construction of the Aswan Dam, contractors were forced to transport labourers from neighbouring governorates to the construction sites. Similarly, for the Bhakra-Nangal Project in India, as many as 60% of the workers had to imported from other provinces (Biswas, 1980b).

The construction of large water development projects often stretches over a decade, and the daily labour force engaged fluctuates tremendously not only from one year to another but also within any year. For example, the peak labour strength for the Sarda Sahayak Project in India varied from a low of 4,000 in 1969-1970 to over 140,000 during 1975-1977. Minimum labour engaged in any year could vary from only 5% to 20% of the peak strength of that year (Biswas, 1980b). There is also a high staff turnover.

In these difficult circumstances, and in view of the lack of adequate medical assistance in most developing countries, it is impossible to provide appropriate medical and sanitation facilities to the majority of the workers who, as mentioned earlier, are poor, unskilled and illiterate, and thus lack any political power base. While a certain amount of medical facilities are available for skilled, salaried and educated workers, the unskilled workers are employed primarily as daily labourers without job security and are mostly on their own so far as health services are concerned.

In addition, those who live in the new settlement but are not directly employed in the project often do not have access to medical facilities. The presence of large numbers of workers within a limited area, living in unsanitary conditions and without adequate medical facilities, is conducive to the prevalence of disease; tuberculosis, leishmaniasis (*espundia* of Kala-azar), etc. Furthermore, in some countries like Pakistan, groups of labourers exist who travel all over the country working from one construction site to another (Biswas, 1980b). Such movements have one important and undesirable side-effect: they tend to increase disease transmission rates.

Longer-term Health Implications

As is to be expected, longer-term health implications of water development are more serious than short-term impacts. So far as diseases are concerned, probably the most widespread and important one is schistosomiasis. This disease, however, occurs only in tropical and semi-tropical countries and not in temperate regions. Even in countries like China, with a wide variety of climatic regions, schistosomiasis can be observed only in areas with warmer climates. While the spread of schistosomiasis is common in most tropical climates owing to dam construction, the situation becomes far worse if extensive canal systems are developed for irrigation. In other words, increases in schistosomiasis depend more on whether the water development project had irrigation as a primary focus rather than on hydropower per se.

Schistosomiasis is not new: it was known during Pharaonic times. The unprecedented expansion of water resources development, especially the introduction of perennial irrigation systems, has introduced this disease into previously uncontaminated areas (Biswas, M.R. 1979, 1984). The disease is contracted percutaneously from water infected by cercaria released by snails, and the victims are debilitated by progressive urinary or intestinal infections, reducing labour productivity by some 30%-50%.

The victims also become progressively more vulnerable to other diseases; they face difficult and unpleasant treatments, which are often not available, especially in rural areas of developing countries. The disease is currently endemic in over 70 countries and affects over 200 million people. Prior to the development of the present extensive irrigation networks 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, and this provided the contact between human beings and parasites. During dry periods, however, there was a lull in infection.

With the stabilization of water resource systems due to the development of reservoirs and extensive canal systems, the habitats for snails were vastly improved and extended, and they also had a pro longed breeding phase which substantially increased their population. More human contacts with parasites were provided, which not only raised infection rates but also greatly increased worm load per person. The incidence and extension of these diseases can be directly related to the proliferation of water development schemes, the stabilization of the aquatic biotope, and subsequent ecological changes.

Infection rates of 70% or more can often be observed in certain regions of countries with large

irrigation development (e.g., Egypt, Kenya and Sudan). The Lake Victoria area of Kenya is hyperendemic, and the infection rate in schools is up to 100% in certain areas associated with irrigation schemes.

Other Diseases

Experience with malaria has been somewhat mixed. There does not appear to be any resurgence of malaria directly associated with the construction of large dams in Africa, but in India, Pakistan and Sri Lanka the incidence of malaria has increased owing to impoundments. Very few in-depth studies are available on the relationship between water development projects and malaria, and this could possibly explain the anomaly. For example, the environmental impact assessments of the Kamburu-Gtaru Dam in Kenya indicate that "increase in transmission in Kamburu will move malaria from the presently low mesoendemic towards hyperendemic level" (Oomen, 1979).

Malaria was a problem during the early days of the dams operated by the Tennessee Valley Authority in the United States. By fluctuating reservoir water levels through means of carefully controlled draw-downs, mosquito populations were successfully controlled. However, on a global basis, there are over 100 species of mosquitoes capable of carrying malarial or filarial infections, like Bancroftian filariasis (elephantiasis) or arboviruses like dengue, yellow fever, and viral encephalitis. The different species of mosquitoes often have different behavioral patterns and prefer different types of habitat, so it is not easy to control all disease-carrying mosquito populations in a specific area by any one technique which may have been successfully used elsewhere. Physical, chemical and biological techniques must often be combined with public education and hygiene for any chance of long-term success. In the final analysis, success will depend very much on the availability and use of knowledge of local conditions.

Gambian trypanosomiasis (sleeping sickness), transmitted by the tsetse fly, is prevalent in West Africa. The tsetse fly prefers light forests, which often tend to lie along watercourses. New reservoirs, especially those with irregular shorelines, often increase forest areas and thus provide suitable habitats for the tsetse fly to flourish. Trypanosomiasis is a debilitating disease which often proves fatal to both humans and animals. Control of trypanosomiasis is not easy, and it is made more difficult by the free movement of people and animals from contaminated to uncontaminated areas.

In contrast to diseases discussed earlier, water developments tend to reduce the incidence of *onchocerciasis* (river blindness). The intermediate host, *simulium* spp. (blackfly), tends to breed in fast-flowing reaches of rivers with turbulent, and thus well-oxygenated, flow. These areas are often drowned by the construction of dams. However, special care must be taken to ensure that new breeding grounds do not develop, especially immediately downstream of the spillways with fast-flowing waters. Construction of the Volta Dam destroyed the blackfly breeding ground that existed upstream. However, blackfly vectors continue to infest many tributaries, and the benefits initially expected from the construction of the Volta Dam have not yet materialized. Furthermore, the vector can travel as far as 300 km, whereas it was formerly thought to be able only to travel 50 km. This naturally increases its sphere of influence.

Resettlement Due to Inundations

One of the major social problems created by large-scale water developments is the displacement of local inhabitants owing to extensive innundations. The Volta Dam, for example, inundated an area of about 3,275 square miles and the resulting lake has a shoreline of over 4,000 miles. Consequently some 78,000 people and more than 170,000 animals had to be evacuated from over 700 towns and villages of varying populations. Eventually, 52 new settlements were developed to house 69,149 people from 12,789 families (Biswas, 1981b).

Resettlement planning for large dams and, what is more important, its implementation, have seldom been successful in developing countries. Most of the sites selected for resettlement are not ready when the settlers arrive, and lack of potable water and sanitary facilities force people to use lake or river water which could be contaminated. People often store water near dwellings for convenience, and this could become potential breeding grounds for mosquitoes which are carriers of numerous diseases. Medical facilities are often nonexistent and people, mostly illiterate and often nomadic, are unaware of the basic precautions necessary for health.

Theoretically, the health of settlers in the new environments should be better than before they were evacuated, but in reality conditions generally turn out to be worse than before. This is because the resettlement process in developing countries has generally not been properly implemented. In addition, when people are relocated to a totally unfamiliar environment they suffer not only from considerable psychological stress but also may have no resistance to diseases prevalent in the resettled area, and thus become more susceptible to certain new forms of diseases (Biswas, 1982b).

AGRICULTURAL AND RURAL WATER DEVELOPMENT

Agricultural and/or rural development projects, of which water development is an integral part, have health implications, both direct and indirect.

Direct health impacts from the constituent water supply and/or irrigation development aspects have been discussed above. The indirect health effects of such projects will be briefly mentioned below.

The main objective of these projects is to improve the income and the quality of life of the people concerned. For example, there is agricultural development through irrigation. By providing better water control in addition to other agricultural inputs, like high-yielding varieties of seeds, pesticides, fertilizers, and credit, cropping intensities and yields are increased. Part of the increased agricultural production is then consumed, improving the food availability and nutritional status of the local populace. The rest is sold and the income can be used for better housing, sanitation, education and health care. Here is an example.

Bhima Command Area Project

An evaluation of the Bhima Command Area Development Project in Maharashtra, India, carried out by the author (Biswas, 1985) indicates that the food and nutrition situation has improved remarkably. Because of production of two to three crops a year, farmers feel that for the first time they have food security; i.e., their families will no longer go hungry as has happened frequently in the past. Without exception, people in the project area feel the quality of food has increased. The variety and amount of vegetables consumed have increased and so has protein consumption. More milk, eggs and meat are consumed through increased livestock holding made possible by the higher incomes generated due to the project. Because of improved food and nutrition, people in the project area are enjoying better health than before.

However, all the health benefits have not been positive. The sudden increase in livestock holdings has created problems since people are now living side by side with their newly acquired animals. Health hazards have increased markedly due to the presence of flies and other disease vectors. Since the farmers are primarily illiterate, they are not aware of the health dangers posed by such insects. Nor are they aware of how to protect food and water stored in their homes. Thus, health education now is one of the biggest problems in the project area that requires priority attention.

CONCLUSION

Health, environment and water development are closely interrelated and changes in one area are likely to have repercussions in others, some of which could be beneficial while others could be adverse. It is thus essential for planners and decision-makers to understand the interrelationships between those fields so that appropriate steps can be taken early during the planning stage so as to maximize the positive benefits and minimize the adverse effects. Without such understanding and appropriate action, development projects are unlikely to be sustainable over the long term or produce optimal benefits.

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