

## Development and Large Dams: A Global Perspective

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**ABSTRACT** *Water-retaining structures have been built to facilitate human development for some 5000 years. This paper focuses specifically on their development during the past 50 years, and points out that analyses of actual impacts of large dams are few and far between. Consequently many myths have now enshrined themselves in the literature as facts. The background to the controversy over the Aswan High Dam is analysed. While the western world has basically constructed the dams necessary, the situation is very different from the perspectives of the developing countries, where progress has left much to be desired. Climatic, technical, economic, social, environmental and institutional conditions are very different between the developed and the developing countries, and hence the approaches to water management cannot be identical for the whole world. The main issue facing the developing countries is not whether large dams have an important role to play in the coming decades, since there is really no other choice, but rather how best we can continue to improve their overall effectiveness for human welfare, eradicate poverty and preserve the environment.*

### Introduction

For some 5000 years, water-retaining structures have been built in different parts of the world to ensure water is available for domestic and agricultural purposes throughout the year. As science and technology advanced, it was possible to construct larger and more complex water storage and distribution structures than ever before, especially during the nineteenth and twentieth centuries. Fortunately, these advances coincided with the growth in the global population during the same period when more and more water became necessary to support ever-increasing human activities in the domestic, agricultural and industrial sectors. The Industrial Revolution further accelerated the demands for water. With very significant advances in technology, the human knowledge base and the global economy, and plentiful availability of water, it was possible to match the accelerating water demand by increasing water availability. Furthermore, electricity requirements to support an ever-increasing global population and economic expansion increased as well. Since no large-scale generation of electricity is possible without water, water requirements increased concomitantly. Navigation became an important form of transportation to move goods produced by the Industrial Revolution. Populations steadily became more dispersed over a larger area, and the rates of urbanization started to increase, as a result of which society had to be protected from the regular ravages of droughts and floods through better water-control mechanisms and management practices.

Thus, water became a critical component of the development process for the entire world for the nineteenth and first part of the twentieth century.

A natural result of all these and other related developments was that a large number of dams had to be built to satisfy the ever increasing demands for water for various purposes, and to generate hydroelectricity to meet the burgeoning energy demands from the domestic, industrial and agricultural sectors. In addition, as from time immemorial human beings have settled in the fertile plains of major rivers such as the Nile in Africa, Euphrates–Tigris in Mesopotamia, and the Indo-Gangetic plain in the Indian sub-continent, floods and droughts have had to be managed to reduce losses to human and cattle populations and also to limit economic damage. During the past two centuries, hundreds of millions of people started to live around rivers, which necessitated controlling these rivers to provide assured water supply for domestic, agricultural and industrial purposes and to reduce flood and drought damage. Thus, building of dams gained steady momentum during this period. Also, in countries to which significant migrations took place, such as Argentina, Australia, Brazil, Canada and the United States, water requirements increased exponentially during the post-1930 period to satisfy the needs of this expanding population.

Water control and assured water availability of appropriate quality became essential requirements for continuing economic and social development worldwide. Hydropower became an important source of energy, so much so that in a country like Canada, the word ‘hydro’ became synonymous with electricity. During the 1930–80 period, numerous dams were built all over the world for hydropower generation, flood control or multipurpose water development.

### **Development during the Post-1950 Period**

Construction of large dams during the pre-1960 period was very significant in the so-called developed world, which included countries such as the United States, Australia, Canada, Western Europe, former Soviet Union and Japan. Institutions like the Bureau of Reclamation and the Corps of Engineers of the United States became famous all over the world because of their expertise in constructing and managing large dams to promote economic development and sustain human welfare. The Tennessee Valley Authority (TVA) in the United States was regarded with awe by the rest of the world for a considerable period. Also, during this period, the TVA was generally viewed through rose-coloured glasses and its weaknesses were not seriously considered, within either the United States or the rest of the world. Only its strengths were the subjects of adulation. A few countries such as India tried to duplicate the TVA experiences with its Damodar Valley Corporation (DVC). Not surprisingly, the DVC model did not work out as well for India, because of problems of technology transfer between the two countries which had different physical, technical, social, cultural, economic and institutional conditions, and also because times and perceptions had changed during the intervening period between the construction of the TVA and DVC.

During the post-1950 period, many countries in Asia and Africa started to shed their colonial past. With their newly gained independence, there was an urgency to accelerate their national development processes, which were not adequately taken care of by their colonial masters during centuries of European rule.

Accelerated social and economic development of all these countries became an urgent necessity to improve the standard of living of their people. Water was considered to be an important means to foster such development processes. Because of the major contributions dams could make to national development processes, construction of large dams often became a symbol of nation-building national pride, and often contributed to national unity. Thus, the most respected first Prime Minister of India, Jawaharlal Nehru, said that dams were the new temples of modern India. Not surprisingly, the Bhakra and Hirakud Dams in India, Volta Dam in Ghana, Kariba Dam in Zambia, and the Aswan Dam in Egypt were all considered to be the symbols of development and progress in the newly independent countries. It is equally clear that these dams helped their national economies through a myriad of pathways, many of which are still not fully known or understood. Eminent leaders of that time such as President Gamal Abdel Nasser of Egypt and Prime Minister Kwame Nkrumah of Ghana viewed these large structures as indicators of post-colonial development and shedding of the colonial past.

By 1975, the United States, Canada and the Western European countries had essentially completed their programme of construction of large dams. In addition, the best and most economic sites were already developed in these countries. The situation of course remained very different in the developing world, where many of the large water infrastructures could not be built for a variety of reasons. Thus, during the post-1975 period, the construction of large dams rarely occurred in the above-mentioned developed countries; the focus shifted completely to developing countries such as Brazil, China, India, Indonesia, Malaysia, Thailand, Turkey, etc., where progress was insufficient earlier. Japan is one of the very few developed countries where large dams continued to be built during the post-1975 period.

### **Developments during the Post-1975 Period**

A major development of the post-1975 period was the emergence of the environmental and social movements, primarily in a few select developed countries, which gradually contributed to radical changes in people's mindsets. In June 1972, the United Nations convened in Stockholm the first of its mega-conferences of the decade of the 1970s, on the Human Environment. This conference was a landmark for the environmental movement, even though it was boycotted by the then Soviet Union and the countries of the Eastern Europe over the political issues linked with East Germany. This conference was followed in rapid succession by similar UN mega-conferences on population (Bucharest, 1974), food (Rome, 1974), women (Mexico City, 1975), human settlements (Vancouver, 1976) water (Mar del Plata, 1977), desertification (Nairobi, 1977), science and technology for development (Vienna, 1979), and new and renewable sources of energy (Nairobi, 1981). All these mega-conferences did have some discussions on water, and also all considered the environment in one form or another. The Stockholm Conference also resulted in the establishment of the United Nations Environment Programme. It was the first UN agency that was to be established in a developing country, and was expected to represent the environmental consciousness of the UN system. All these events cumulatively, and in their own ways, had some impact on the current societal perception of large dams in one form or another.

When the Stockholm Conference was held in 1972, very few countries had environmental ministries. Now, some 30 years later, it is difficult to find a single significant country that does not have an environmental ministry or department. The environment has now rightly become a mainstream subject, and environmental impact assessments of large development projects have equally become mandatory in nearly all countries of the world.

While ensuring that environmental issues are properly considered in all development projects was a most welcome development, it has also to be admitted that developments to improve the quality of life of people and ecosystems in the developing world are now frequently prevented or delayed by vocal activists, mainly 'environmentalists', primarily from the developed world, or through their direct financial and intellectual support to their counterparts in the developing world. These activists from the developed world, who already have a good standard of living and access to clean water, adequate food and energy, and a very good lifestyle, have often eschewed scientific and technical facts, have manipulated available information, quoted data and statements that are patently erroneous or out of context, and always had their own hidden agendas.

For some reasons that are still difficult to identify, construction of large dams became the lightning rod for many of these so-called 'environmental' activist groups. In an era when 'small was beautiful', large automatically became bad and ugly on ideological grounds, irrespective of desirability and overall benefits to society. Accordingly, and not surprisingly, a myth started to develop that all large dams are bad, and thus that water problems in the developing world could be successfully and cost-effectively resolved only by small dams. There is no doubt that small dams and water-harvesting techniques will undoubtedly help in rural areas and smaller urban areas. Thus, their use in appropriate areas and climates needs to be encouraged to the techno-economically desirable extent. Equally, however, small water structures alone would not be able to resolve the complex water problems of urban areas and major industries where demands for water are extremely high, and are increasing, and where rainfall is scanty and erratic. Large and medium dams will be essential to continue to provide water to meet the escalating needs of a steadily urbanizing world for decades to come.

People in the western world will have to realize that the water problems of the developing world cannot be resolved by small dams alone. The situation was previously no different in their own countries, where large dams had to be built to satisfy their own water needs. Having completed the necessary construction of large dams in their own countries, they are now opposed to the construction of large dams in the developing world, where societal needs are growing exponentially. It has to be realized that small can be beautiful, but under many conditions it could be inadequate or even ugly. Equally, big could be magnificent, but it could also be bad and undesirable. Whether a small or large dam is the most appropriate solution depends on many specific local conditions. Thus, what is desirable at this point is not a dogmatic debate between small versus large dams, since both are necessary, but rather what could be a judicious mixture of small and large dams which could solve the water problems of the developing world, and simultaneously could contribute to an improvement in the quality of life of its citizens. The decision as to what is the most appropriate balance has to be made by the people of each developing country themselves,

based on their own requirements and aspirations, and physical, social, economic and environmental conditions. More specifically, the decisions must be made by the people who are living in the river basins whose development is being contemplated, and which may affect their future lifestyles positively and/or negatively. In the present era, where democracy is considered essential, these complex decisions must be made after informed debate, primarily by the people in the development areas concerned. Thus, the decision to develop or not to develop a river basin in a specific state in India should be made by people of that area, and must not be imposed on them by activists from the USA or elsewhere, irrespective of their motives and hidden agendas, as a form of neo-colonialism, or by the urban élites of India outside the region. They can make a contribution to the debate, but they should not be allowed to manipulate the process so that their dogmatic views, whatever they may be, prevail in the end. Sadly, this is not happening in many cases where people from outside the development area are influencing the decisions because of their economic power and media savvy. These decisions are often detrimental to the people of the region.

### **Absence of Proper Impact Analyses of Large Dams**

To a significant extent, the water profession itself must shoulder some of the blame for the present unacceptable situation with respect to the current situation on the large dams. For example, the authors are unaware of even a single large dam whose benefits and costs have been properly and systematically documented after 10–20 years of operation. The nature of the beneficiaries of these projects, and also who benefits and who pays the costs, are basically unknown at present, except in an anecdotal fashion. Irrespective of the current rhetoric of the supporters or opponents of the large dams on their overall social and environmental costs and benefits, the fact remains that these are not known. Much of the information available at present is anecdotal, quality of information is often dubious and objective and comprehensive analyses, if any, on which many conclusions and recommendations are based, are so poor that an undergraduate student could probably do better! Not surprisingly, in the absence of good and reliable studies on the socioenvironmental impacts of large dams, both positive and negative, the proponents and opponents can get away with whatever dogmatic statements they wish to make. After nearly 20 years of fruitless debate, the fact still remains that the number of large dams anywhere in the world, whose economic, social and environmental impacts (both positive and negative) have been scientifically and objectively monitored and evaluated on a regular basis, can be counted on the fingers of one hand, with some fingers left over! It is difficult to understand why the proponents of large dams have not carried out such definitive assessments.

Anecdotal information available at present on the overall impacts of large dams such as the Bhakra and the Hirakud in India, the Aswan in Egypt and the Ataturk in Turkey, indicate that they have had very substantial impacts on the development processes of the regions, assisted their national economies, and have very significantly improved the quality of life of the people of the regions. Similarly, hydraulic structures like the Chukha I and II projects in Bhutan have been primarily responsible for lifting the per capita GDP of that country from being the lowest in South Asia in 1960 to the second highest in the region at present. This economic transformation has occurred in Bhutan within a short

period of less than two decades, primarily through the export of hydropower generated to India. There is no doubt that the construction of a third dam will transform Bhutan into a country with the highest GDP in the region, certainly within the present decade. Judicious balance of development and environmental requirements is enabling Bhutan to enter the twenty-first century as a much stronger nation, where the Bhutanese people are rapidly tasting the fruits of water development and simultaneously ensuring that their environment and culture are maintained. The environment and development professions will do well to analyse such successful case studies objectively and comprehensively in the near future so that lessons could be learnt from these experiences which could be used elsewhere. The Bhutan–India development is also one of the best examples of inter-country collaboration to foster regional peace and stability by managing their water resources prudently and efficiently.

Another issue is the number of so-called armchair water or environmental experts from the developed world, who visit major water projects in developing countries, usually for a period of only 1–2 weeks (sometimes for even less), and then decide to write ‘authoritatively’ on the projects, mostly by deriding them. It is often their only visit to the countries concerned. Thus, they know basically very little about the history, economy, social circumstances, culture or needs of the countries concerned because they cannot read the local language, or if the documents are available in English, they do not make a determined and sustained effort to get them. Thus, based on a very brief bird’s-eye view of the projects, and equally limited knowledge of the area and the people, they make pronouncements, which clearly are for the most part uninformed and erroneous. The problem is further compounded by the fact that the senior water professionals and decision makers in the countries concerned are invariably busy, and thus they can spend very little time, if any, with these flying foreign visitors, because they consider such discussions to be primarily public relations exercises and thus basically unnecessary to their line of work.

In contrast, the opponents of the projects always have considerable time, and they ensure that the visitors return with biased information, documents and conclusions, which in the absence of detailed reliable information they mostly accept hook, line and sinker. When they return to their countries, they write erroneously but ‘authoritatively’ about the projects they saw during a very brief visit. People who have never visited the projects read these biased and erroneous interpretations, and they then quote them as definitive sources, as if the conclusions and opinions are correct. After several such attributions to the original inaccurate documentation appear in the water literature, the world accepts the errors and the erroneous views as facts. This confirms the veracity of Goebbels’ famous statement that if lies are repeated often enough, lies become truths! In other words, facts may be facts, but the general erroneous perception becomes the reality.

One can document numerous such mis-statements on major dams like the Aswan, Euphrates or Sardar Sarovar in recent years, many of which are now widely believed to be accurate. Only a few examples will be given here.

#### *Ataturk Dam*

A well known American water expert claimed publicly at a major water meeting in the USA, in 1997, that runoff from irrigated agriculture has severely polluted

the Euphrates River. Irrigation as a result of the Ataturk Dam started only in 1995, and agricultural return flow does not drain to the river. Under these conditions, it was theoretically impossible that the Euphrates River could have been polluted at that time with an irrigated area of less than 5000 ha that was used over only a few seasons. This statement has been repeated several times since then. Another American expert has claimed that the very high inflation rate in Turkey is due to high governmental borrowings for investment in the Southeast Anatolia Project (GAP), of which the Ataturk Dam is an important component. The fact is that the Turkish textile companies in the public sector lost more money each year in the recent past compared with what was invested in the GAP project. It is thus ludicrous to claim that Turkish inflation is due to the GAP project.

A recent publication (1999) by the International Committee on the Red Cross (ICRC) on Water and War claimed that the Manager of the Ataturk Dam had said that water is a weapon, and that Turkey can cut off the flow of water to Syria at any time for months. The claim had no reference attached to it, nor was the name of the Manager given. This report had first surfaced in a US newspaper a year earlier. Unfortunately, no one had even bothered to discuss the issue with the Manager of the dam, even though the quote was falsely attributed to him. This claim was not only fabricated initially to make a good newspaper story but also absolutely ridiculous technically, since south-eastern Turkey would be badly flooded if the Euphrates were not allowed to flow through its neighbours, Syria and Iraq.

### *Aswan High Dam*

A French Government expert visiting India claimed at public lectures in late 1999 that the Aswan Dam has not increased agricultural production in Egypt by even one kilogram. This of course would be news to the Egyptians, but his view was extensively quoted by the Indian media as if it was a fact. More about this dam will be discussed later.

### *Sardar Sarovar Project*

The belief is almost universal in the West that the Narmada Bachao Andolan (NBA, Save the Narmada Movement) is a democratic movement of the *adivasis* (tribals), who are affected, or going to be affected, by the inundation resulting from the Sardar Sarovar Dam. NBA at present is the major opponent of this project. The villages affected are nearly 100% *adivasis*, and most surprisingly, in nearly two decades, not even a single *adivasi* has been represented in the NBA leadership, whose leadership continues to be 100% urban élites. Gail Omvedt, a leading Indian social scientist, points out that NBA is “a worldwide alliance with considerable money and backing from upper middle class people in North America and Europe, not to mention Delhi and Mumbai, along with a rather small local base in the Narmada Valley”. How democratic is this process, where urban élites from outside the country and outside the project area claim to speak for the project-affected people, who have no representation in the leadership of the movement?

Issues associated with the large dams debate are complex. They range from superpower politics of the 1950s and 1960s, as was the case for the Aswan Dam,

to hidden agendas and power bases of many NGO groups, as well as governmental bungling and inaction in the earlier years of the projects. International financing institutions must also accept a significant part of the blame for the past and existing states of affairs.

Only one large dam will be briefly reviewed here, the Aswan High Dam. This is undoubtedly the best known dam in the world. Unfortunately, however, most people are unaware as to how this dam acquired a bad reputation because of past geopolitical factors.

### **Background to Controversy on the Aswan High Dam**

A detailed analysis of all the current evidence indicates that the Aswan High Dam became a victim of the Cold War between the two superpowers, the United States and the Soviet Union, right from its very beginning. Irrespective of its overall benefits and costs, this super-power rivalry of the past probably was instrumental in giving it a bad name, which has prevailed to date. The facts are as follows. The United States had initially agreed with the Egyptian President Gamel Abdel Nasser to support the construction of this dam. However, President Nasser, Prime Minister Jawaharlal Nehru of India and President Soekarno of Indonesia started a new grouping of countries. These countries were not going to be linked to either of the two superpowers, and thus the new group was called the Non-Aligned Movement (NAM). The formation of NAM clearly upset the United States, whose then Secretary of State, John Foster Dulles, told President Nasser that either Egypt was with the United States, or it was against it. There simply was no third alternative such as the NAM. Should Egypt decide to be a part of NAM, the United States, contrary to its earlier indication, would not support the construction of the Aswan High Dam, which was the most important project the Egyptians had embarked upon following the revolution. President Nasser fortunately rejected the ultimatum, and the United States promptly announced that it would not assist Egypt to build the dam.

With the withdrawal of US support, and following various negotiations, the Soviet Union stepped in to finance the dam, and also to provide the necessary technical assistance for its construction. In terms of superpower rivalry and global politics, the dam thus became a contentious issue because it became the first-ever major structure in the entire continent of Africa that was to be built with Soviet funds and assistance. Because of these political manoeuvrings between the two superpowers, the dam became an important component of the geopolitics of the world of that time.

When the construction of the Aswan High Dam was completed, Prime Minister Nikita Khrushchev of the Soviet Union informally sent a message to President Nasser requesting that he be formally invited to participate in the opening ceremony of the dam. The Egyptian Government extended this invitation to the Soviet Prime Minister, who boasted during his inauguration speech that the Soviet Union would drown capitalism in the African continent, and the Soviet assistance to Egypt to construct the dam was the beginning of this process. These political factors ensured that the dam generated considerable media and public interest in the West as well as in other parts of the world. Thus, not surprisingly, the Aswan Dam became the best known dam in the world.

Soon after the construction of the dam was completed, some well-known

American journalists published a series of articles condemning the dam because of its adverse social, environmental and economic impacts. Since the construction of this dam was completed before any country in the world required environmental impact assessments (EIAs), or methodologies were even available for carrying out EIAs, not surprisingly no environmental impact studies were conducted. Accordingly, all these views were of course at best only conjecture, since the real impacts, both positive and negative, were unknown as there was no systematic analysis or monitoring of such impacts. It is now well known that the intelligence agencies of both the two superpowers at that time routinely used journalists and academics to plant stories that were detrimental to the other side. To what extent these dirty tricks were used to denigrate the reputation of the Aswan Dam because it was constructed with Soviet help, and also because it was the first major Soviet-assisted structure in Africa, will probably never be known definitively. However, to a very significant extent, the current bad image of the Aswan Dam in the West and the rest of the world could be traced to these early journalistic writings which were accepted at face value by people outside Egypt, even though most were misleading at best, and incorrect at worst.

In retrospect, the high-profile media articles which focused exclusively on the so-called negative environmental impacts of the Aswan High Dam found a receptive audience in the West, many of whom were already convinced at that time that such large development projects could only be environmental disasters. Very few, if any, people realized that the articles were based on supposition rather than facts, and it was highly likely that many such stories were 'planted' by the intelligence agencies. Not surprisingly, most of these stories were later found to be incorrect.

These writings in the US media simply reinforced the then prevailing biases such as 'small is beautiful', and ensured that the dam became a *cause célèbre* among the newly emerging environmental movement as a shining example of a bad, large development project. Irrespective of detailed studies later, which refuted many of the earlier shortcomings of the structure, the legend of the Aswan High Dam has continued to live on until the present day. The detailed studies that were carried out in the 1980s and early 1990s on the actual impacts of the dam with the support of the Canadian International Development Agency (CIDA) are basically known to a very few people who were directly associated with the project. The CIDA-assisted studies indicated that contrary to the popular belief that the Aswan Dam was a 'complete disaster', it is actually one of the best dams in the world because of the very substantial overall benefits it has brought to the country and its people.

It would be highly desirable to summarize the results of the authoritative studies carried out on the environmental and social impacts of the Aswan Dam in a book, which could then be read by interested parties. However, several years after these studies have been completed, there does not appear to be any plan to make the results available to a wider audience. Easy availability of such authoritative information would undoubtedly constitute a major contribution to the debate on large dams.

The myths surrounding the Aswan High Dam have been repeated so many times that these are now accepted as facts, especially outside Egypt. In reality, evidence indicates that although Aswan has been a remarkably successful dam, without which Egypt would have been in dire economic straits, it has unquestionably contributed to some adverse environmental impacts as well as to many

positive ones. Thus, the real question can no longer be whether this dam should have ever been built, since without it Egypt would have been facing a continuing economic and social catastrophe over the past three decades, but rather what steps should have been taken to maximize further the positive socioenvironmental benefits and reduce the negative ones so that the net benefit to the Egyptian people could have been even higher.

It should be noted that it is also unfair to judge this dam, which was planned and designed in the late 1950s and constructed during the 1960s, on the basis of the criteria currently prevalent in the twenty-first century. The world has changed dramatically during the past four decades, as have our perceptions, societal beliefs and knowledge base. For example, the National Environmental Protection Act (NEPA) was passed in 1970 in the United States, making environmental impact assessment (EIA) of projects mandatory. Prior to 1970 not a single country required EIA studies to be carried out for project clearance. The planning and design of the Aswan was carried out more than a decade before NEPA, when no environmental assessment was required. This of course does not mean that environmental issues were not considered when this dam was planned, but rather the depth of analyses and overall coverage would not meet the current requirements. However, the most noteworthy fact remains that even though no formal environmental impact assessment was carried out during the planning phase of this dam, it still can take its place as one of the best planned hydraulic structures in the world in social, economic and environmental terms.

There is no doubt that what is considered as desirable at the dawn of the twenty-first century may not be the same in another 40 years, in the year 2040, exactly as we now consider the then prevailing views of the 1950 and 1960s as *passé* and leaving much to be desired. One can always be wiser in hindsight, and as our knowledge base advances significantly. No matter how best we plan, design and construct large infrastructures, we could always have done better because of the complexities and uncertainties involved, absence of perfect knowledge and availability of all the relevant data. Unfortunately, development cannot wait until mankind has perfect knowledge and wisdom, in which case nothing ever will get constructed, and the world will become increasingly unable to meet the needs of its societies. Poverty alleviation and eradication of hunger are simply not possible in a world of increasing population, unless development takes place in a timely and efficient manner. Delaying development will not improve the lifestyles of the people or eradicate poverty, nor will it benefit the environment.

### **Perspective from the Developing World**

Both the water and development professions have basically assumed that water issues facing the entire world are very similar. This, however, is incorrect. There are some very fundamental differences between the developed and developing world in terms of water problems, issues and management practices, which are not generally recognized at present. It is of course well known that the developing world has a problem in terms of availability of clean water and sanitation. There are, however, many fundamental differences between the developed and developing world because of climatic, economic, historical factors and the status of economic development which have not received adequate attention so far. Only two of these issues will be discussed herein.

First, climatic conditions are very different in developed and developing countries. All developed countries are in temperate regions, where precipitation is more evenly distributed over the year. In contrast, developing countries are located in tropical and semi-tropical regions, where seasonal rainfall patterns are very pronounced. For example, London, England, and Sokoto, Nigeria, have somewhat similar average annual rainfalls. However, in London, the distribution of rainfall over the year is significantly more even compared with Sokoto, where there is virtually no rainfall for seven months of the year. It is thus essential for Sokoto that the rainfall that occurs over the five months of the year be stored effectively so that this water may be used over the entire year. In contrast, in England, because of its more even precipitation pattern, irrigation is not necessary. However, this simply is not a feasible alternative for Nigeria.

Similarly for monsoon Asia, most of the annual rainfall occurs in no more than 20–30 days (not consecutive) during the rainy season. The issue then becomes how to store this extremely high rainfall over a very short period of less than one month so that it can be used effectively over the remaining 11 months. Small dams and rainwater harvesting will work in some parts of monsoon Asia, where the population is dispersed and there is a reasonable amount of annual rainfall. However, monsoon countries such as India, Bangladesh, Sri Lanka and Pakistan simply have no choice but to consider large dams to store water to ensure their increasing urban population has access to water for drinking, as well as for agricultural, industrial and energy development, and for ecosystem conservation. The differences in climatic conditions between the developed and developing countries mean that storage of water is an important issue for human survival in the developing world. Large-scale storage to supply water to major urban centres, assure the necessary food production, employment and electricity generation, ensure ecosystem conservation and to mitigate the adverse impacts of floods and droughts simply is not feasible without large dams. This is a fact the world will have to acknowledge. The question thus is not whether large dams are necessary, but rather how these can be constructed and managed, where essential, so that the overall benefits to the society are maximal.

Second, economies of the developed countries are no longer dependent on water. Accordingly, if there are droughts and floods, these mean only temporary inconvenience for the people but no serious long-term damage. In contrast, drinking water availability in developing countries often depends on rainfall because of lack of infrastructures. Furthermore, agriculture continues to be a very important factor for the survival of the developing world, in terms of both food and employment. Prolonged droughts mean low reservoir levels, and thus also lower hydropower generation. This often results in regular power cuts and voltage reductions, which seriously disrupt industrial production. Industrial employment suffers. Reduced agricultural production and disruption of industrial activities as a result of power shortages contribute directly to serious human hardship. Absence of proper water management thus produces a 'lose-lose' situation all round. Developed countries are basically immune from this process at present. They may have been vulnerable some 70–100 years ago, but their economies are significantly more diversified and resilient at present.

In many countries, drinking water availability becomes a problem because groundwater cannot be pumped up at certain times because of lack of electricity. Water is not only essential for large-scale electricity consumption, but also the water sector is a major consumer of electrical power. In an increasingly interde-

pendent world, the close linkages between the water and energy sectors need urgent consideration.

### **Dams, Environment and Development**

Probably the most critical issue facing large dams at present is the issue of resettlement of people from the inundation caused by their construction. There is no question that the governments all over the world have not generally handled the resettlement issues arising from large infrastructure development projects sensitively and properly in the past. Dams were no exception. International financing institutions did not handle these issues adequately earlier either, nor did they give them adequate attention.

During the past decade or so, it has been realized that the past resettlement practices for large infrastructure development projects were inadequate and thus must be improved upon. No sane person will disagree with this conclusion. It is now universally accepted that the people who have to be resettled must have a better quality of life than they had before, and also better facilities. All the necessary expenses for such resettlement practices must be included in the project cost, and it is the duty of the authorities concerned that the allocated funds are properly spent in a timely manner for the benefit of the people who have to be resettled. The resettled must not bear the cost of the project, but also must benefit from it. Water development projects are not an exception to this rule.

There is no question that large dams will have to be built in the developing world to satisfy basic human needs for water, food and energy, alleviate poverty, generate employment, improve people's quality of life, and maintain environmental quality. It is equally certain that their construction will be strongly opposed by a certain group of activists and interest groups for some reasons that are right and/or because of their own dogmatic views, and/or vested interests and hidden agendas. The water profession must listen carefully to all the views expressed, irrespective of whether they are for or against the development projects, and the reasons therefor. If the points raised are valid, the issues must be addressed promptly, courteously and in a timely manner.

### **Conclusion**

As the populations in the developing countries continue to increase and as per capita demand for water increases from the current low levels owing to increased economic development, more and more water will be required in the coming years. In addition, agricultural, industrial, energy and environmental sectors will require their fair share of water. Some of this additional water will be available as a result of the use of more efficient management practices and conservation measures, but in most cases this will not be adequate. New developments will be necessary to meet this shortfall.

In addition, technological developments will undoubtedly contribute to more efficient water production, use and management. In spite of all these positive developments, the developing world will require more, and not less, water than it is using at present. Construction of large dams will continue to be one of the important policy alternatives to solve the water crisis in the coming years. These new dams must be built and managed with the best scientific and technical

knowledge available so that development is not hindered, poverty is eradicated and the environment is protected.

The main issue facing the developing countries of Latin America, Asia and Africa is certainly not whether large dams have an important role to play in the coming decades, but rather how best we can continue to improve their performance so that their societal and environmental benefits can be maximized, adverse impacts can be minimized, and simultaneously equity issues can be properly considered. This will be a challenging task, but is one we must face squarely and successfully.

The water profession must be dynamic and responsive to the changing needs of society. As our knowledge base expands, as technology develops and as we learn from our past development practices, it should be possible to design, build and manage large dams more efficiently to meet the changing societal norms, needs and requirements of the future.

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