GUIDELINES ON LAKE MANAGEMENT

Volume 2

Socio-Economic Aspects of Lake Reservoir Management

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FOREWORD

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Natural lakes and artificial reservoirs are fundamentally important in that they provide drinking water for millions, fishing grounds for numerous communities, water for agriculture and industrial development, and unique recreational opportunities.

The rapid rate of socio-economic development in lake/reservoir basins has come to be recognized increasingly as a major threat to the quality of the lake environment. Agricultural growth, the demands for more irrigation and drainage systems, the use of fertilizers and pesticides, the clearing of forests, the building of factories and release of untreated domestic and industrial wastes into the lake - all may cause environmental damage to lakes and lake basins. Since, once they reach an advanced stage, problems like eutrophication are virtually irreversible such problems need to be tackled at the earliest stage possible.

The environmentally sound management of lakes should be considered as a key part of sustainable development in almost every country. This requires that all uses and functions of water resources should be considered simultaneously and all interactions between environmental conditions, ecosystems and human activities need to be reviewed and tackled on a basin- wide approach.

The second guideline book on "Lake Management" entitled "Socio-Economic Aspects of Lake/Reservoir Management" should appeal to a wide range of readers from administrators to NGOs, practitioners to academics. It is hoped that all concerned readers will find this guideline book, which was prepared under a joint UNEP/ILEC program, useful in their daily activities.

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SECTION 1

UTILIZATION OF WATER RESOURCES AND PROBLEMS OF LAKE MANAGEMENT

Tatsuo Kira and Hideko Sazanami

INTRODUCTION

The lake, with its clear-cut boundary, is one of the best-defined natural ecosystems on earth. It is comparable with an island in that the natural system within its shoreline is fairly independent of related outside systems. That is why lakes and islands, if they are sufficiently old geologically, tend to have highly specialized biota containing a number of indigenous species.

In terms of the bio-geochemical flow of organic and inorganic matter, however, lakes are by no means independent of surrounding land systems. Water flows into lakes from their catchment areas and is drained by outflowing streams. Lake ecosystems cannot survive without the inflow of water and its associated supply of matter and energy. Therefore, the physiochemical and ecological attributes of the lake system depend largely upon the natural environment, human population and activity in the catchment area. A lake can only be environmentally stable as long as its catchment area maintains ecologically sound conditions.

Among inland water bodies, lakes are relatively stable in contrast to rivers. This has favoured local residents using the lakes to fulfill their needs for a number of resources and services. Lakes and reservoirs are an important source of drinking water. They are a source of water for washing, for agriculture and energy production. They provide a mode of transportation, an opportunity for recreation and sadly a site for waste disposal.

In the case of subsistence economies, the communities along the lake shores often adapt themselves to the lake environment so closely that very specialized lifestyles develop. Thus the Inders dwelling on Lake Inle in the Shan States of Burma live by fishing and vegetable farming on peculiar farms made of long strips of root mats cut from floating meadows of reed and other water plants. Their stilted houses stand in the coastal shallow waters, with pagodas rising above the lake surface at the village center. The well-known floating life of the Uros on Lake Titicaca is another similar example from the Americas. Similar close bonds with lakes are common in many lake shore communities throughout the world. The stable existence of the lake provides a basis for the material and spiritual lives of the people in these communities who would not trade their lakeside life for any other lifestyle in spite of the invading modernization in recent years.

THE VULNERABILITY OF LAKE ENVIRONMENTS

The stability of lakes as water bodies is ironically responsible for the instability or vulnerability not only of lakeside communities but also of lake environments in general. Since inflowing water stagnates temporarily in the lake, all substances carried into the lake with the water, be it silt, nutrients or toxic substances, tend to be trapped in lake sediments or in the bodies of lake organisms, resulting in changes in water depth, water quality and other environmental conditions. The continuous inflow of nutrients and organic matter is known to cause gradual eutrophication of lakes. In artificial lakes the natural supply of organic matter alone may induce eutrophication, even where human activity in their catchments is negligible. Thus lakes are extremely sensitive to changes in terrestrial environments in their watersheds.

In the past, water resource planning has tended to treat fresh water as an unlimited resource that can be provided cheaply and in any quantity desired. Only recently has it been realized how fundamentally flawed this attitude is. Although adequate quantities of water are available to meet projected needs throughout the globe in the near future, poor management, lack of conservation, pollution and rapid increases in localized demand are endangering supply in many areas.

The availability of uncontaminated water is perhaps the single most important factor limiting the attainment of improved quality of life for almost two thirds of the world's population. As the rate of development in developing countries continues to accelerate, many lake basins have become susceptible to increased pressures which tend to give rise to a number of water resource management problems. These issues can no longer only be dealt with by specific water-related programmes and projects. There is now a clear need to address the issues on a basin-wide scale in a broader socio-economic context. Three problems deserve special attention. The first is the problem of environmental, economic and social effects of water resource development projects. In the past planning for water resource developments has tended to concentrate on major construction projects such as dams and reservoirs, with little consideration given to the environmental, economic and social effects on the basin communities. Although benefits accruing from water resource projects are many and at times substantial, a whole series of negative secondary effects may occur, including involuntary resettlement and the consequent problems of adaptation to environmentally different sites on the part of the displaced population, the aggravation and spread of waterborne diseases, and changes in the aquatic environment resulting in the disruption of fisheries.

The second is the problem of access to, and allocation of, water resources among competing users. Water resources are unevenly distributed in space and time and by social group, leading to both over-abundance and shortages. Water resource planning almost always involves some form of allocation process of which the main criterion has so far been economical efficiency. There is a clear tendency to divert water resources to those areas and sectors where the maximum return can be obtained with the minimum investment.

The third is the issue of environmental and social problems arising from water and land use interactions. Although a lake basin forms a convenient unit for water resource development and management, the increasing use of land and water resources in the basins can lead to potential conflicts between upstream and downstream areas, and between different sectors such as agriculture and fisheries. In most cases these conflicts occur because development in the lake basin proceeds haphazardly with little or no regard for the impact on the lake environment.

THE NEED FOR EFFECTIVE LAKE MANAGEMENT

The lake environment is extremely sensitive to environmental changes in its watershed and when phenomena like eutrophication and pollution occur, though they may proceed slowly, the damage caused is correspondingly difficult, if not impossible to reverse. Changes in land use patterns, alterations to the natural vegetation, increases in population, industrial development and other human impacts on the lake/reservoir catchment conditions may lead to a deterioration of lake/reservoir environments. In addition, water development projects such as dams, canals, and river/stream channelization programs may lead to a serious degradation of water quality, displacement of population, destruction of farmland, the ruination of wetlands and fisheries downstream, and may also contribute to species extinction through habitat destruction. Different human activities have varying degrees of impact on the lake and its environment. Changes in activity have their own cause-effect function. Many such functions have already been identified, but many more remain unknown. Little is yet understood regarding the interactions between the different functions and how to assess their relative impact. Hence, there has been a growing awareness of the need for a comprehensive strategy of sustainable development of lake resources and catchment areas.

It is now commonly accepted that the concept of sustainable development of lake resources and catchment areas requires a delicate balancing between human activity and the environment. This can be attained only by integrated management of the whole catchment area and the lake ecosystem, based on sound evaluation of many relevant cause-effect functions and their interactions. Increased emphasis should be placed on preventive planning based on environmental impact assessment. These policy approaches have been fairly successful when applied effectively. Other policy issues, however, remain as yet unresolved. These include the problem of forced resettlement and the question of whether a large scale water resource project is more beneficial to society as a whole than say a series of well-linked smallscale schemes. These are hard political decisions and policy-makers would benefit greatly if more information were to be available to help improve the decision-making process. This, in part, explains the need for the production of a series of guidelines on the environmentally-sound management of lake resources.

Environmentally-sound management encompasses the management of human influences on the lake environment and the corresponding feedback effects that can occur in terms of health, economic effects and the general quality of life of local inhabitants. A great deal of research has been carried out on the limnology of lakes, the ecological management of terrestrial environment and socio-economic aspects of regional development, but the existing knowledge has not yet been synthesized into environmentally sound principles for the use of resources in lake/catchment areas. There is a clear need for the development of a management system for integrated land/water ecosystems of the lake/reservoir environment in the context of social, cultural and economic aspects and for easily understandable guidelines for management strategies.

THE SECOND GUIDELINE ON LAKE MANAGEMENT

The papers presented in this guideline bring together the most important socio-economic aspects of lake environment management. Topics covered range from the development of an analytical framework for water resource management through to description of the environmental and social problems related to particular developments. There are four sections in addition to this introductory section.

The second section of this guideline deals with the problems of lake management from the perspective of local residents and interest groups with case studies from Japan and the United States. The third provides an analytical framework for water resource management with papers on planning, implementation and management of water resource projects, lake water monitoring, integrated land-water systems, and also economic and other analytical appraisals of the impact of such activities. The fourth discusses the environmental and social impacts of water resource development projects with particular reference to reservoir and dam construction in developing countries, resettlement and compensation issues, and water resource developments in brackish lakes. The final section summarizes the main points discussed in the guideline and outlines a number of recommendations. Throughout this guideline two-page summaries are provided to give the reader details on the situation at various lakes and reservoirs in the world. The profiles also provide case studies for the arguments presented in the main papers.

No excuses are made for the wide range of information and any possible inconsistencies that may occur. These inconsistencies are thought to be a strength rather than a weakness in that they reflect the complex reality where relatively simple concepts are open to a wide range of interpretations influenced by cultural and societal circumstances.

SECTION 2

LAKE MANAGEMENT FROM THE PERSPECTIVE OF LOCAL RESIDENTS AND INTEREST GROUPS

SECTION 2.1

UNDERSTANDING THE STATE OF THE LAKE ENVIRONMENT FROM A SOCIO-CULTURAL PERSPECTIVE - AN EXAMPLE FROM LAKE BIWA, JAPAN

by Yukiko Kada

2.1.1 Legends and Lakes

Once upon a time, there was a young fisherman who lived on the shores of Lake Biwa. One day, on the way back from fishing at the lake, he found some small children teasing a snake. He angrily scolded the children and told them they should never treat living creatures so cruelly. He then took the snake and let it go.

After a few days, he heard knocking at his door. He opened the door to find a beautiful young women. She said, "Good sir, I have lost my way. Please can you give me shelter for the night?" At first, the fisherman, who lived alone, hesitated but her beauty overcame him and against his better judgment he allowed her to stay. One night turned to two, two to three and still she did not leave. She cooked and took care of him. They fell in love and got married. After a while a baby boy was born and his wife asked him never to look in on her while she was feeding the baby in the nursery room. The fisherman, however, could not resist the temptation. One day he peeped into the room and to his great surprise he found a huge snake cradling the baby.

It turned out that his wife was the lake spirit and that her usual form was that of a snake. Changing into a lady, the lake spirit had come to the young fisherman to thank him for saving her from the children. Now that her real form was known she had to return to the lake. With great sadness she departed leaving one of her eyeballs as food for the newborn baby. Unfortunately, some time later the fisherman accidentally lost the important eye ball. He went to the lake and asked the lake spirit for another. She gladly gave it too him. But without eyes she could not see the sun and plunged into darkness she would not be able to keep track of the time. So in return for the eye she asked that the father and the son ring the bell of the Mii Temple every morning and every evening. Even today the bell of Mii Temple rings twice a day.

This legend originates from the middle ages and is well known throughout Japan.

What sort of message does this story have for contemporary times? At least we can say that people around the lake once had a motherly image of the Lake Spirit and that they communicated with the spirit through the toll of the bell.

Man's image of the lake, however, is not always one of the caring mother. In other stories Lake Biwa is portrayed as a harsh and uncontrollable entity. Such stories are not limited to Japan. Similar fairy tales or legends are told in many Asian and European countries. Although from a scientific viewpoint such stories are without factual base they do help clarify our understanding of how people have traditionally viewed lakes and other natural phenomena. They also reflect certain cultural and natural characteristics.

2.1.2 How and Why?

This paper aims to identify the factors which reconcile the cultural and historical characteristics of the relationship between man and lake environment, and people's attitudes and perception of that environment. The paper also identifies the need to validate lake environmental management policy in the context of local socio-cultural settings.

It is important here to distinguish between two key issues related to lake environment management, namely "How?" and "Why?". The former focuses mainly on techniques and methods for the "sound management" of the lakes based on the scientific research and methodologies. These processes are relatively easy to communicate among people who are educated in the formulation of modern technological and scientific concepts. The latter, on the other hand, tries to find out why particular aspects or certain problems are selected from a huge number of possible standpoints and why a particular problem is considered to be a problem in a given social and cultural context. In other words, "Why?" is strongly concerned with the ways of thinking, experiences, value systems and behavioral patterns of ordinary people in relation to the notions of a desirable environment and lifestyle. It is recommended that the framework for a sound environment should be determined by the local people because they are most affected by changes in the lake environment. Policy-makers, scientists and planners should support this process.

2.1.3 Surveys of the Lake

People who live around a lake generally feel some kind of affinity (commitment) with the lake environment. Identifying the pattern and structure of this relationship from local production patterns and living conditions should be a basic requirement when pursuing lake environmental management plans. However, many such plans seem to jump too quickly to the "How?" stage and set out to define rational, scientifically based objectives. The "Why?" stage receives little attention and even worse the understanding of the problem and proposed solutions are often imported from another country without an assessment of their appropriateness. This occurs in both developing and developed countries. Some Chinese scientists referred to this problems as follows;

"....Countries and areas of differing development levels have different social and economic conditions, therefore there are different balances among different water-use purposes. China is a developing country and is facing increasingly obvious contradictions between demand and lack of water resources during economic development, and limited funds for treatment measures........"(Xiangcan J., et al. 1990, pp103).

Every lake possesses its own ecological conditions, and people have utilized or developed the lake environment in relation to its ecological and historical conditions. It is essential, therefore, to collect basic information about the lake's socio-cultural conditions and local perceptions as well as natural conditions. There are two main ways to collect socio-cultural information. One is to utilize historical documents, administrative materials and statistics from published sources. The other is to gather first-hand material on living conditions, attitudes and/or desires and possibly conscious and unconscious knowledge about nature. The author of this paper and a group of anthropologists, sociologists, geographers, historians and folklore specialists conducted such field research at Lake Biwa and discovered several important aspects of the Lake's history (Torigoe and Kada, 1984, Torigoe 1989). This research was the first of its kind in the Lake Biwa area. It is relatively simple to undertake and does not require costly machines nor big organizations. The only necessary conditions are an awareness of the importance of this type of work and the questions it addresses, and a deep curiosity about phenomena and behavior otherwise taken for granted. As Kenneth Ruddle (based on years of experience of resource management research and practice) states;

"Only a small part of what is known about the nature, utilization and sound management of renewable natural resources in non-Western societies has been documented. Yet the users of such resources are an important and sometimes the only source of information. Although many traditional empirical models of renewable natural resource use are capable of further refinement and improvement, they can still serve effectively as a basis for new, low-cost investment schemes in both tropical and temperate lands and waters."(personal communication).

These traditional empirical models, however, perhaps have another more important role. That is they provide increased opportunities for local people to enhance their awareness of the implications of everyday practices on living environment systems. This awareness and the new information source it produces is an important input to the lake management process. As the American physicist, Fritof Capra, says;

"we need to combine our rational knowledge with an intuition for the non-linear nature of our environment. Such intuitive wisdom is characteristic of traditional, non-literate cultures, in which life was organized around a highly refined awareness of the environment. In the mainstream of our culture, on the other hand, the cultivation of intuitive wisdom has been neglected. (Capra F., 1982, pp25)

Modern societies place too much faith in scientific knowledge and rational and/or efficient decision-making. But that very knowledge in most cases is only a partial and limited understanding of the deep and stochastic nature of the social and environmental system.

2.1.4 Historical Changes in Lake Environment Activities

Each lake has a varied relationship with people and society. It provides, for example, fishing opportunities, a source of drinking water and a route for transportation. Taking the example of Lake Biwa, let us next overview the historical changes in the relationship between lake and people.

2.1.4.1 Utilization of Aquatic Resources

(A) Fishes and Shells

In ancient times, the first and foremost role of lakes was probably resource supply for the subsistence of the local population. Around 10,000 years ago, when people first settled near Lake Biwa, the staple diet included lake fish and shells, nuts, water birds and game. It is highly likely that the people who utilized the local fauna and flora gradually acquired detailed knowledge about the availability and possible utilization of those resources. For example, quite recently, evidence from a shell mound found at the bottom of Lake Biwa showed that people at that time ate a variety of food according to the seasonal changes, Shijimi shell in spring, fish in summer, nuts in autumn, and ducks and some game in winter. This tells us that the lives of people in those days were much more closely tied to the seasonality of nature than they are now. In addition, only large Shijimi shells were discovered (no infants). There may be a number of possible explanations for this but it does seem to suggest that the people may have been concerned about resource preservation and thus did not gather the infant shells. Such a system of aquatic resource utilization continued into the agricultural stage. In the case of Lake Biwa, after rice cultivation was introduced, resources obtainable from the lake and surrounding environments continued to be utilized right up to modern times.

Table 2.1.1 outlines the key changes in the environmental activities at Lake Biwa from the ancient to modern times. In recent years, the relative importance of lake fishing activities in relation to the total economic activity has been declining. The number of fishermen declined from about 10,000 in 1900 to about 3,000 in the 1980's. Figure 2.1.1 shows the recent changes in total amount of fishery catch. The amount of fish caught has slightly increased whereas the amount of shells gathered has declined since the 1960's. In addition to the quantitative changes, fishing at Lake Biwa has experienced qualitative changes. For example, recently the emphasis has been on catching certain types of fish in order to stock rivers all over Japan for sports fishing rather than food (this is especially the case for the Ayu fish, whose spawning grounds in many rivers have been environmentally degraded).

(B) Evaluation of Eutrophication and the Use of Water Plant and Sediments

After the introduction of agriculture farmers began to use water plants and muds from the lake bottom as fertilizers. In addition some reeds and water plants were utilized as roofing or screens for houses or certain types of fixed gear for fishing. However, these have now almost been completely replaced by synthetic materials.

It is not known when the practice of using plants and lake muds as fertilizers first started but at least in Edo period we can find written documents referring to the utilization of these lake aquatic nutrients. This continued until the 1960's when artificial fertilizers began to be used in the area. In addition to the lake water or lake muds, domestic effluents from the kitchen or human nightsoils and cattle manures were also used as fertilizers. This practice is thought to have helped prevent the eutrophication of Lake Biwa itself. This is not to say that eutrophication is necessarily bad. In fact in the context of water resource utilization in a subsistence economy, a degree of eutrophication may be desirable. Jin Xiangcan states:

"Euthropic is not always harmful and dystrophic is not always beneficial, especially in developing countries where protein demands are increasing and(such as when producing the aquatic products) water bodies prefer relative euthropic to dystrophic. (Xiangcan J., 1990, pp104)

(C) Social Institutions for Water Space Utilization

Aquatic resources are limited. Consequently, people living in the vicinity of seas, lakes and rivers tend to invent certain customs or institutions to control aquatic resource use. In this context the term "Water Tenure" can be used. This concept has been recognized by a number of scholars (Ruddle and Johannes, 1985). Before its introduction to water resource thinking most scholars thought that water space was free in both access and utilization terms. A great deal of research has been carried out on the subject of sea tenure. However, work on lake and river tenure remains in the initial stages with very little information available. The concept of lake tenure is however vitally important to the investigation of the relationship between lakes and people.

Lake Biwa is one of the few cases where documentation is available and some of the customs are still on-going concerns for the local people (Kada, J., 1984). The earliest documents concerning fishing in Lake Biwa date from the 9th century A.D. when the Emperor authorized a wier be constructed at the point where the Seta River flows out of the lake. Fishermen were given permission by the Emperor, local aristocrats, shrines and temples to exploit the fishing grounds.

At the start of the feudal period fishing rights were given to each local community in exchange for taxes. Although there were some variations according to the type of fishing, these taxes were usually levied on fishing villages by the administrative units (Shogunate or local fief). Inside the village, each fisherman or fishing group were allotted the rights by the village council. The nature of fishing rights in Lake Biwa in the Edo Period was similar to a "right in rem" which allowed exclusive rights as well as several methods for their transfer; sale, rental, pledging and/or inheritance. Similar principles were applied in the relation to the use of water weeds, bottom muds and reeds exploitation. This means that lake resources were managed by each village community in the same way that the village land was managed. After the modernization of Japan, when the national Fishing Law or Fishing Association Law was established, the basic idea of local management of fishing resources was inherited.

2.1.4.2 The lake as a Water Resource

Since ancient times human energy has been used to take water from Lake Biwa for the irrigation of paddy fields. Initially the irrigated area was limited to the paddy directly facing Lake Biwa and the canals. In the 1910's automated irrigation pumps were first utilized around the lake and in the 1960's lake water was being pumped to around 30% of the paddy fields in Shiga Prefecture (Fig. 2.1.2). As far as industrial water is concerned, the textile industry began to locate at the shore of the lake in the 1920's and benefited greatly for the abundant supply of water of appropriate quality for artificial textile production. In the 1960's, when Japan entered a period of rapid economic development, the role of Lake Biwa as a water resource was identified by local administrators and the general public. Domestic water use was switched from well or river water to tap water systems (Fig. 2.1.3), and per capita water use increased ten times from the early 1960's to the 1980s. Fig.2.1.4 shows the increases in the area where the population relies on water from Lake Biwa for drinking usage from the 1960's to the 1980's. The water supply systems have been geographically widened and now even people living far away from the lake rely on it for water. The population relying on Lake Biwa water accounts for more than 13 million people in the Western part of Japan. Their attitude towards the lake, however, is one of indifference and lack of concern. This is one of main problems facing the management of Lake Biwa and some programs are needed to enhance public awareness of the importance of this water resource.

2.1.4.3 Lake as a Pollutant Reservoir

There are three main types of pollution threatening Lake Biwa's water quality. First is pollution by toxic substances. Second is pollution by eutrophication, and third is pollution by waste or garbage. Pollution by toxic substances has tended to be very localized although recently the use of chemicals in agriculture and at golf courses has become more widespread. The use of toxic substances can be considered a "civilization" specific problem. Pollution caused through eutrophication and waste, on the other hand, can be described as "culture" specific problems. Eutrophication means that the nutrients originally necessary for the growth of organisms are present at levels over certain acceptable standards. The standards are determined by human values which are in turn determined by the culture. Waste is created when a thing is considered as unnecessary during a process of production or in life in general. An empty can can be a resource when it is used as a water cap in an African village or when it is recycled. But it is waste when discarded by visitors to the lakeshore.

According to a survey in the surroundings of Lake Biwa, those who said "the lake has become dirty lately" meant mainly that waste in the lake has been increasing. We can find waste everywhere along the lakeshore. The things that are considered waste include not only the recent industrial products such as empty cans and polystyrene foam but also water plants which were once used as fertilizers and ditch reed which was used for roofing. This tells us that the value we place on things is not static but constantly changing,

Unfortunately as the amount of water use increase so does the amount of effluent entering the lake. Accepting this effluent is also a role of Lake Biwa. One simulation showed that seventy percent of the nutrients flowing into Lake Biwa are deposited at the lake bottom, and only thirty percent flow downstream. Most of the sewage treatment plants constructed to prevent eutrophication are near the lakeshore. A cycle has developed whereby the water supply department of the local government draws more and more from the lake and the sewage treatment department has to construct more sewage treatment plants. Both are following rational judgments based on the social mechanisms involved. The consequence of which is the creation of more effluent and the further eutrophication of Lake Biwa.

2.1.4.4 Role as a Traffic Network

The significance of the lake as a traffic route has been recognized from ancient times: canoes were found in remains from the prehistoric age which suggests that the lake was utilized as a traffic route. Historically, Lake Biwa was an important route for the transportation of people and goods. The interchange of goods between the northern and southern areas Japan was supported by a route from the Japan Sea via Lake Biwa to Kyoto and Osaka. In the Edo era it was estimated that there were as many as 3000 ships transporting goods on the Lake. Agricultural products and sea foods from northern Japan were transported to Kyoto and Osaka, while finished goods such as fabrics, mosquito nets, and ceramics went in the opposite direction. The role of Lake Biwa as a transportation route disappeared completely after motorization in 1960s. The only traffic on the lake now consists of sightseeing and leisure boats.

2.1.4.5 Generating Electricity

Hydropower in Japan began in Kyoto in the 1890's. Kyoto used water from a canal connected to Lake Biwa to produce electricity for the operation of the street car system and to support industrial development. At the start of the 20th Century additional hydropower generation plants were constructed in Uji and elsewhere. These plants are still in operation. However, Lake Biwa's role as an energy supply source declined in significance from the1960's onwards with the advent of major dam construction programs in the mountainous areas of Japan. Few local residents are aware that Lake Biwa is being utilized for hydropower generation.

2.1.4.6 Scenic Beauty

Lake Biwa once represented a place of beauty and mystery for the people of Kyoto and has been the theme of many Japanese poems. One such poem is "Ausaka o uchiidete mireba ouminomi, siramomen banani namitachiwataru" (After passing over Ausaka Hill, I can see the beauty of the lake shore white as cotton flower). It was only after the eight beauty spots in Omi Province (the old time provincial name for the Lake Biwa area) were designated that the scenic beauty of Lake Biwa became known to the majority of Japanese. Color prints of the eight beauty spots in Omi Province were mass-produced in the middle of the Edo era. More recently, people have tended to prefer the beauty of the mountains and the sparsely inhabited areas to the original Omi beauty spots. Lake Biwa nevertheless has retained its scenic value and the first sight-seeing boats appeared at the beginning of the 20th Century. After some ups and downs in the history of tourism at the lake, at present, about one million people utilize the sightseeing boats annually.

For the local population familiarity with the scenery seems to breed complacency. It tends to be travelers and newcomers that recognize the scenic value of Lake Biwa. The increase in water front development in the 1980's, however, did serve to bring the issue of preserving Lake Biwa's scenic beauty to public attention.

2.1.4.7 Leisure Activities

Leisure in this section refers to swimming, yachting, boating, sports fishing activities and the like. The first bathing spot at Lake Biwa was established in the1920's. Lake Biwa was important for the people living in the Kinki District as the place for bathing and swimming. Yachting and boating also began in 1920's. As water leisure activities diversified in the1980's, the lakeside at holiday periods became more crowded with people enjoying yachting or surfing. Also in line with the current trend of resort construction in Japan, there is strong pressure for the construction of marinas and hotels resorts in the lakeside area. This resort construction boom, however, may result in some destruction of the living environment: traffic jams, scattered waste and damage to fishery have become serious problems in some areas.

2.1.4.8 Fear of Flood

Water from almost all of Shiga Prefecture flows into Lake Biwa. There are as many as 100 rivers flowing in whereas there is only one river flowing out, the Seta River. Heavy rain in the rainy season or from typhoons can suddenly raise the water level of the lake, causing flooding over fields and houses at the lakeside. This is called "Mizukomi" and is greatly feared by the local inhabitants. According to records of a village in the Edo era, "Mizukomi" occurred on average once a year. The highest water level ever recorded was +3.76 meters in 1896, when the present Otsu City and other towns in the lakeside such as Hikone and Nagahama were flooded and about 20 thousand hectares of ricefield were damaged. To prevent damage from flood, the villages in the Edo era prepared flood defenses, stored materials to fight the flooding and monitored the state of the banks on rainy nights. When they thought that the bank was in danger, they rang an alarm bell to call all adult men aged 16 to 60 years from the village to try to protect the bank. For the distribution of boiled rice and for the support of people whose fields or houses were damaged, Shasoumi (corresponding to the present mutual aid insurance) was offered. The procedures, expenditure and construction work necessary for repair of the bank were supported at times by the superior administrative organs but were mainly the responsibility of the villagers. The villages which often suffered flood damage cooperated together to protect against flooding, for example, by dredging the Seta River.

From the Meiji era onwards, prevention of flood damage has been one of the main concerns not only of the inhabitants in the lakeside but also of those living in Osaka and other downstream areas. They dredged the Seta River, strengthened riverbanks and constructed dams to control the water level (Nango Araizeki). Fig. 2.1.5 shows the change of the water level of Lake Biwa in the past 100 years, suggesting that the danger of flooding was reduced dramatically after the Nango Araizeki was constructed.

2.1.4.9 Religious and Symbolic Meanings

As mentioned at the beginning of this paper, the legend of the Spirit of Lake Biwa is known throughout Japan. The Mii Temple in the story is the main temple of the Jimon sect of the Tendai, an important sect of Buddhism, and the legend suggests that the lake spirit and man communicated with each other via the bell of the temple. The head temple of the Sanmon sect of the Tendai, another important sect of Buddhism, which has often feuded with the Mii Temple, is located on Mt. Hiei in the south of Lake Biwa. One of theteachings of the Sanmon sect is that the lakewater goes up Mt. Hiei and then comes down back again to the lake. This idea may reflect the notion of the transmigration of souls. Lake Biwa is a kind of holy place in Tendai teachings. Lake Biwa, like religion, holds a symbolic meaning for the people of Shiga Prefecture. It is a symbol of their unity (all rivers in Shiga lead to Lake Biwa) and as that symbol has become increasingly threatened by environmental problems the unity of the local population has increased. The symbolic meaning of the Lake has recently gained greater significance in the media, school education and administrative campaigns.

2.1.5 Appropriate Management

An old man living in a village near the lake, my mentor, often warns me that the relationship between the local inhabitants and the lake have not always been harmonious nor beneficial. This suggests that management of water resources which only aims to promote convenience for human beings may face significant problems in the future. Water not only fulfills basic needs but also poses considerable dangers.

In the context of Lake Biwa, the water supply and sewerage system has in itself contributed to the eutrophication of the Lake. The system has broken the link between human-consciousness and the lake and increased reliance and belief in technology. The lake as an appropriate source for public water supply, however, is not necessarily appropriate for fishery. All of the functions of the lake (which are often conflicting) have determined the present state of the lake and will likewise determine its future.

Whether the resources of the lake should be managed by the residents themselves or by national or administrative organs has been the subject of some discussion over the last 10 years or so. It is not a matter of two mutually excluding alternatives but of mutual concessions between the groups and opinions with different and various cultural backgrounds. In planning the appropriate management of the lake environment, it is important to be aware of the existence of the socio-cultural system based on the recognition of the diversity of human and natural- ecological systems and their relationships. Attaining an ideal state of the lake environment is no simple task because of the diversified demands involved. The point that I would like to lay emphasis on in this paper is that management of water resources is a problem which includes both the ecological system and human society. Moreover, the social-cultural processes of the latter are specific to time and culture.

References:

Berkes F. (ed), 1989, Common Property Resources-Ecology and Community- Based Sustainable Development, Belhaven Press.

Brotoisworo E., 1989, Environmental Management of The Saguling Dam, Guidelines of Lake Management, Vol.1, Jorgensen, S.E. and Vollenweider, R.A. (eds), ILEC and UNEP.

Capra F., 1982, The Turning Point: Science, Society and the Rising Culture, Simon and Schuster, New York.

Ruddle K., Furtado J.I., Zhong G.F. and Deng H.Z., 1983, The Mulberry Dike-Carp Pond Resource System of the Zhujiang Delta, People's Republic of China. Applied Geography, 3, pp.45-62.

Ruddle, K. and Johannes R.E., (eds), 1985, The Traditional Knowledge and Management of Coastal Systems in Asia and the Pacific. Jakarta:UNESCO, pp7 3.

Kada, Y., 1984, The Evolution of Joint Fisheries Rights and Village Community Structure on Lake Biwa, Japan, K. Ruddle and T. Akimichi(eds) Maritime Institution in the Western Pacific, Senri Ethnological Studies 17, National Museum of Ethnology, Osaka, Japan.

Torigoe,H. and Kada, Y. (eds), 1984, Environmental History of Man and Water, Ochanomizu-Shobo.

Torigoe, H., 1989, Social Theory of Environmental Problems, Ochanomizu-Shobo.

Xiangcan J., Hongliang L., Quingving T., Zongshe Z., Xuan Z., (eds), 1990, Eutrophication of Lakes in China, The 4th International Conference on the Conservation and Management of Lakes "Hangxhou '90".

Berkes F., 1989, Common Property Resources-Ecology and community-based sustainable development. Belhaven Press, London.

Table 2.1.1 Historical Changes in the Environmental Activity of the Lake

		Pre-Historic (-6C)	Ancient (6C-12C)	Medieval (13C-16C)	Feudal (17C-19C)	Modern (19C-1960)	Present (1960-)
Aquatic Resource Use	fish/shell	◎	◎	◎	◎	○	△
	waterweeds reeds, etc.	◎	◎	◎	◎	○	×
Water Resource		△	△	△	△	○	◎
Transportation		△	△	◎	◎	○	×
Pollutant Reservoir		?	?	?	?	△	○
Generating Electricity		×	×	×	×	△	△
Scenic Space		?	△	△	◎	△	△
Leisure Space		?	?	?	?	△	○◎
Religious or Symbolic Activities		?	○	○	△	△	○◎
Food Control		?	?	?	△	◎	○
Pollution	Eutrophication	?	?	?	×	×	△◎
	Garbege pollution	?	?	?	?	?	△◎
	Toxic pollution	?	?	?	?	?	△○

◎ : Most Important Activity
○ : Considerably Important Activity
△ : Slightly Important Activity
× : Almost Nonexistent Activity
? : Very little information available as to extent of this Activity

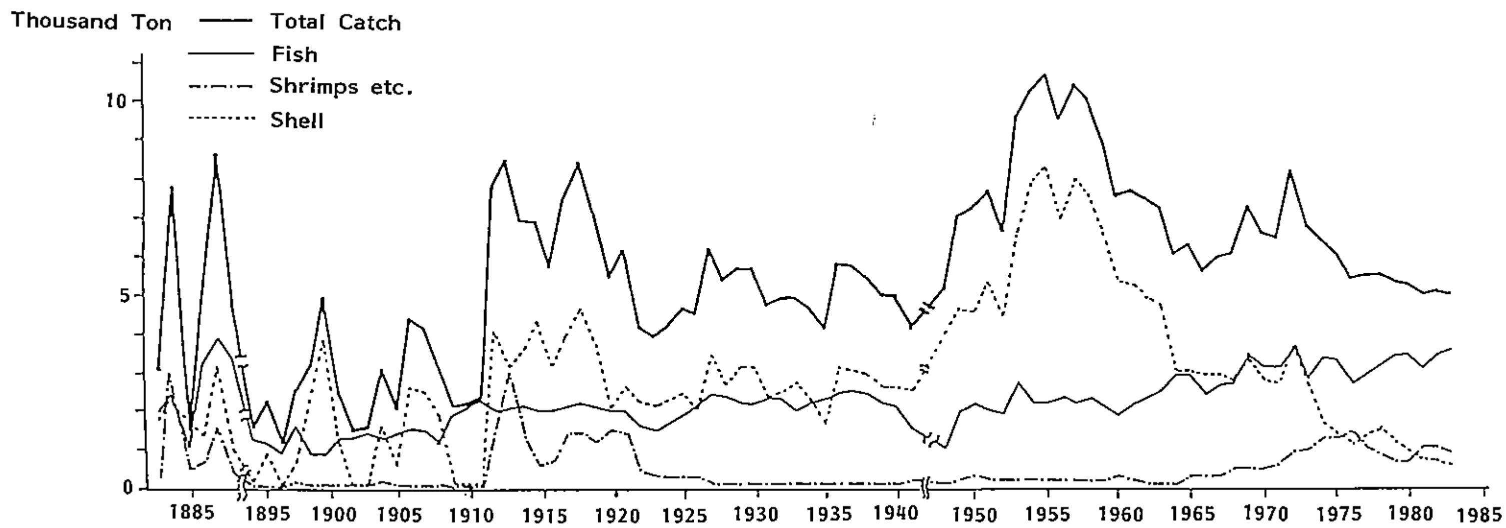

Figure 2 1.1 Annual Change in the Fishery Catch (1883 - 1983)
Source: Shiga Prefecture Fishery Experiment Station

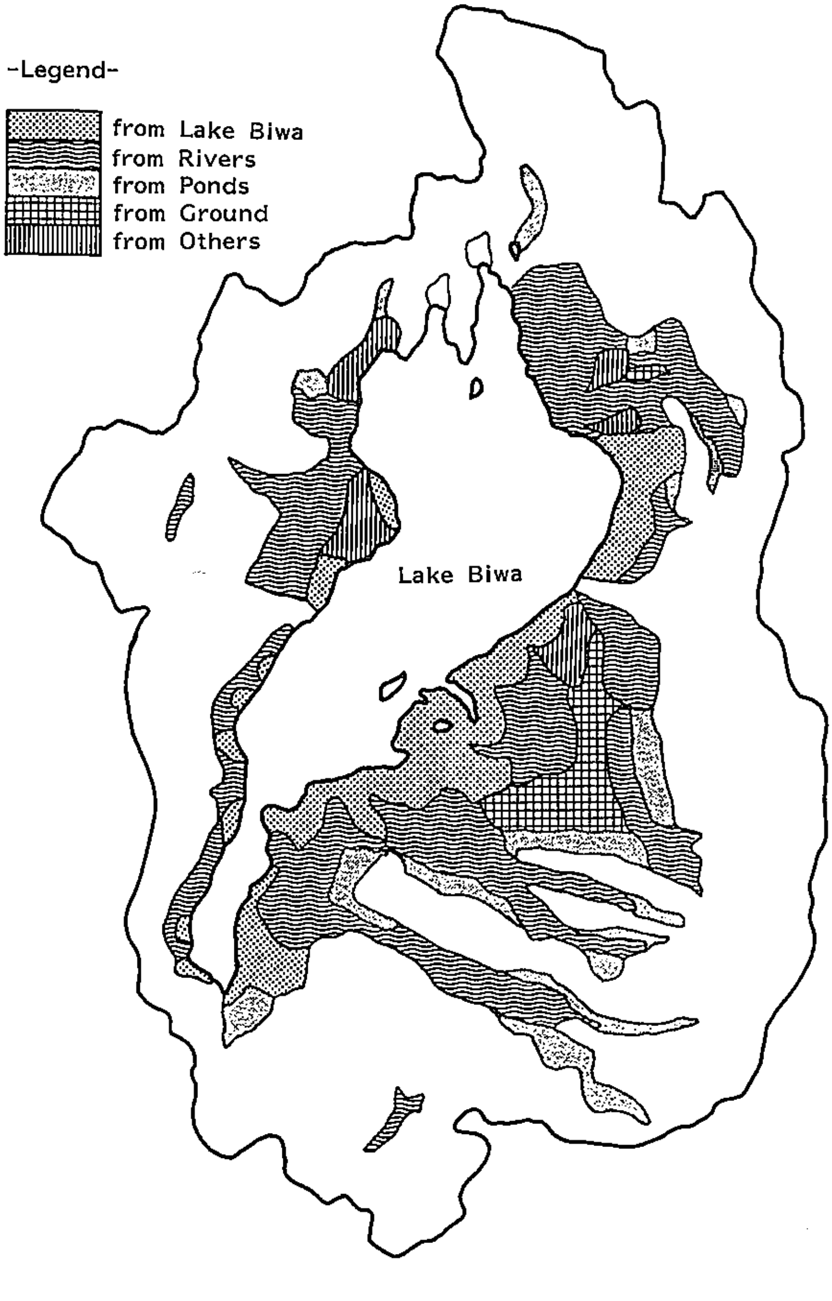

Figure 2.1.2 Status of Water Use (1985)

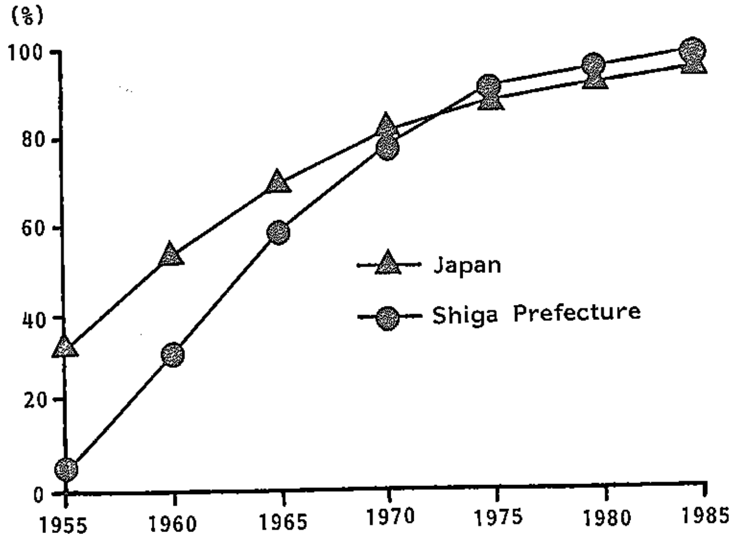

Figure 2.1.3 Change in Water Supply Provision in Shiga Prefecture and Japan 1955 to 1985.
Source: Statistics for Water Supply, Ministry of Health and Welfare

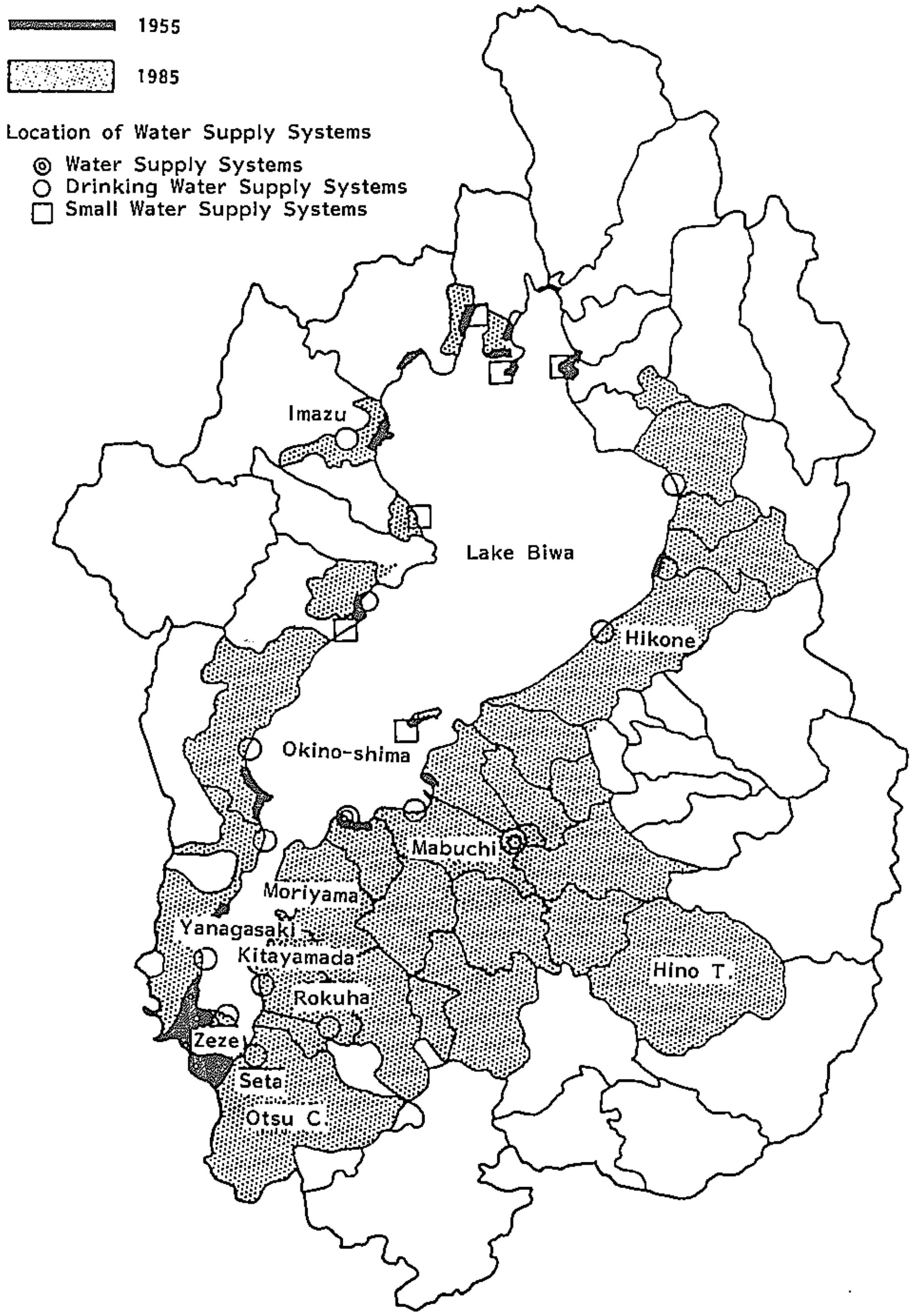

Figure 2.1.4 Expansion of area whose population are relying on Lake Biwa for drinking water - 1965 to 1985

Source: 1985 Division of Public Health, Shiga Pref., Division of Drinking Water of each Municipal Town and Village.
1955 Observation by Lake Biwa Research Institute

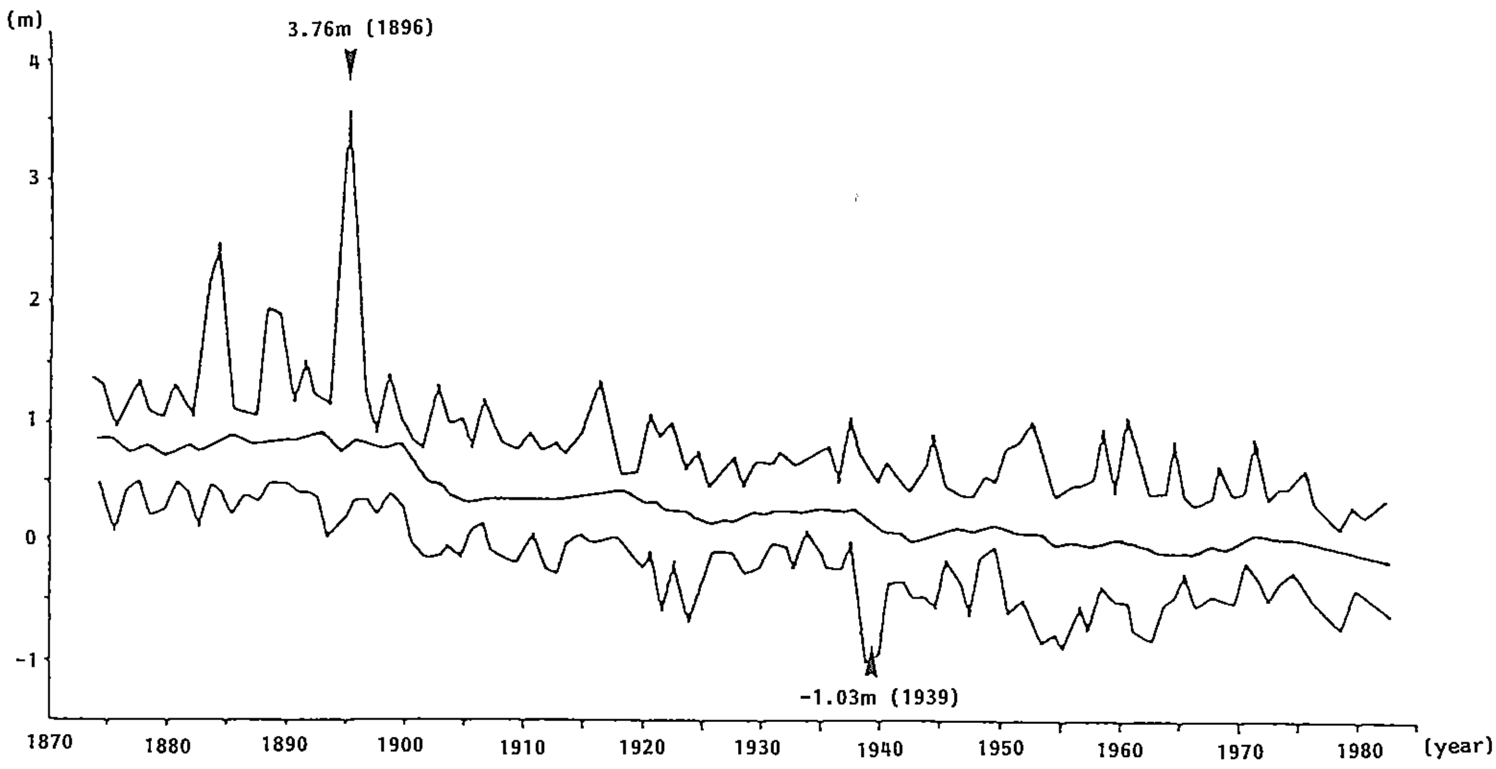

Figure 2.1.5 Annual Water Level Variation for Lake Biwa
Source: Shiga Prefectural Govt.

SECTION 2.2

INTEREST GROUPS INVOLVED WITH THE USE OF WATER RESOURCES/ENVIRONMENT

Ken-ichi Nakagami

2.2.1. INTRODUCTION

In the past, water resource planning was concerned mainly with the perceived adequacy of institutional arrangements and infrastructure developments. Recently, however, concern has come to focus on intangibles, such as the notion of quality of life, aesthetics and, to some extent, spiritual values. One of the implications of this change in perception is that non-physical factors like environmental amenities have become more important in water resources planning. For this reason, the environmental impact assessment (EIA) of the subject area is now an integral part of water resource planning. However, the concept of EIA has not been clearly delineated as yet, nor can it be easily and concretely defined. For the purposes of this paper the aim EIA is defined as the identification of the existing comprehensive conditions in the subject area, the prediction of the likely impacts of policies, plans and programs and the presentation of mitigating measures for any foreseen negative effects. More generally, EIA seeks to provide the decision-maker with better information on which to make his decision.

Although most of the decisions made in the planning process should be based on the results of a reliable environmental assessment, three factors may limit an assessment's reliability in relation to water resource developments:

1. The existence of complexity in the water resource environment and with water resource planning which incorporates the concept of environmentally sound management.

2. The existence of uncertainty among those elements used in decision- making.

3. The existence of different interest groups involved with water resources planning and management and the role of local community participation in plan formation for water resources.

This paper attempts to examine the rationality of local community participation and interest group involvement with the use of water resources/environment (Nakagami 1983).

2.2.2. THE UTILIZATION SYSTEM OF WATER RESOURCES/ENVIRONMENT

Understanding of the socio-economic context of river/lake basins has undergone profound changes throughout history. Transportation along rivers has declined and consequently this has reduced social and cultural interaction between the upstream and downstream communities.

The use of a river or lake basin as the territorial unit of planning has so far remained immature with limited application. In order to fully develop the philosophy of river/lake basin management as well as relevant planning methods, it is essential to establish a set of rules for managing river/lake basin resources/environment with a systematic inventory of their uses. A simplified systems diagram showing the utilization of river/lake basin resources/environment is presented in Fig. 2.2.1.

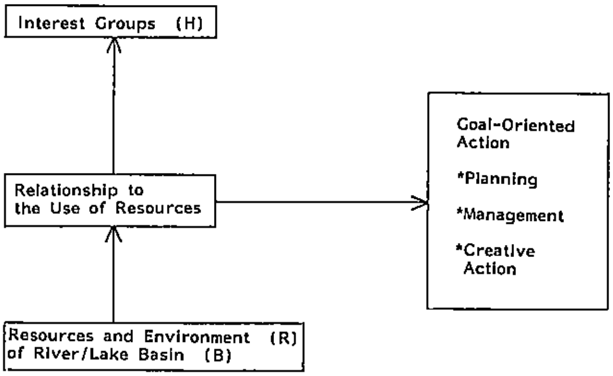

Figure 2.2.1 Utilization System of Resources and the Environment As human history reveals, conflicts of interests among individuals or groups of people (H) emerge over the use of resources (R) -- water, land and forests -- in any river/lake basin (B). In order to ensure the rational and efficient use of river/lake basin resources, goal-oriented actions such as planning and management should be promoted in an innovative/creative manner.

To be more precise, planning for a river/lake basin involves the clarification of the planning goals, who undertakes the planning exercise, the major planning variables involved, where the planning is directed, how long the planning period is, and what method of planning is to be used. On the other hand, management involves decisions aimed at minimizing the gap between the planned actions and the current state of resource use. Finally, creative actions involve a task of discovering, in an innovative manner, a possible break away from the present situation where creation of new resources is increasingly called for as a result of resources depletion and changes in production methods and lifestyle.

In order to enhance the economic value of resources and the environment, it is necessary to define an optimal state of resources/environment-use as well as to develop a system whereby that state can be achieved. For the purpose of addressing these tasks, a clear understanding of the relationship between resources/environment and man is essential. In addition, a rational rule of decision making among interest groups has to be established in order to guide the resources/environment-use practices to an optimal state. What is called for is therefore not to seek an advantageous position over others with regard to resources/environment-use, but to search for a long-term collective management approach directed at conserving the river/lake basin.

Man-water relations change as the local lifestyle and the method of production changes. Also, the manner in which water is used varies according to the form in which water resources are made available (such as lakes, rivers and groundwater).

The manner in which people come into contact with water varies in accordance with the size of settlements. Moreover, the relationship between human society and the water environment has evolved over time. Changes in the water environment often give rise to direct and indirect conflicts of interest among individuals and/or groups. As a result of this process, interest groups are formed.

In recent years, a number of interest groups have formed centering around public projects. Their goals and objectives are many and varied. In order to reflect the views and opinions of these interest groups in the process of public decision making, a coherent goal acceptable to all and a principle of collective action have to be established. However, as the goals of interest groups change in response to the group dynamics that take place under the strained situation, it may not be possible to define a unified principle of action agreeable to all groups concerned. Thus it is extremely difficult for interest groups to come up with a set of unified yet distinct views and actions towards public policies including river/lake basin management.

Under certain circumstances in a particular river/lake basin, however, it may be possible to establish a common principle of action among interest groups. While it will certainly enlarge the scope of planned actions and policy tools to be applied, it necessarily involves the difficult task of making a decision acceptable to conflicting interests involved with plan formulation. An optimal state of resources/environment-use in a river/lake basin from the socioeconomic viewpoint may be realized through consensus forming among interest groups concerned.

This, however, requires the institutionalization of mechanisms of social consultation through which the views and aspirations of different interest groups can be synthesized and reflected into public decision making. In order to make such a mechanism effective, the following three points should be given due consideration:

1. An agreement must be made beforehand among interest groups on the role of decision making with regard to the use of resources/environment in a river/lake basin;

2. Every effort must be made to come up with a unified goal of resource/environment use among interest groups as well as coordination with other goals in order to reduce conflict;

3. Every effort must be made to realize information sharing among interest groups so as to enable them to make a collective decision on the rate of resource/environment use.

In order to resolve the problem of multiple interests in a rational manner, impartiality (fairness) must be ensured among interest groups concerned while making sure that realistic policies are formulated and concrete proposals of action articulated. In cases where each of the interest groups involved is capable of independently making decisions, the situation must be seen in a dynamic social context. Under such circumstances, a simple mechanical method of deriving an optimal solution is no longer viable. Technological progress coupled with development activities undertaken under the policy of regional development have certainly given rise to changes in the region-specific environmental conditions.

A proper understanding of these change processes analyzed in relation to the performance of interest groups within the socioeconomic structural context may serve as the first requisite for harmonizing the resource-use practices in a river/lake basin with policy efforts towards environmental conservation.

The second requisite is to develop a system capable of reflecting people's views and opinions in the process of river/lake basin management and planning, thereby ensuring that the method of consensus formation will be accepted as a common sense method. The prospect of realizing a harmonious balance between development and environment may basically depend on the extent to which our efforts are made in carefully observing the environmental changes as well as in devising integrated approaches to problem-solving (Nakagami 1989).

2.2.3. THE PROCESS OF POPULAR PARTICIPATION IN PLAN FORMATION

The viability of river/lake basin management and planning (RLBMP) may be enhanced, provided a consensus is reached among the interest groups concerned. Fig. 2.2.2 shows a process of popular participation in RLBMP. As RLBMP acts through A: strategic level, B: tactical level, C: implementation level, and D: operation and maintenance level, the focus of popular participation also shifts from conceptual aspects, and eventually to monitoring and surveillance aspects (Nakagami 1989). There are stages in the planning process where people's views and opinions are crucial. Taking the planning process given in Fig. 2.2.2 as an example, decisions are to be made at stages x, y and z in the light of people's views and opinions. However, popular participation takes various forms. What form of popular participation is to be adopted largely depends on the perception of decision makers.

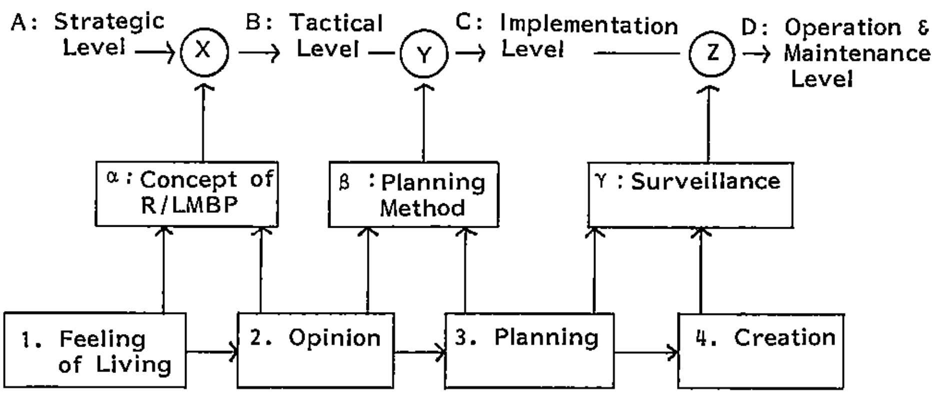

Figure 2.2.2 Popular Participation in RLBMP

An attempt is made below to examine the role of the local population in the process of RLBMP. Those who are concerned with RLBMP may be divided into four groups as given in Fig. 3 in accordance with their functional attributes (local people and government agencies: both national and local) as well as their locational attributes (upstream and downstream). Within this framework, let us assume a situation where: 1) R2 has a plan to develop water resources (O) for the purpose of promoting economic and social development. In view of the adverse effects on the community life and productive activities of R1, 2) R1 submits a claim (D) to improve infrastructure and social services in the watershed community.

In order to materialize the claim submitted by R1, A1 may request A2 to cover the costs. If the costs have to be eventually shouldered by A2, the relationship between A1 and A2 communities may become tense with the result of weakening solidarity among them. Under these circumstances, it is difficult to harness, among the local population, a collective sense of sharing resources and the environment in the river/lake basin. At the same time, collective actions cannot be taken towards RLBMP. Hence the government sector has to take a leading role in RLBMP.

In order for the local population to play a leading role in RLBMP, the following conditions should exist between R1 and R2:

1. The adverse effects of water resources development on the upstream community must be fully recognized by the people in the downstream community. This implies the need to generate relevant information be shared by all in the entire basin community;

2. Efforts must be made to harness, among all in the basin community, a common understanding about urgent policy issues such as water resources development and conservation. Without this common understanding, unified goals of RLBMP cannot be formulated; and

3. Efforts must be made to facilitate dynamic interaction between the upstream and downstream communities in order to articulate issues and problems to be addressed through RLBMP. This implies the need to establish a permanent organization for promoting such upstream community interaction (Nakagami 1989).

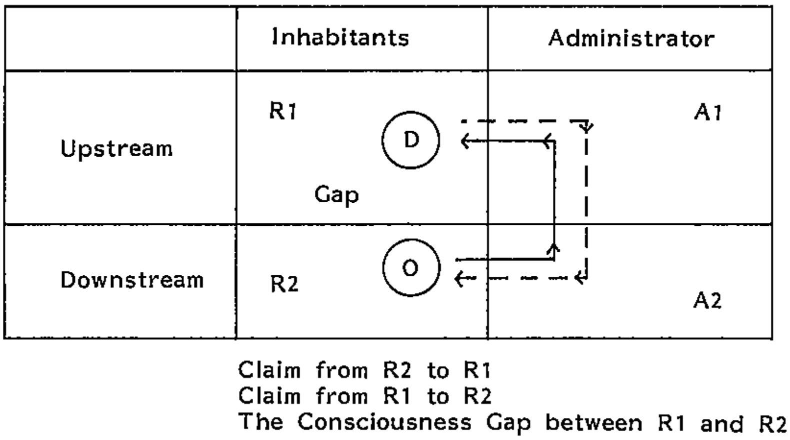

Figure 2.2.3 Consciousness Gap Process of RLBMP

2.2.4 INTERACTION AMONG INTEREST GROUPS INVOLVED WITH THE USE OF WATER RESOURCES/ ENVIRONMENT OF LAKE BIWA

The objective of the Lake Biwa development project has shifted from that of electric power development (1950s) to water resource development (1960 - early 70s), and finally to a multi-purpose one (water use, flood control, environmental conservation).

The latest project ("The Lake Biwa Comprehensive Development project") was established in 1972. Budgeted at 430 billion yen, it was to be implemented over a ten-year period.

The shift in the aim of development projects is due to the persistent efforts of the residents of Shiga Prefecture to become involved with the planning of projects affecting their community. Their desire to preserve their environment is based on their long history in the region. As the magnitude of development becomes greater, it is increasingly difficult for residents to ensure a stable water supply to downstream residents and industries as a number one priority. For this reason, the Lake Biwa Comprehensive Development project had to begin with an overall definition of its objectives, incorporating water quality and environmental conservation, as well as development measures.

The institutional framework for this project is unlike that of others of its kind. Decisions are made according to a unique institutional mechanism. It is the governor of the prefecture (and not the national authority) who has the ultimate power to make decisions that concern parties, such as the governors of neighboring prefectures.

However, this institutional peculiarity makes the decision-making process more complicated. The governor becomes directly involved in the complex and dynamic process of interaction between various interest groups. This interaction is schematized in Fig. 2.2.4.

The position of the Shiga Prefectural Government is a pivotal one in this interaction. The governor functions as the negotiator for different, often conflicting, interest groups; he elaborates plans and implements them for a wide variety of management purposes, from those of conservation to those of development (Nakagami 1983).

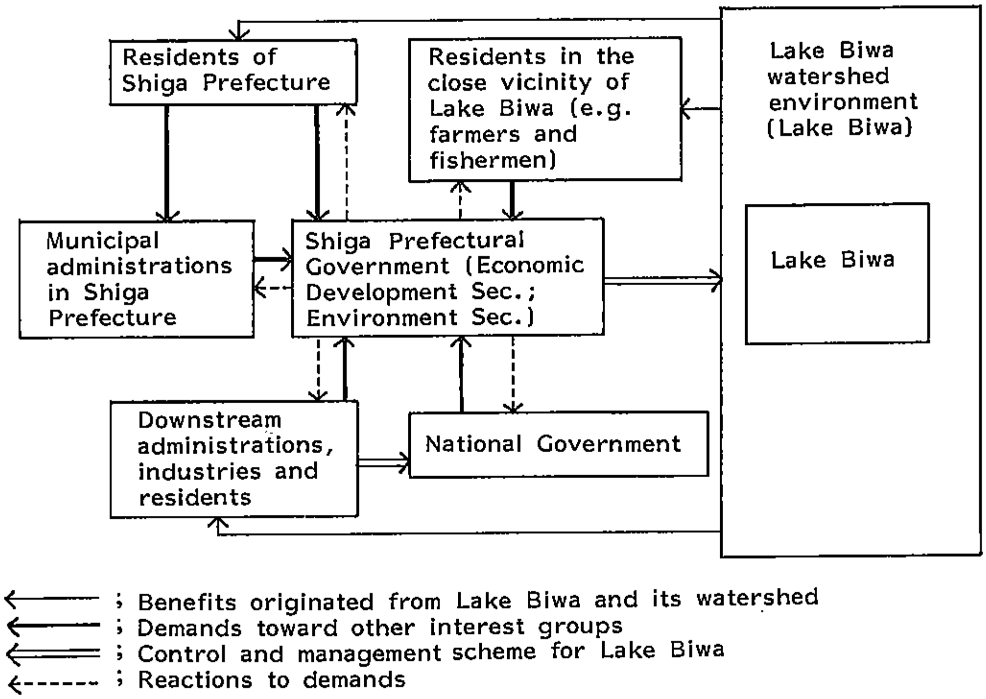

Figure 2.2.4 The Interaction of Interest Groups involved with the use of water resources/environment of Lake Biwa

REFERENCES

Nakagami, K. et al. 1983. Conservation of the Environment and Economic Development. World University Congress. Tokyo, Japan, August, 1983.

Nakagami, K. 1989. A Strategic Concept of River/Lake Basin Management and Planning. Second Expert Group Workshop on River/Lake Basin Approaches to Environmentally Sound Management of Water Resources. Thailand, January, 1989.

Nakagami, K. 1990a. Sustainable Development and River/Lake Management. Third Expert Group Workshop on River/Lake Basin Approaches to Environmentally Sound Management of Water Resources. Otsu, Japan, February, 1990.

PROFILE A:

DISCONTINUATION OF THE LAKE SHINJI AND NAKAUMI PROJECT - JAPAN

Keikichi Kihara

The Japanese government has promoted a policy of high economic growth since the 1960s in the hope of developing the Japanese Archipelago. Many comprehensive development plans were prepared throughout the country. One such plan was a project for land reclamation and the creation of a fresh water supply at Lake Shinji/Nakaumi located near the border between Shimane Prefecture and Tottori Prefecture (see Fig.4.4.1).

The Ministry for Agriculture, Forestry and Fishery started this project in 1963 with National Government subsidies. A water gate was planned to prevent the backflow of seawater, thereby isolating Nakaumi from the Japan Sea. This would change both the brackish Nakaumi and Shinji Lakes into fresh water lakes. The project sought to reclaim approximately one-quarter of Nakaumi (2,542ha) to create new agricultural land and to supply fresh water from these two lakes to the reclaimed land and adjacent municipalities for irrigation.

Local citizens feared the possible environmental destruction caused by this project for the following reasons:

1. Adverse impact on the water quality and the ecosystem of the lakes would be unavoidable. Turning the brackish water into fresh water could have diminished the self-purification process. The absence of tides would have resulted in the stagnation of the lake water, and the accelerated sedimentation of organic substances and nutrients. In addition, the project would remove salt which presently inhibits the blue tide, so that the lakes would have become prone to outbreaks of algae and resultant water pollution, as found at Lake Kasumigaura in Ibaraki Prefecture.

2. Water pollution of the lakes was likely to degrade the quality of life for citizens living in the coastal area, and cause economic loss in the tourism industry in the area, including Matsue City, which is well known as an "Aqua-city".

3.The land reclamation and desalinization projects were not expected to adversely affect flood control as long as the Hii River, which flows into Shinji Lake, is diverted to the Kando River during flooding. It would, however, have been very dangerous to operate the gate before the river diversion work was completed.

4. In relation to the economic effects on the local communities, the disadvantages seemed greater than the advantages: the fishery at Shinji Lake with an annual revenue of 4.1 billion Yen would have been seriously damaged because the project could have destroyed the habitats of the major fish and shellfish species such as the Yamato corbicula (Corbicula japonica) and icefish. The project could have damaged the best lake fishery in the country.

5. Water pollution of the lakes could have serious impact on the tourism industry. The agricultural activities conducted on the reclaimed land could have caused a heavy debt burden among the farmers, because the calculated land prices were expected to be very high. Rice production in Japan has recently been subject to regulation because of oversupply and projects to create agricultural land run contrary to present trends.

These likely adverse consequences of the project suggested that both environmentally and economically this project was undesirable and unreasonable, asserted the citizens.

The local Fishermen's Union (1,300 members) adopted a resolution to postpone closure of the gate. In June 1982, citizens organized the Group for Conservation of Shinji Lake. In July, the Matsue Young Men's Chamber of Commerce and Industry put a one-page opinion advertisement in a newspaper and declared opposition to the project. In October, the Group for Re-examination of the Project was formed, which started a movement requesting the prefectural government to establish a "Eutrophication Control Ordinance". In February 1983, the group sent an appeal for the establishment of the ordinance to Shimane Prefecture with 24,406 signatures. Furthermore, in 1984 the majority of the citizens in the coastal area, 320,000 persons, signed a petition declaring their opposition to the project. In 1988, 43% of the electorate in the coastal area asked the prefecture to formulate a Landscape Conservation Ordinance. The Matsue Chamber of Commerce and Industry announced its resolution to oppose the project. These movements were a clear sign of opposition from the citizens and the local business community. Citizens who had attended the Shiga Conference '84 on Conservation and Management of World

Lakes from all over the country convened the Japan Water Environment Conservation Conference in 1984. Its first annual meeting was held in Matsue City and it adopted a resolution to support the local movements against national projects.

On the other hand, in August 1984 the Ministry of Agriculture, Forestry and Fishery issued a report which stated that "the water quality of the lakes can be maintained at the present level even after completion of the project", and asked Shimane and Tottori Prefectures to agree with trial operation of the gate. Around this time, there was extensive scientific debate about water quality and the environment between the citizens and the prefectures.

In response to this situation, the governors of Shimane and Tottori announced in 1988, "it is desirable to postpone operation of the water gate". The next day, they sent this opinion to the Ministry, which then declared the freezing of the project on July 5. This freezing meant discontinuation of the project in actuality.

Thus the desalinization project of Lakes Shinji and Nakaumi, which had been 25 years in the planning and which cost 72 billion Yen, was abandoned. The discontinuation of the development project due to strong opposition by local citizens after the national and prefectural governments had invested a huge amount of money was really epoch-making.

The leader of the citizen movement, Professor Takehiko Hobo, said, "Citizens studied independently and could offer scientific arguments against the administrative authority and the local assemblies and conducted their own scientific investigations to make concrete proposals for decision-making. Thus, the citizens were always leading, and local people in a variety of sectors showed very clearly and strongly their own will against the project so that the administrative authority could not ignore them any more".

The group which played the central role in these movements, The Liaison Center of Citizen Groups Against the Project, has started to re-examine the Water Quality Management Plan for the Shinji and Nakaumi Lakes and actions for promoting fisheries and establishing the Landscape Conservation Ordinance. In 1989, the center established the Brackish Water Research Center.

SECTION 2.3

THE PUBLIC'S ROLE IN LAKE MANAGEMENT: THE EXPERIENCE IN THE GREAT LAKES

John Jackson and Tim Eder

2.3.1. THE GREAT LAKES

The Great Lakes in the heartland of the North American continent are phenomenal bodies of water. They extend over 1600 km along the Canadian- U.S. border. The five Great Lakes comprise the world's largest body of fresh surface water. The largest of these -- Lake Superior -- is almost half a kilometer deep, over 550 km long and almost 250 km wide. The first Europeans described them as "sweet water seas".

The Great Lakes Basin is home to a diverse range of plants, fish, birds and animals. More than 35 million people live in the Great Lakes Basin -- 27 million on the U.S. side and 8 million on the Canadian side of the Lakes.

As a result of human activities over the past 200 years, this Basin has endured dramatic stress. Two-thirds of the wetlands have been drained, filled or bulldozed out of existence (Weller, 1988). Massive quantities of toxic wastes have been belched into the air, flushed into the water or buried in the ground. Along the Niagara River, which is only 45 km long, lie over 160 old dump sites, many of which are leaking their toxic burdens into the river (Gradient Corporation and Geotrans, Inc., 1988).

The legacy of these wastes is now haunting us. Numerous wildlife species living near the shores of the Great Lakes, including bald eagles, osprey and mink, are unable to reproduce. Other birds that eat Great Lakes fish, such as gulls and cormorants, are giving birth to offspring with serious physical deformities such as crossed bills. In some locations, 100% of some fish species sampled have cancer (Colborn et al., 1990).

What are these toxics doing to the health of the human residents of the Great Lakes Basin? The warning signs are clear. The evidence indicates that contamination in the Great Lakes Basin is resulting in birth defects, cancers and subtle changes in the immune system, metabolism and behavioral and sexual development of our children (Colborn et al., 1990).

One study of mothers who ate Lake Michigan fish found that their babies had smaller birth weights and skull circumferences, and slower cognitive, motor and behavioral development than did the babies of mothers who did not eat Lake Michigan fish (Fein et al., 1984). A study conducted on the same children when they were four years old demonstrated continued poor performance on short-term memory tests. These results were associated with exposure to toxics (Jacobson et al., 1990).

The National Wildlife Federation in the U.S. found that levels of four contaminants in Lake Trout 30 inches long caught in Lake Michigan were so high that eating just one meal in an entire lifetime would result in an increased cancer risk of 1 in 100,000 (Glenn and Foran, 1989).

These sorts of evidence mean that individuals are confronted by frightening questions: Should I eat the fish or wildlife? Should I breast feed my children? Should I drink the water? Is it safe to swim in the Lakes?

2.3.2 ACTION TO CLEAN UP THE GREAT LAKES

These fears and concerns have led to a dramatic rise in citizen activism around Great Lakes issues over the past decade. This is not surprising. Those living around the Lakes are the ones most directly affected by them, who share in their use and enjoyment and value the Lakes for their multitude of essential and delightful characteristics.

As a result of public concern about the rampant growth of algae in major parts of the Great Lakes, the U.S. and Canadian Governments signed the Great Lakes Water Quality Agreement in 1972. Under this Agreement the two Federal Governments committed themselves to take strong actions to clean up and protect the Lakes. This Agreement was renewed and strengthened in 1978 and 1987 to take into account the public's growing concern with toxics contamination throughout the Great Lakes system.

The Great Lakes Water Quality Agreement is an outstanding, precedent- setting document. It pledges the two countries to work together using an ecosystem approach to rid the Great Lakes of toxic contamination problems. It espouses a philosophy of zero discharge and virtual elimination for managing persistent toxic substances.

As a result of commitments made in these international agreements, Canada, the United States, and the Great Lakes Provinces, States and municipalities have spent billions of dollars over the past decade to clean up the Lakes. Despite progress as a result of these programmes, the problems continue and many of them worsen.

2.3.3 THE IMPORTANCE OF ZERO DISCHARGE

The residents of the Great Lakes Basin are vehemently demanding that no more toxics be dumped into their cherished environment. They feel that the impacts and the risks are already too great.

This call for zero discharge has focused on persistent toxic substances consistent with Article 2 and Annex 12 of the Great Lakes Water Quality Agreement. Such substances, once released, can remain in the Great Lakes for a very long time because the Great Lakes have long flushing times. The largest and deepest of the Great Lakes -- Lake Superior -- has a retention time of approximately 200 years (Environment Canada et al., 1987). If these substances settle in the sediments and are recirculated later from the sediments into the water, the contaminants could remain in the system for an even longer period of time.

This long persistence time combines with the high solubility of these compounds in fat to create harmful effects even from very low concentrations in water. The combined processes of bioconcentration and biomagnification result in dramatic increases in the concentration of contaminants. For example, PCBs increase in concentration 25 million times as they pass from water through the food chain to the eggs a herring gull lays (Colborn et al, 1990).

As a result of this kind of information, citizens' groups are saying that production processes must be changed to minimize the use of toxic substances and to avoid the production of wastes. They are also calling for a move away from chemically-dependent agriculture, and for the cleanup of the massive quantities of contaminated sediments in the Great Lakes.

The citizens' calls for "zero discharge" are reverberating around the Basin and reaching the ears of government and industry.

In the late 1970's and early 1980's zero discharge was all but written off as an unrealistic, unattainable goal. People who called for zero discharge at Great Lakes meetings were usually viewed as idealistic and extremist. Now, these words are a part of the regular lexicon of government officials who deal with Great Lakes issues. Even some industries have begun to endorse the concept.

2.3.4 GREAT LAKES UNITED

The numerous activist citizens' groups in the Basin quickly realized that their voice could be immeasurably strengthened by forming a coalition. As a result, Great Lakes United (GLU) was formed in 1982.

This coalition is made up of almost 200 environmental, sports, labour and civic groups. These groups have a combined membership of approximately half a million people in Canada and the United States.

GLU is based on an ecosystem understanding of the Great Lakes Basin. Its membership reflects the need to transcend political boundaries and to work with the full diversity of residents of the Basin. Its understanding of the Basin ecosystem is reflected in a combined concern about water, air and land as pathways for pollutants.

GLU has played a central role in drawing together, articulating and strengthening the voices of the Basin's concerned residents. It has helped citizens set the agenda for government and industrial action.

2.3.5 THE RENEGOTIATION OF THE GREAT LAKES WATER QUALITY AGREEMENT

The renegotiation of the Great Lakes Water Quality Agreement in 1987 was a prime example of GLU's success in pulling together the Basin's residents to set the agenda. The Great Lakes Water Quality Agreement between the U.S. and Canada was negotiated in 1972 and 1978 under a veil of diplomatic secrecy. Hardly a soul knew that anything was going on. In contrast, the citizens of the Great Lakes Basin played an unprecedented role in the development of the 1987 changes to the Water Quality Agreement. This role developed as a result of GLU's initiatives.

The terms of the 1978 Great Lakes Water Quality Agreement required that the Agreement be reviewed in 1987. GLU decided that those most capable of judging the successes and failures of the Agreement were the residents of the Basin. Therefore, GLU set up the Citizens' Hearings on Great Lakes Water Pollution. These hearings were designed to give the public an opportunity to express their concerns and to present proposals for improving the Great Lakes Water Quality Agreement. GLU committed itself to convey these concerns to the government bodies responsible for reviewing progress in implementing the Agreement.

GLU organized 19 hearings in locations scattered across the wide expanse of the Lakes between Duluth, Minnesota, Montreal and Quebec. Over 1200 people attended the hearings. Three hundred and eighty-two made presentations or presented statements by mail. The presenters came from a wide range of organizations and backgrounds, including citizens' groups, Indian Bands, environmental groups, long-term residents, fishing and hunting associations, school children, wildlife groups, labour industry, chambers of commerce, clergy, academics, political parties, employees of the International Joint Commission and federal, provincial, state and municipal elected officials and civil servants.

The message conveyed by these people was virtually unanimous. The Lake's residents called on the governments to be more aggressive in protecting the Lakes. They condemned the governments for failing to live up to the excellent objectives in the Great Lakes Water Quality Agreement and for, in some instances, not even enforcing their own laws and regulations. They saw zero discharge of persistent toxic substances as an imperative for their future and the future of the Lakes. They also insisted on being much more directly involved in decision-making on issues that affect the quality of the Lakes and the quality of their lives.

As a result of the hearings, GLU concluded that the root of the problem is a lack of political will. Intense, on-going public pressure is the mechanism that produces political will. They concluded that lack of information and lack of mechanisms for holding the governments accountable to the public have militated against the generation of this public pressure.

GLU wrote up the findings from its hearings around the Lakes in a report entitled Unfulfilled Promises: A Citizens' Review of the International Great Lakes Water Quality Agreement. This report conveyed the concerns and hopes of the Basin's residents. Unfulfilled Promises also detailed their ideas for cleaning up and protecting the Great Lakes.

This report was strategically timed to come out just as the Canadian and U.S. Governments were beginning to review the Agreement. In this way, the public took the lead in setting the review agenda.

Several meetings were held between GLU and Canadian and U.S. officials to review the public's concerns as expressed in Unfulfilled Promises and to discuss the Government's plans for the review. As a result of GLU's persistent articulation of the public's voice developed during the tour of the Lakes, copies of preliminary Government proposals for amendments to the Agreement were released to GLU for comment. The Governments also gave the public a chance to review drafts at seven public hearings. No such hearings led up to the 1972 and 1978 Agreements.

Finally, five representatives of environmental groups, three from GLU, one from the National Wildlife Federation (U.S.) and one from the Sierra Club (U.S.), were granted observer status in the negotiations between the Canadian and U.S. Governments. This meant that members of the public were part of each negotiating team, helping develop positions and strategies. They also sat at the negotiating table and were called on for comment and input during the negotiations.

This high degree of public input into usually secretive international negotiations was virtually unprecedented. The uniqueness of this situation was emphasized in a letter from Canada's Minister of the Environment to Canada's Secretary of State for External Affairs. He wrote, "Although I realize that it is unusual to involve the public directly in government-to-government consultative sessions, I believe that ... the presence of GLU would be useful" (McMillan, August 1987).

As a result of GLU's activities, the public adopted the Agreement, making it reflect their hopes and expectations.

2.3.6 AFTER THE 1987 AMENDMENTS

The public was not fooled. They knew that the Agreement was simply a piece of paper and the energy they put into its renewal would be wasted if they sat back. They recognized that the strength of the Agreement depends upon the public's determination to ensure that the Governments follow through on their commitments.

Citizens realized the potential of the Agreement as a tool to organize around and as a benchmark against which to judge government actions. What better measuring mark than one that the governments themselves had signed?

The public's adoption of the Agreement is reflected in the increased number of people using it. According to the Regional Office of the International Joint Commission (IJC)* in Windsor, Ontario, requests for Agreement-related information rose 162% in the two years since the 1987 amendments (Cole-Misch, 1990).

To assist citizens in playing this role, GLU prepared A Citizens' Guide to the Great Lakes Water Quality Agreement. This 80-page booklet was intended to help citizens understand the potential of the Agreement and the ways they could use it in their work to clean up and protect the Lakes.

2.3.7. THE 1989 INTERNATIONAL JOINT COMMISSION'S BIENNIAL MEETING

Every two years, the IJC, government representatives, the media and a smattering of scientists and citizen activists gather for a few days to assess progress under the Great Lakes Water Quality Agreement on cleaning up the Great Lakes and to set the agenda for action for the next two years.

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* The IJC was established by the Boundary Waters Treaty of 1909. It is composed of six commissioners -- three from each country. Its authority in water quality matters is limited to evaluating and providing advice and recommendations on the Governments' progress at implementing the Agreement.

The 1989 Biennial Meeting of the IJC, which was held in Hamilton, Ontario, was quite different from previous meetings. It was no longer simply a meeting of the insiders or of "the IJC family", as it is often called. Over 300 concerned citizens from communities from throughout the Great Lakes Basin attended the meeting.

To accommodate environmental groups' requests, the IJC scheduled two afternoons and one evening for public presentations at which citizens could express their concerns about water quality and water levels. The demand to speak was so great that the IJC added an extra morning for testimony. Over 125 citizens took the opportunity to present 18 hours of testimony to the IJC.

This high level of citizen participation at the IJC's biennial meeting did not happen by accident. Nor was it the product of good public outreach by the IJC. Rather it was one more indication of the extent to which citizens throughout the Great Lakes have gotten together in their determination to set the agenda for government actions on Great Lakes issues.

Well in advance of the October IJC meeting, several environmental groups began jointly planning input for that meeting. These groups included the Canadian Environmental Law Association, Great Lakes United, Greenpeace, Lake Michigan Federation, Canada's Pollution Probe and the Program for Zero Discharge, an international organization.

During August and September, these groups held eight citizens' workshops around the Great Lakes. These workshops brought together citizens to form a Great Lakes agenda and to prepare people to voice their concerns at the IJC meeting.

The common rallying cry at these meetings and at the subsequent IJC meeting was "No Time to Waste: Zero Discharge Now." The citizens presented the IJC and the Governments with a report card assessing their progress. The IJC received a "D" grade; the Basin's Governments received an overall "F" grade.

The groups also detailed their expectations for the next two years. The Great Lakes' citizens expect the IJC to be an advocate for the Great Lakes. They made it clear that if the Commissioners fail to takea strong leadership role in the following two years, the public will pass harsh judgement on them.

The IJC heard the message. In a striking break with their usual pattern, five months after their biennial meeting, the IJC issued a special report to convey to the Canadian and U.S. governments the urgent message they had received.

The increasing level of public concern for the Great Lakes ecosystem and insistence on governmental response to Agreement objectives were strikingly evident, and outspokenly vented at the Commission's recent Biennial Meeting. Because of the importance -- and the abundant evidence this occasion provided -- of public support and individual demands for government action, we concluded that we should deal specifically with that meeting in this report (IJC, 1990).

The tone of this report is very different from previous IJC Biennial reports. Rather than cloaking expressions of concern and recommendations in diplomatic language, the report presents the public's sentiments directly.

[T]here was virtual unanimity of opinion that real progress towards achievement of the Agreement's objectives is sadly, if not totally lacking; further, that responsibility for this fact must be faced and accepted by the Governments of the United States and Canada who have the overall responsibility for ensuring that the objectives of the Agreement are put into effect in order that its principles and purpose may be attained (IJC, 1990).

In part two of their report which was issued a month later, the Commissioners concluded:

Despite the significance of the Great Lakes and our collective rhetoric to restore and enhance them, we as a society continue to mortgage their future by poisoning, suffocating and otherwise threatening them because of insufficient knowledge, other priorities and short-sightedness.

2.3.8 THE BENEFITS OF A WELL ORGANIZED PUBLIC

The experience of the 1980's in the Great Lakes Basin shows quite clearly that there is a growing active public. This public has greatly increased its strength by learning to work together in coalitions. This has resulted in the active citizens in the Great Lakes Basin being able to play the leadership role in setting the agenda for Great Lakes clean-up and protection actions.

At the IJC meeting in 1989, Mark Van Putten of the National Wildlife Federation in the U.S. summarized the results of the past decade of citizen activism. Addressing the Commissioners, he stated: "You have a constituency that is concerned, that is articulate and that is obviously organized and vocal. I think that is something that most government agencies would relish" (IJC, 1989).

The public is an effective lobbying force to ensure the development and implementation of programmes to protect and clean up the Great Lakes. Strong vocal public support has resulted in increased government funding for essential programs. In response to public concern over the well-being of the Lakes, the Canadian Federal Government announced in 1988 a five-year $125 million Great Lakes protection and clean-up program. In the U.S., the budget of the U.S. Environmental Protection Agency's Great Lakes National Program Office increased from generally steady levels of around $5 million per year through the early and mid-1980s to nearly $11 million in the late 1980s.

Legislation, regulations and programmes to deal with many of the complex issues confronting the Great Lakes do not exist. The public is facing difficult issues such as how to achieve zero discharge, how to regulate and monitor very low levels of toxics, how to deal with the problems caused by land run-off, atmospheric deposition and contaminated sediments. Governments are facing the same challenges. The recognition that in many cases there are not obvious, easy solutions has led to a cooperative mutual search for solutions by citizens' groups and government.

There are numerous examples in the Great Lakes of the public working with governments to develop new programs. On the U.S. side, due to pressure from the National Wildlife Federation and others, the U.S. EPA launched its Great Lakes Water Quality Initiative in 1989. The goal of this initiative is to improve implementation of the Great Lakes Water Quality Agreement by integrating its requirements into regulations under the U.S. Clean Water Act. Great Lakes citizens collaborated on a report to U.S. EPA titled "Promises to Keep" (National Wildlife Federation et al., 1989). The report coalesced citizen involvement around the EPA Initiative and played a central role in defining the issues to be addressed. Citizens also have representatives on the committees developing the Initiative.

Citizens have been active in a similar programme in Ontario. Since 1986, the Ontario government has been developing regulations to control direct dumping through the Municipal-Industrial Strategy for Abatement (MISA), the goal of which is the virtual elimination of persistent toxic substances.

The public has also become a vital source of support for the development of increased scientific information. By emphasizing critical data gaps such as impacts of toxics on human health and the effects of toxic deposition from the air, the public is helping define government and academic research agendas. For example, citizens are now on committees that are making decisions about which research projects will be funded by the Great Lakes Protection Fund in the U.S.

Citizens have also been extremely effective at lobbying to ensure that research budgets are funded. When the Canadian government tried to cancel its research programme on toxics in herring gull eggs, a major public outcry arose that led to a partial reinstatement of the programme. In the U.S., persistent public lobbying has been essential in assuring ongoing funding for the Great Lakes research labs.

Another benefit of an involved and committed public in the Great Lakes has been the ability of citizens' groups to cut across the political boundaries that separate the U.S. and Canada. Activists can be found lobbying on either side of the border irrespective of their own nationality.

The presence of public activists working together on both sides of the border has reduced the potential for one country to blame the other side for slow progress. The citizens' groups refuse to accept political boundaries as legitimate reasons for inaction. Also, by being experienced with both countries' legal and regulatory systems, citizens are able to advocate the best elements of each side's system.

The public in the Great Lakes has set an example for the governments by demonstrating that there is a commonality that transcends political borders. For example, when Michigan officials attempted to locate a new pulp and paper mill on the shores of Lake Superior, a steering committee of environmentalists was formed. This steering committee was comprised of citizens from Michigan, Wisconsin, Minnesota and Ontario -- all the jurisdictions surrounding the Lake. They requested that they be provided access to information and the right to participate in all decisions leading to the siting of the mill. Part of the strategy of involving citizens from all jurisdictions was to let government and industry know that should they decide to leave Michigan and build the plant elsewhere on Lake Superior, the concerns of the public would be represented there also.

2.3.9 GOVERNMENT ROLE IN SUPPORTING CITIZEN ACTION

The Lakes gain immeasurably from the actions of dedicated citizens' groups. Unfortunately, governments often fail to recognize the incredible value of this work and, therefore, fail to appreciate their own role in removing the roadblocks that can result in considerably unnecessary expenditure of valuable citizen energy.

Funding for Citizens' Groups

Citizens' groups desperately need funds to carry out their work. A few of the Great Lakes environmental groups have substantial budgets, but the overwhelming majority of citizens' groups on Great Lakes issues have annual budgets of less than $1,000.

As issues have become more technical and as the groups have begun playing more aggressive roles, many citizens' groups have begun to seek greatly expanded funding. These groups recognize that highly trained specialists such as lawyers and scientists are needed to be effective Great Lakes advocates. The best example of this is the National Wildlife Federation's Great Lakes Natural Resource Center. The office is directed by an attorney who has litigated several Great Lakes cases. The office also hires scientists at the PhD and Masters levels with expertise in environmental toxicology, biology and public health. These specialists have worked on several special projects, including a risk assessment-based consumption advisory for Lake Michigan sport fish.

Most citizens' organizations are totally dependent on the generosity of their members and supporters. Several charitable foundations, including Joyce, C.S. Mott, Donner and George Gund, have provided substantial support for a dozen or more Great Lakes organizations. Some large national organizations in the U.S. have made major financial commitments to set up Great Lakes offices. But funding remains a major struggle for all groups.

Despite the profound benefits of having a well-organized public, in the United States very little government funding flows to citizens' organizations. The governments in the U.S. usually refuse to even pay for travel expenses for citizens to attend government meetings. The inability to cover travel costs often precludes citizens from taking part in government decision-making.

In Canada, the Federal and Ontario governments provide more financial support for citizens' groups. For example, travel costs for citizens to attend government meetings are provided as a matter of course. Grants are also given to support citizens' groups' projects. Great Lakes United has received project support from the federal government, which will help it open an office in Canada.

Canadian support for advocacy efforts as extended to paying citizen groups to directly challenge specific government proposals. Known as intervenor funding, this system recognizes that citizens need access to lawyers and scientists to adequately evaluate whether proposed projects are suitable. For example, Ontario provided $840,000 over two years to support citizens who are challenging a proposed provincial hazardous waste incinerator and landfill before an administrative hearing.

Access to Information

The ability of citizens in the Great Lakes to be effective is directly related to their access to information. "Freedom of Information" laws in the U.S. and Canada have helped open up governments' files but the public is still not satisfied. During GLU's hearings in 1986, government was often criticized for delaying the release of significant information, for "sugar coating" bad news, or for making information available in a form that is too technical to understand.

In the U.S., the power gained by public access to information has had dramatic results in reducing the industrial use of toxics. In 1986, Congress passed the Emergency Planning and Community Right To Know Act, which required the preparation and release of a Toxics Release Inventory. Users of toxic substances must report on the amounts of toxics stored and released into the environment. This information must be made readily available to the public, including on a computer data-base.

The news derived from the first Toxics Release Inventory that industries in the U.S. had dumped 18 billion pounds of hazardous chemicals into the land, air and water in 1987 startled the general public (U.S. EPA, 1989). Using information from the Toxics Release Inventory, citizens' groups in Ohio, New Jersey, California, Louisiana and Massachusetts were able to obtain pledges from industries for substantial toxics discharge reductions and have used the information to help create the public pressure to pass state-wide toxics-use reduction legislation (Dean et al., 1989).

The Toxics Release Inventory has been a prime example of how arming the public with information can result in substantial reduction of toxic emissions. Unfortunately, a similar information base does not exist on the Canadian side of the Great Lakes.

Access to Decision-making

Substantial progress has been made in the past ten years in the Great Lakes region in increasing public access to decision-making forms. Citizens' groups have learned much from their experiences over the past decade. They are not content to react to government proposals. They are insisting on helping to set the agenda. Their experience in the renegotiation of the Great Lakes Water Quality Agreement proved to them the power that comes from this kind of approach.

This means that governments must be much more flexible and break down the traditional boundaries between the bureaucracy and the public. Mechanisms must be set up that allow the public to sit at the table as programmes and policies are being developed and decisions are being made. The public must be involved in formulating the scope of work, in choosing the consultants to do the work and in writing the first drafts.

The Great Lakes Basin is proving to be an excellent experimental area for the development of these new mechanisms. The Remedial Action Plans being developed in each of the Basin's 42 designated areas of concern or "toxic hot spots", as they are commonly called, are experimenting with various forms of public advisory committees. The Great Lakes Initiative in the U.S. has citizens on its committees -- committees that in the past would have been made up entirely of government employees.

Governments must continue to open the doors to allow the public full access to decision-making. Only in this way will the benefits that derive from an active public be realized. The experience of the past ten years in the Great Lakes basin shows that the public will give the governments no choice but to open the doors.

2.3.10 CONCLUSION

Over the past decade there have been two major areas of progress in the Great Lakes. The one has been the increased awareness that the goal of zero discharge that is enshrined in the Great Lakes Water Quality Agreement is a necessary objective that must be translated from rhetoric into reality. The understanding of this concept has grown to the realization that zero discharge necessitates changing production processes and raw materials in order to dramatically reduce the use of toxic substances. This is commonly referred to as "toxic use reduction" or "source reduction".

The other major advance over the past decade is in the development of the citizens' movement. The true strength of the Great Lakes environmental community has been its ability to bring together individuals, grass-roots members, small community groups and large national environmental organizations. This has meant that the expertise, experience, financial resources and access of the large environmental groups has been combined with the wisdom, the passion and determination of the grassroots to forge an incredibly powerful force. This creates a voice that governments and industry have no choice but to listen to.

Citizens' efforts in the Great Lakes are already having dramatic effects throughout the region and will continue as long as the promises of the Great Lakes Water Quality Agreement remain unfulfilled.

REFERENCES

Colborn, T. et al. 1990. Great Lakes, Great Legacy?. Conservation Foundation & Institute for Research on Public Policy. Washington, D.C.

Cole-Misch, S., Public Information Officer, International Joint Commission, Windsor, Ontario. February 1990. Personal Communication. Dean, N., Poje, J., and Burke, R. August 1990. The Toxic 500. National Wildlife Federation.

Eder, T. and Jackson, J. December 1988. A Citizens' Guide to the Great Lakes Water Quality Agreement. Great Lakes United. Buffalo, New York.

Environment Canada, United States Environmental Protection Agency, Brock University and Northwestern University. 1987. The Great Lakes: An Environmental Atlas and Resource Book.

Fein, G. et al. 1984. Prenatal Exposure to Polychlorinated Byphenyls: Effects on Birth Size and Gestational Age. The Journal of Pediatrics 102(2): 315-320.

Glenn, B. and Foran, J. 1989. Lake Michigan Sport Fish: Should You Eat Your Catch?. National Wildlife Federation.

Gradient Corporation and Geotrans, Inc. 1988. Potential Contaminant Loadings to the Niagara River from U.S. Hazardous Waste Sites. Prepared for the Niagara River Toxics Committee. U.S. Geological Survey and U.S. Environmental Protection Agency. Washington, D.C.

Great Lakes United's Water Quality Task Force. February 1987. Unfulfilled Promises: A Citizens' Review of the International Great Lakes Water Quality Agreement. Buffalo, New York.

Great Lakes Water Quality Agreement, signed November 1978, as amended by Protocol signed November 18, 1987, consolidated by the International Joint Commission, United States and Canada, January 1988.

International Joint Commission. October 1989. Transcripts: 1989 Biennial Meeting on Great Lakes Water Quality. Hamilton, Ontario.

International Joint Commission. March 1990. Fifth Biennial report on Great Lakes Water Quality, Part I. Ottawa, Ontario.

International Joint Commission. April 1990. Fifth Biennial Report on Great Lakes Water Quality, Part II. Ottawa, Ontario.

Jacobson, J., Jacobson, S. and Humphrey, H. January 1990. Effects of in utero exposure to polychlorinated biphenyls and related contaminants on cognitive functioning in young children. The Journal of Pediatrics.

McMillan, T., Minister of the Environment. 24 August 1987. Letter to Right Honourable Joe Clark, Secretary of State for External Affairs.

National Wildlife Federation et al. June 1989. Promises to Keep: Making the Great Lakes Water

Quality Agreement Work Through the Development of Uniform Water Quality Standards and U.S. Regulations.

U.S. Environmental Protection Agency. June 1989. The Toxics Release Inventory: A National Perspective.

Weller, P. 1988. State of the Great Lakes Region Environment: Wetlands. Prepared for Environment Canada. Ottawa, Ontario.

PROFILE B:

LAKE BALATON

V. Istvanovics

Lake Balaton is the largest lake in Central Europe (596 km^2). The Zala River drains about half of the total watershed area of 5,776 km^2 into Basin I. The only outflow is the Sio Canal from Basin IV (Fig.B1).

Industrial development of the watershed is moderate. Agriculture is significant; more than half of the area is cultivated. Fertilizer use increased from 200 tons/yr in 1950 to 15,000 tons/year in the mid-1970s. Of applied phosphorus fertilizer, 1-3% may be washed into the lake. In the early 1980s, 40 large-scale livestock farms discharged 360-550 tons/yr of liquid manure, 5-20% of which was estimated to reach the lake (Somlyody and van Straten, 1986).

Lake Balaton is the most important summer resort in Hungary. Tourism increased 14 times between 1950 and 1978. Nowadays 40% of Hungary's gross tourism income (39 billion Ft, $1 ~ 50-60 Ft) originates from this region. The number of permanent residents in the 37 shoreline settlements is about 140,000. During the relatively short peak season in July and August, 480,000 tourists spend eight days on average on the shoreline. During summer weekends, 270,000 additional people visit the lake.

In the early 1960s phytoplankton production was 90 g C/m^2/yr in the whole lake. As a consequence of enhanced phosphorus loading, Lake Balaton has undergone rapid eutrophication. For 1977, primary production increased two times in Basin IV, three times in Basins III and II, and eight times in Basin I. The southwestern area became hypertrophic, whereas the northeastern parts remained mesotrophic. In 1982 an exceptionally large bloom of Anabaenopsis raciborskii occurred in all basins of the lake. Primary production reached 150-200 mg C/m^3/h (Herodek, 1986). Increased public attention and scientific pressure clearly contributed to a new government decision about eutrophication control for Lake Balaton in 1983, after earlier decisions in 1969 and 1979. The new decision principally tripled the water management budget for 1986-1990 from that of 1981-1985.

Between 1975-1981 the multiannual average biologically available phosphorus (BAP) load of the lake was 169 tons/yr. The total phosphorus (TP) load reached 314 tons/yr (Somlyody and Jolankai, 1986). In 1985 the first stage of the Kis-Balaton reservoir started to operate on the mouth of the Zala River (Fig. 1). This resulted in a 15% BAP load reduction to Lake Balaton. Sewage diversion was finished by 1988 for about two-thirds of the shoreline zone (52,000 m^3/d, Fig.B1), and chemical phosphorus removal has been introduced in the shoreline sewage treatment plants where sewage is directly discharged into the lake (29,000 m^3/d). These projects decreased the BAP load of the lake by 25%. Together with other measures (e.g. closing up large-scale animal farms, changes in agricultural technologies, amelioration programmes, emission control measures, etc.) the BAP load to Lake Balaton has been reduced by 50-55%.

In spite of this significant load reduction, the sequence of management measures is somewhat questionable. The approximate costs of the main projects implemented and planned are as follows:

project	Total investment costs (million Ft)	Ft/kg BAP/yr	Ft/kg TP/yr
Implemented			
sewage div., P removal	3,500	100,000	100,000
Kis-Balaton, 1st stage	440	20,000	1,000
Planned			
P removal, Zalaegerszeg	60	4,000	4,000
Kis-Balaton, 2nd stage	1,600	100,000	8,000

It is clear that the most cost-efficient measure would have been the introduction of chemical phosphorus removal in the sewage treatment plant of Zalaegerszeg, a large town situated on the watershed (Fig.B1). The annual phosphorus emission from this plant is 30 tons, 50% of which was estimated to reach Lake Balaton (Joo, 1986). This single source made up 9% of the BAP load to the whole lake, and 30% of the BAP load to hypertrophic Basin I in the period 1975-1981. At present, 50% of the BAP load to the Kis-Balaton reservoir (3.2g/m^2/yr, 1986-1989) originates from Zalaegerszeg.

Although this project should have been implemented by 1985 according to the government decision of 1983, only upgrading and expansion of biological treatment (25,000 m^3/d) was finished by 1986. Since the total investment cost of the project is one or two orders of magnitude lower than that of any other project, whereas its cost-efficiency is the highest in terms of BAP load reduction, postponing of phosphorus removal at Zalaegerszeg until 1991 could not have only direct financial reasons. The reasons are multiple and cannot easily be elucidated due to a lack of appropriate information. Conflicting interests may also be involved.

There are three regional Water Authorities which are responsible for planning, implementation, and control of management activities concerning Lake Balaton. The Central Transdanubian Water Authority (CTWA) coordinates the activities, and is responsible for management measures on the northern part of the lake. The South Transdanubian Water Authority (STWA) operates on the southern area, whereas the West Transdanubian Water Authority (WTWA) operates on the Zala River subwatershed. Due to serious economic problems in Hungary, the centrally allocated budget for eutrophication control of Lake Balaton was 2-3 times less during the last four years than that required for implementation of all approved projects. Central distribution of the available budget is primarily a question of attitude to an optimum combination of management measures, although the conflicting interests of the three Water Authorities as well as other institutions and organizations may also have an impact. The unity of the lake and its watershed has properly been emphasized during the policy-making procedures (e.g. Lang, 1986). Practical decisions, however, gave preference to management measures related directly to the lake. The CTWA and STWA, for instance, could finish the sewage diversion and phosphorus removal projects on the shoreline on time. In 1988 the budget for these measures was roughly 400 million Ft. The WTWA could invest the same amount of money into the second stage of the Kis-Balaton reservoir only over a period of three years (1987-1989).

Furthermore, the scientific concept of Lake Balaton management included an abortive hypothesis which stated that the short-term behaviour of the lake is determined by its BAP load, but that the TP load plays a dominant role in long-term changes in water quality. This did not cause problems during policy-making, since priority was given to remedial ("short-term") measures concerning hypertrophic Basin I. These measures included in the first place phosphorus removal at Zalaegerszet (Joo, 1986; Lang, 1986; Somlyody and Jolankai, 1986). Later, when the water management budget was cut down, the hypothesis, however, served as an argument for reservoir building rather than phosphorus removal at Zalaegerszeg. In addition, the cost-efficiency of the reservoir projects is higher in terms of TP load reduction. The consideration that reservoir building and phosphorus removal from the sewage on the watershed are not complementary but alternative measures coincides with the interests of the WTWA which gains more profit from the larger investment necessary for reservoir construction.

The prescribed sewage effluent standard on the Lake Balaton watershed is 1.8 g P/m^3. Zalaegerszeg should pay about 400 million Ft/yr only for the excess of phosphorus emissions. Although the fine is based on about 30 different effluent standards, the WTWA imposed a fine of 40 million Ft on the community in 1988. The difference is probably due to the fine reduction guaranteed for communities which make efforts to improve the quality of their sewage effluent. For this purpose, Zalaegerszeg invested 2.5 million Ft in 1988, without any financial support from the WTWA. In this way the sewage fine system is not efficient enough in mobilizing the interests of local residents. Moreover, the control system is highly questionable. The organization of an independent control system concerning any water management activities is urgently needed.

The 50-55% BAP load reduction in Lake Balaton which has been achieved since 1983 in a rapidly deteriorating economic situation required great efforts from all relevant institutions and organizations. This could not have been possible without the proper organization of public attention, the extensive water quality monitoring data provided primarily by the Water Authorities, as well as the solid scientific background of the policy- making procedures.

REFERENCES

References cited can be found in:

Somlyody, L. and van Straten, G. (eds.). 1986. Modeling and Managing Shallow Lake Eutrophication. Springer-Verlag. Berlin.

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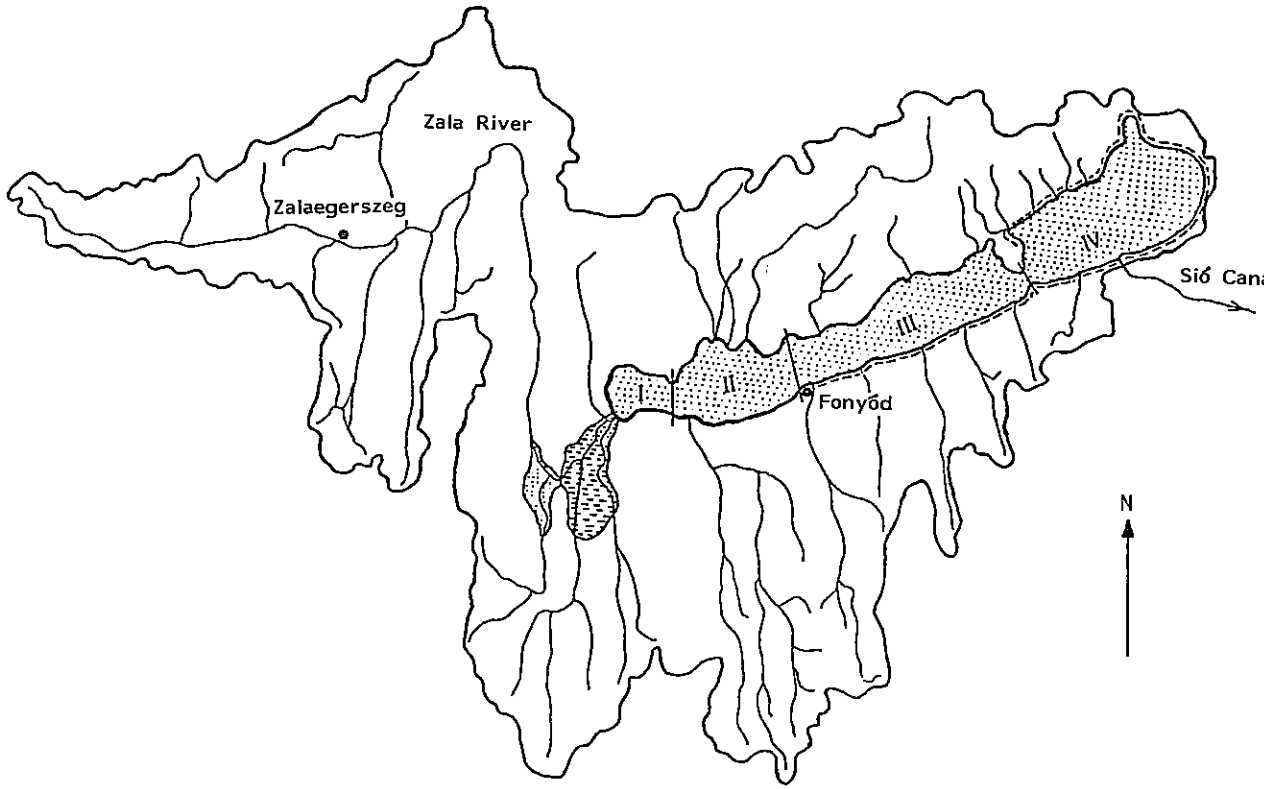

Dotted area: four basins of Lake Balaton and first stage of the Kis-Balaton reservoir.
Striped area: second stage of the Kis-Balaton reservoir under construction.
Dashed line shows the shoreline zone from which sewage is diverted.

Figure B1. Lake Balaton and its watershed area

SECTION 3

ANALYTICAL FRAMEWORK FOR WATER RESOURCE MANAGEMENT

SECTION 3.1

WATER RESOURCE MANAGEMENT: PLANNING AND IMPLEMENTATION

M.M. Hufschmidt and D.S. McCauley

3.1.1. INTRODUCTION

Management of lakes and reservoirs is a sub-field of the broader domain of water resource management, which usually includes consideration of entire surface water and ground water systems as well as human demands for water-based services. Accordingly, emphasis in this section will be on water resource management as broadly defined, with the application to lake and reservoir management illustrated by using specific cases of lake or reservoir management.

The term "water resource management", as used in this section, includes both the planning phase and the implementation phase. This is in contrast to restricting the use of the term to the construction and operation of water resource projects or programs that have already been planned.

3.1.2 CONCEPTUAL FRAMEWORK

In discussing water resource management in a river/lake basin context, it is useful to establish a conceptual framework as a basis for analysis. The framework shown here has been adapted from reports by Bower and Hufschmidt (1984) and Hufschmidt (1986).

As a start, water resource management can be viewed as a system in which natural and human inputs are processed to yield useful outputs and environmental and natural systems effects are generated. The schematic of this system is shown in Fig. 3.1.1. Water resource management itself is conceptualized as having three dimensions:

1. The management process, involving the various steps involved in planning and implementation;

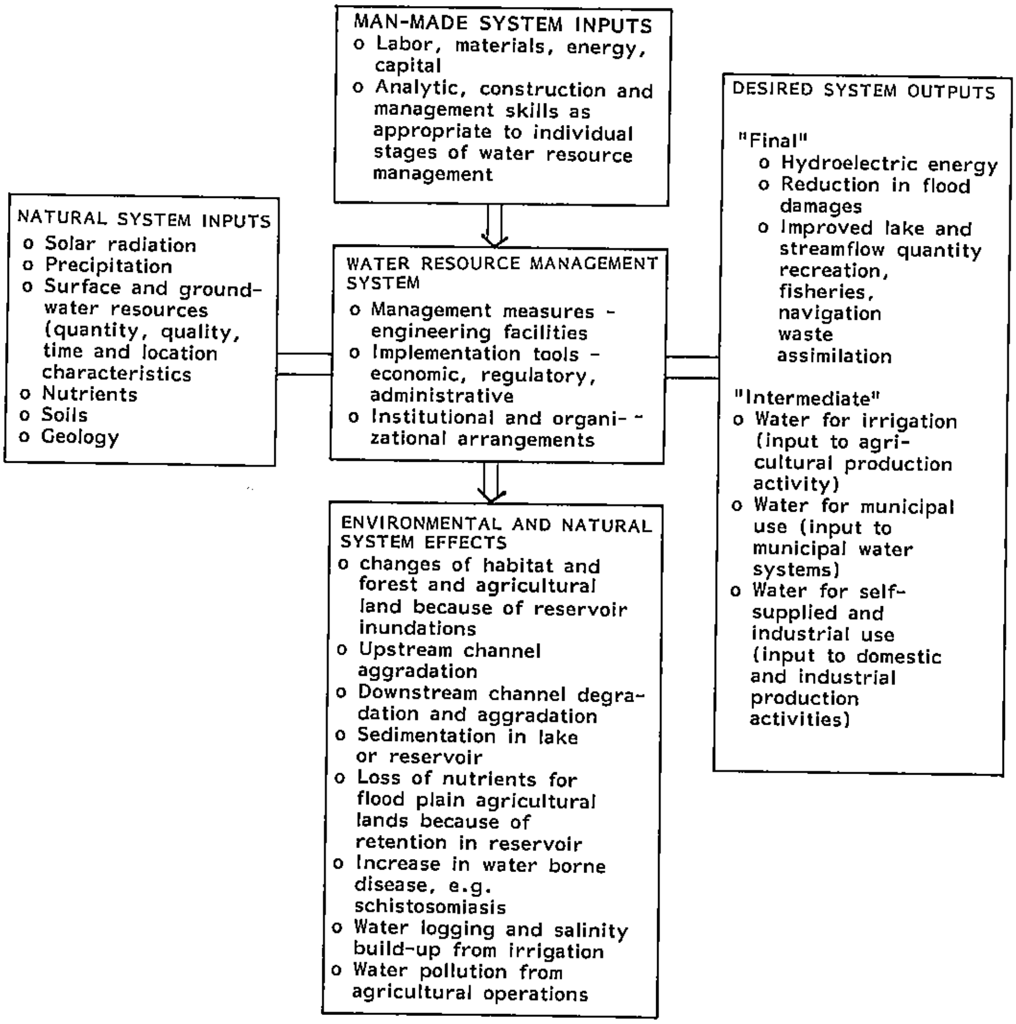

Figure 3.1.1 Schematic of a Generalized Water Resource Management System (Adapted from Bower and Hufschmidt, 1984)

2. Management system elements, consisting of physical facilities to be built and operated, implementation tools, and institutional and organizational arrangements; and

3. Management activities required to achieve specific project purposes or outputs.

The three dimensions are brought together and shown as a cube, in Fig. 3.1.2.

This analytical framework is a diagnostic tool which allows one to examine management in terms of specific tasks that can be analyzed along the three dimensions depicted in Fig. 3.1.2 (Hufschmidt 1986). The analysis of any specific case of management can proceed by starting with one dimension, for example management process, and for one component of that dimension -- planning, for example -- examining the components of the other two dimensions -- management activities and management system elements.

Thus, for the planning phase, we can examine the management system element dimension for specific tasks required for management and operation of the lake/reservoir in terms of the physical facilities and operating rules ("things to be done"), implementation tools ("ways of getting things done") and institutional and organizational arrangements needed to "get things done". The framework depicted in Fig. 3.1.2 will be used as a basis for analysing water resource management strategy at the planning and implementation stages, taking full account of institutional and organizational factors. Before discussing the details of the water resource management process, however, we take up the issue of appropriate spatial units for water resource management.

3.1.3 RIVER/LAKE BASIN APPROACH TO WATER RESOURCE MANAGEMENT

It is clear that management of lakes and reservoirs must be carried out in the context of the river/lake basin of which the lake or reservoir is a part. In fact, the concept of river basin management has a long history, for example, going back to the early twentieth century in the United States (Holmes, 1972). But we are concerned here with more recent efforts for effective management of small to medium-sized watersheds or river/lake basins. Hamilton (1985) defines these as basins of up to 1 million acres (4050 km2), roughly comparable to the Citanduy river basin in Indonesia and the Lake Biwa watershed in Japan.

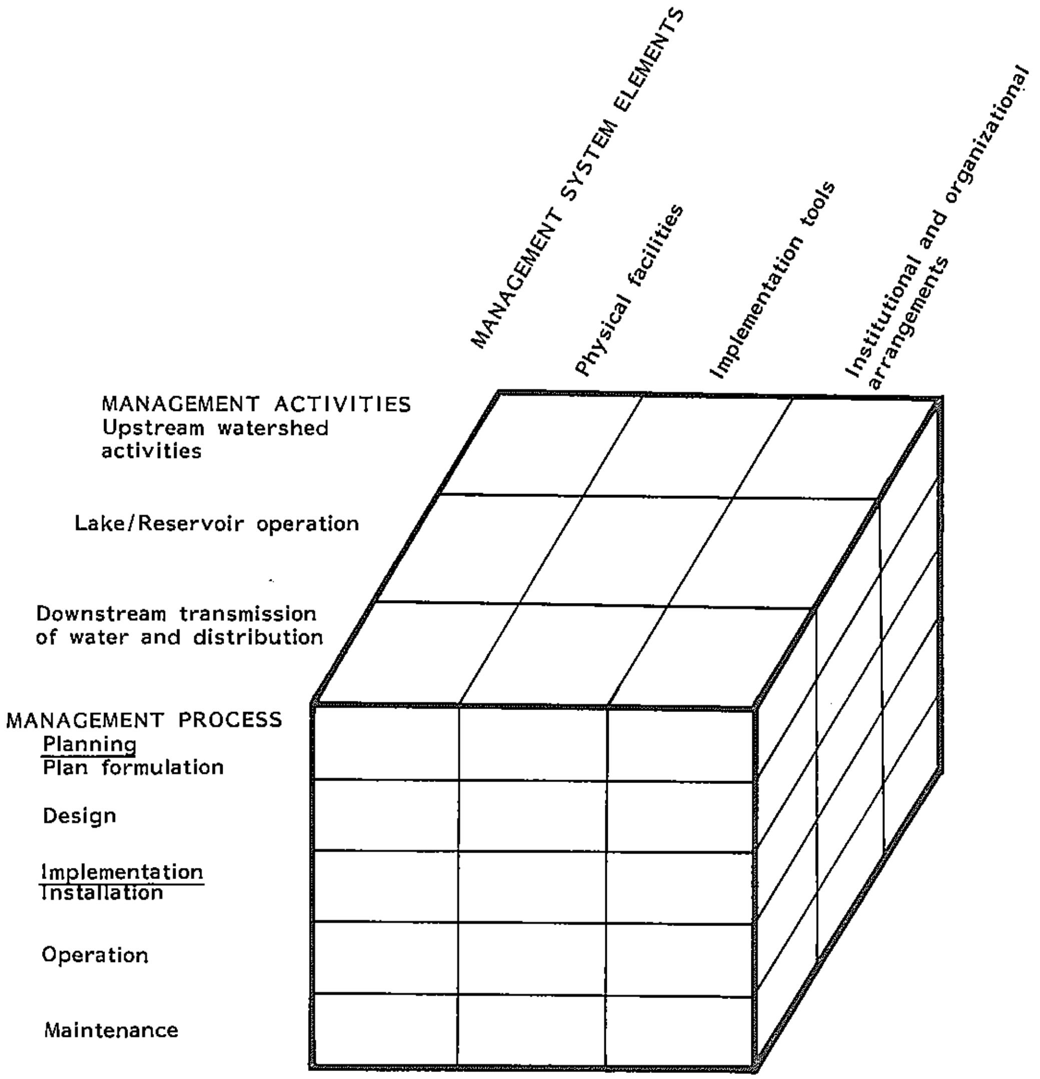

Figure 3.1.2 Analytical Framework for Lake/Reservoir Management (adapted from Hufschmidt, Chap. 2 in Easter, Dixon and Hufschmidt, 1986)

Regardless of scale, the watershed or river basin can serve as an excellent spatial unit for a scientific understanding of natural processes. "It is an ecological unit; linkages based on physical processes make it work" (Hamilton 1985). The watershed is a functional region involving key interrelationships and interdependencies of concern for land and water management (Easter and Hufschmidt, 1985). Although there may be very little uniformity of landforms or vegetation within a watershed, key natural processes such as precipitation, stream flow, erosion, sedimentation and infiltration have major influence on landforms, ecosystems, streams and lakes from the headwaters to the coastal areas.

Use of the watershed as a unit for planning enables planners to consider all relevant facets of resource development including on-site and off-site changes and impacts (Fig. 3.1.3). This systems perspective accounts for the entire complex of biophysical, social, economic and institutional factors that bear directly on the development of sustainable management programs. For example, the watershed allows for ready assessment of most environmental impacts, including the effects of land use activities on upstream and downstream ecosystems. Thus the effect of upland disturbances, which often trigger a series of downstream consequences, can be readily examined within a watershed context (Easter and Hufschmidt, 1985).

However, the watershed approach can lead to problems when used at the implementation stage of water and land management. Rarely do administrative and political boundaries coincide with watershed boundaries. When management programs cut across these man-made boundaries, success depends on close coordination among the different administrative and political units. Also, a watershed management program may cover only part of a county or province; the result may be complaints from those outside the area to be benefited leading to possible delays in implementation.

The solution to these problems appears to lie in planning the programs on a watershed basis but implementing them using administrative or political boundaries. This will require some overall responsibility for coordination at the implementation stage, but if this need is recognized when programs are planned, effective coordination arrangements can be developed.

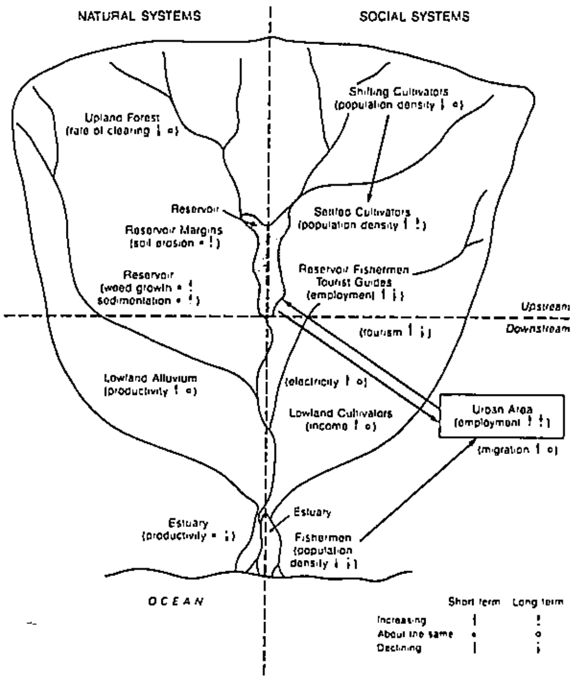

Figure 3.1.3 A Natural and Social System Schematic of a Watershed (from Hamilton and King, 1984)

It is clear that effective management of water resources must come to terms with the physical realities of the hydrologic cycle, including the bio-physical, economic and social linkages of the river/lake basin. But how to do this effectively remains an unresolved issue. In spite of the theoretical advantages of managing water resources developments on a river/lake basin or watershed basis, cases of successful application of basin-wide management are relatively few. Most water resources developments are undertaken on a sectorial basis, for irrigation, hydroelectric power, domestic and industrial water supply, or other purposes, with the individual project as the dominant element. Although the river/lake basin or watershed is often the spatial unit used by public agencies for collecting and analyzing physical data and preparing broad- brush, perspective water development plans, there are few examples of detailed, integrated basin-wide management programs, involving both planning and implementation.

Part of the problem is the question of scale. At one extreme, there are the huge river basins typified by the Yangtze in China, the Mekong in southeast Asia, the Ganges in South Asia and the Amazon in South America. These large river systems have many tributary watersheds, each of which may be a sizable management unit. Furthermore, some of them are international in scope. Detailed integrated management of such large river basins is probably administratively unfeasible and may not be desirable in any event.

At the other extreme are many small watersheds composed of tributaries and sub-tributaries of larger river/lake basins. Although detailed management of such watersheds is administratively feasible, in most cases management on a watershed basis has been limited to basic data collection and planning, with implementation continuing to be done by public or private agencies on a project or sectorial basis.

3.1.4 THE WATER RESOURCE MANAGEMENT PROCESS

As shown in Figure 3.1.2, the management process has two broad divisions: planning and implementation. Each of these can be subdivided into a number of steps, as discussed in detail in the sections to follow. It is recognized that in many management situations, the planning and implementation phases are not strictly sequential but may overlap or be undertaken simultaneously. However, it is convenient to treat them as separate steps in this discussion of management strategy because of important differences between the activities and tasks involved at each of these stages.

3.1.5 WATER RESOURCE PLANNING

The process of water resource planning can be delineated as four sequential stages as shown in Fig. 3.1.4. The process begins with an inception or "plan for planning" stage during which water resource problems, needs, and opportunities are identified, geographic and temporal scope are determined, planning objectives and criteria defined, and the conditions for and approach to the studies and analyses are established. The outputs of this stage are a workplan, and statement of planning objectives and criteria for use in the plan formulation stage.

The next stage consists of three interrelated background studies and analyses of 1) macro-economic and social conditions and projects; 2) water- using and water-related human activities; and 3) the natural and human-influenced water and related land resource systems. The outputs of this stage are estimates and projections of human activities, associated water resource demands, problems and impacts, and water and related land resources supplies, availability, and quality.

The third stage is concerned with formulating alternative water resource plans or strategies in a systematic manner, directed toward meeting water- use demands and resolving water-related problems as identified in the preceding stage. Plans or strategies include physical measures, implementation tools and institutional and organizational arrangements. Plan formulation involves 1) identification of specific projects or water management activities, 2) preliminary screening of such projects and activities, and 3) formulation of alternative integrated water resource plans or strategies composed of combinations of promising projects and activities. Formulation and analysis of alternative water resource projects and plans would be on a systems basis, using appropriate computer-based models. Preliminary screening and detailed plan formulation would apply planning criteria derived from the applicable multiple planning objectives. The economic efficiency objective and associated criteria as embodied in social benefit-cost analysis would play a key role in the choice process. Environmental objectives would be fully considered along with other multiple objectives. The output of this third stage would be one or more integrated water resource management plans or strategies.

The fourth and final stage would be 1) the detailed review and evaluation on a systems basis of the alternative plans or strategies; using social benefit-cost analysis and analysis using other multiple objectives and associated choice criteria, and including application of sensitivity analysis, and 2) the presentation of the results of the review and evaluation to decision-makers for selection of the preferred plan or strategy.

As shown in Fig. 3.1.4, the planning process is iterative, with feedback of information from later stages to earlier stages. Thus, if the decision- makers do not accept any of the alternative plans or strategies, action returns to the plan formulation stage. In addition, further background studies and projects may be called for.

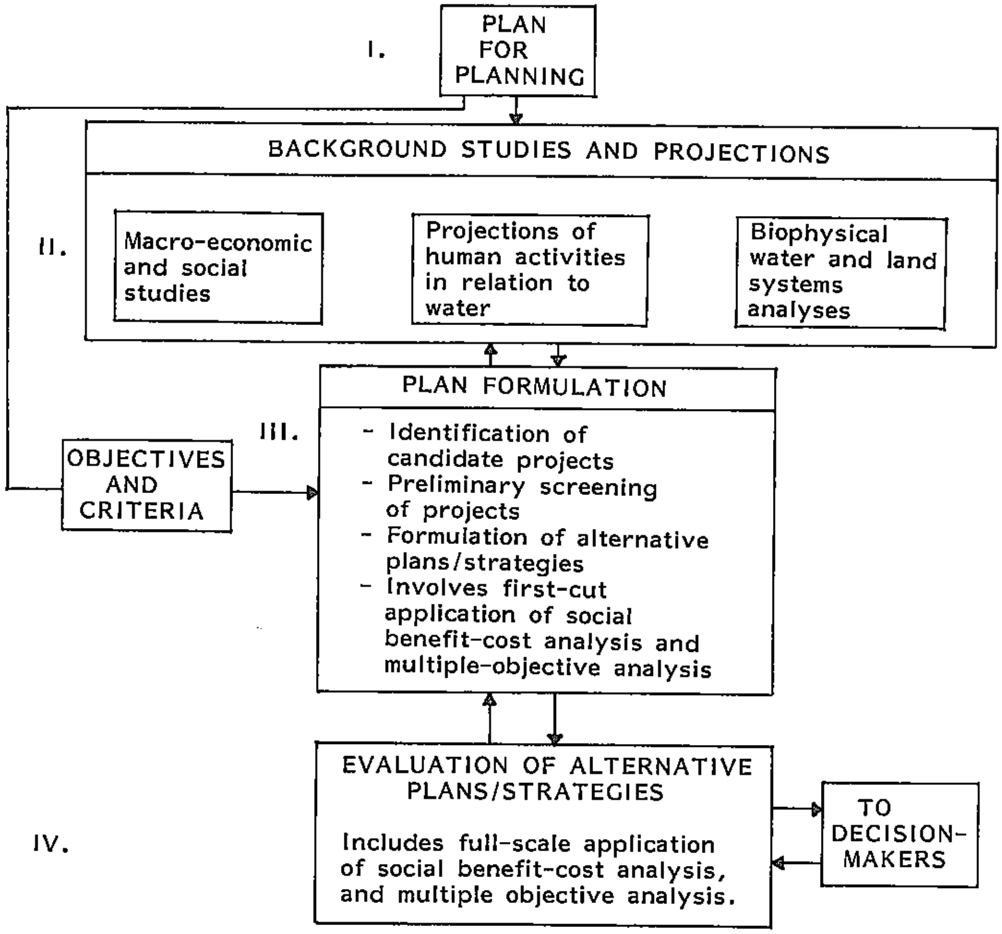

Figure 3.1.4 The Water Resource Planning Process.

Plan for Planning

a. Selection of geographic area for planning

The importance of the river/lake basins as a planning area has already been discussed. In those cases where planning areas already chosen on the basis of political or administrative jurisdictions are not co-terminous with hydrologic boundaries such as river/lake basins or groundwater aquifers, special attention must be paid to the linkages between portions of the hydrologic region, e.g., river/lake basin, or groundwater aquifer, that are outside the management region and those portions inside the region (Dixon and Easter, 1986). Where the choice of planning area is still possible, a general rule for choice is: 1) where administratively and politically feasible, the planning area should be co-terminous with the surface water and groundwater gydrologic region or regions; where this is not feasible, planning should take account of hydrologic linkages to areas outside of the planning region.

b. Election of planning objectives

Planning objectives will vary from case to case and are a function of the specific political-institutional situation in the country involved, including relationships of the country with outside agencies such as the World Bank and other donor or technical aid organizations. Accordingly, water resources managers or analysts are not free to specify these objectives a priori, but should seek to identify them from the political process.

Almost always, there will be more than one relevant objective. The most common objectives are economic development (technically defined as economic efficiency in the benefit-cost literature), equity (sometimes measured in terms of income distribution), regional or national self-sufficiency, and environmental quality. The objective of sustainability has emerged recently as important to water resources planning. As pointed out in Hufschmidt and McCauley (1990) it should be possible in most cases to achieve sustainability in water resources management along with achieving other satisfactory levels of objectives.

c. Selecting multiple purposes

Multiple purpose planning of water resources has been recognized for almost a century. By the 1930's in the United States, five major purposes for water resources development were considered to be relevant: navigation, flood control, irrigation, hydroelectric power and domestic and industrial water supply. By the early 1950's this list had expanded to include a number of what are now considered "environmental" purposes such as fish and wildlife, water-based recreation, watershed management, erosion control and water pollution control, as shown in Table 3.1.1. In almost all water management situations, more than one purpose is involved, although in only a few cases would all of the purposes listed in Table 3.1.1 be present. At least in principle, a water resources management strategy should be broad in scope so as to accommodate all relevant purposes. In some cases, single-purpose projects are appropriate, but even in these cases account should be taken of the relationship of the single-purpose project (such as an irrigation development) to other purposes in the river/lake basin or region involved.

A brief review of the UNCRD/ILEC case studies (Hufschmidt and McCauley, 1990) reveals that all of them deal with several water resources management purposes. For example, Table 3.1.2 shows that the Lake Victoria cases includes 11 of the 13 listed purposes, followed by the Yahagi basin with 10 purposes and Lake Kasumigaura with 9 purposes. For all 9 cases, the average number of purposes is 7.

Background Studies and Projections

a. Macro-economic and social studies

These studies include analyses of current population, urbanization and macro-economic activities, and one or more projections of future population and economic activity levels, and their spatial distribution. These scenarios of the future, for one or more time horizons, are based on a combination of underlying national goals and policies as expressed, for example, in national development plans. As such, the scenarios are a composite of national and regional goals and realistic estimates of what is likely to happen, on a macro-economic and social basis.

These summaries and underlying studies provide the basis for projecting demands for water resources by major sector, such as agriculture, energy, and industry, as well as environmental impacts of such sectors on water and land, e.g. soil erosion, sedimentation, water pollution.

Table 3.1.1
Elements of a Water Resources Plan
(adapted from U.S. President's Water Resources Policy Commission, 1950, p.47)

No.	Element	Purpose
1.	Flood control	Flood damage prevention or reduction, protection of economic development, conservation storage, river regulation, recharging ground water, water supply, development of power, protection of life
2.	Irrigation	Agricultural production
3	Hydro-electric power	Provision of electric energy for economic development and improved living standards
4.	Navigation	Transportation of goods and passengers
5.	Domestic and industrial water supply	Provision of water for domestic, industrial, commercial, municipal, and other uses
6.	Watershed management, soil conservation and erosion control	Conservation and improvement of the soil, sediment abatement, run-off retardation, forests and grassland improvement and protection of water supply
7.	Recreational use of water	Increased well-being and health of the people
8.	Fish and wildlife	Improvement of habitat for fish and wildlife, reduction or prevention of fish or wildlife losses associated with man's works, enhancement of sports opportunities, provision for expansion of commercial fishing
9.	Pollution abatement	Protection or improvement of water supplies for municipal, domestic, industrial and agricultural use, and for aquatic life and recreation
10.	Insect control	Public health, protection of recreational values, protection of forests and crops
11.	Drainage	Agricultural production, urban development, and protection of public health
12.	Sediment control	Reduction of silt load in streams and protection of reservoirs
13.	Salinity control	Abatement or prevention of salt water contamination of agricultural, industrial, and municipal water supplies

Table 3.1.2
Water Management Purposes in the Nine UNCRD/ILEC Cases
(from Hufschmidt and McCauley, 1990)

Case Study	flood control	irriga- tion	hydro- power	naviga- tion	water supply	watershed management
1. Lake Dianchi, China	x				x	x
2. Lake Victoria basin, Kenya	x	x	x		x	x
3. Yahagi River basin	x	x			x	x
4. Laguna Lake	x				x	x
5. Songkla Lake	x			x		
6. Lake Kasumigaura	x	x				
7. Brazil Reservoir			x			
8. Saguling Reservoir		x	x			x
9. Lake Biwa	x				x	
Number of Cases	7	4	3	1	5	5

Table 3.1.2 (cont.)

	recrea- tion	fish & wildlife	pollution control	insect control	drainage	sediment control	salinity control	number of purposes
1. Lake Dianchi, China			x					4
2. Lake Victoria basin, Kenya	x	x	x	x	x		x	11
3. Yahagi River basin	x	x	x		x	x	x	10
4. Laguna Lake		x	x					5
5. Songkla Lake	x	x	x			x	x	7
6. Lake Kasumigaura	x	x	x		x	x	x	9
7. Brazil Reservoir				x				3
8. Saguling Reservoir		x	x	x		x		7
9. Lake Biwa	x	x	x			x		7
Number of Cases	5	7	8	3	3	5	4	63

b. Projections of human activities as related to water

Information from the macro-economic and social scenarios is used to project the levels and spatial distribution of water uses and impacts by major sectors, such as agriculture, aquaculture, urban domestic, commercial, transport, industry and energy.

These projects, which may be expressed as ranges rather than as point estimates, provide information on the demand side of the supply-demand equation. For example, in terms of lake or reservoir management, these projects would provide information on possible water quantity and quality demands for fisheries, water-based recreation as well as for irrigation, domestic and industrial water supply and hydroelectric power.

As pointed out in Hufschmidt and McCauley (1988) for the Beijing-Tianjin water management case, such demand projections should not be taken as givens, but should be considered as variables which are subject to reduction through demand management measures. Nonetheless, these projections provide useful starting values as inputs to the plan formulation stage of planning, when both demand and supply management options are formulated and evaluated as elements of alternative water resource management plans or strategies.

c. Biophysical water and land system analysis

In this section natural and man-made water resource systems, that constitute the "supply" side of water resources, are analyzed. Included are the water quantity elements -- precipitation, streamflow, groundwater flows and levels, extreme hydrologic events -- as well as water quality, both surface and groundwater, and related physical processes such as erosion, sedimentation and channel degradation. Included also are the existing man-made water use and control works -- dams, reservoirs, canals, pumping plants -- that provide the infrastructural basis for current water resource management.

The details of these natural and man-made systems are covered elsewhere, especially in Volume 1, Principles of Lake Management (Jorgensen and Vollenweider, eds., 1988) of this Guideline series, and are not discussed further here.

Plan Formulation

a. Selection of candidate projects

As pointed out by White (1969) it is important to use a broad range of choice in selecting candidate projects for a water resource plan or strategy. Thus, in addition to considering supply-side projects for meeting assumed or projected water-resource demands -- capital intensive projects such as storage dams and reservoirs, diversion dams, canals, groundwater pumping plants -- demand-side projects are also considered as an integral part of the water resource plan. These include technical, regulatory or economic ways of reducing per capita and per-unit demands for water. Drip or sprinkler irrigation, recycling of industrial water, wastewater reuse including dual water supply systems, and water-saving commercial and household equipment are examples of technical measures which can often be achieved via economic incentives and regulation. Metering accompanied by increasing block rate volumetric pricing is an example of combining technical and economic incentives to reduce water use. Examples of such demand options are shown in Millikan and Taylor (1981), and Hufschmidt et al. (1988).

Multiple means involving a broad range of choice can also be used to deal with problems such as flood damages and pollution. Flood plain zoning, flood insurance, flood warning systems can be used along with physical measures such as flood proofing, dams and levees to reduce flood hazards. Similarly, regulatory and economic incentives can be used to reduce generation of gaseous, liquid and solid residuals.

b. Preliminary screening and formulation of alternative plans

At this stage of planning, the multiple objective approach plays a key role. The approach is to formulate alternative plans which show different mixes of achievement of objectives. For example, one plan would emphasize the economic development objective with less emphasis given to the objectives of equity, environmental quality and economic development. The important point is that all relevant objectives would be seriously considered from the very start of plan formulation. At least at the outset of planning, each objective would be given consideration in plan formulation, so that information on trade-offs among objectives would be available to planners and decision-makers.

A major problem of the multiple objective approach is incommensurability; measurements of achievement of the various objectives usually cannot be made in common units, such as dollars or yen. Although some ingenious solutions have been proposed (Haimes et al., 1975), the most practical approach is to formulate alternative plans with different levels of achievement of objectives, and compute the trade-offs among objectives. Under this approach, one can compute the loss (or opportunity cost) to one objective caused by achieving a second objective, with effects on each objective measured in appropriate monetary or physical units. Thus, economic analysis can be used to estimate the contributions in monetary terms to the economic efficiency objective, as well as the distributional (equity) consequences. This information on trade-offs would be used in the decision-making process to rank alternative plans and ultimately to select a preferred plan. As discussed in detail by

Dixon in Section 3.4, social benefit-cost analysis is an essential element of multiple-objective analysis.

c. Evaluation and plan selection

The outputs of the Plan Formulation stage, in the form of alternative water resource plans or strategies, are subjected to detailed and intensive review and evaluation by the planning staff with inputs from the affected publics. At this stage there is detailed, full-scale application of social benefit-cost analysis, as discussed in Section 3.4, along with relevant multiple-objective analysis. The results of these analyses are then presented to the decision-makers in the form of a recommended plan or alternative plans.

Typically, decision-makers may be a national Ministry of water resources or public works, or the head of the national government -- Prime Minister or President -- sometimes subject to approval of the Legislative Branch.

In cases where decision-makers do not accept any of the alternative plans, or require major modifications before acceptance, action returns to the plan formulation stage for further planning and evaluation. And, if considerable time has elapsed in the initial plan formulation and evaluation stages, revised background studies and projects may be required before the second round of plan formulation can proceed.

Important Factors in Planning

Experience has shown that success in water resource planning is related to several important factors, including the extent to which there is detailed planning for implementation, local publics are closely involved in planning, and the planning team is multidisciplinary in makeup (Hufschmidt and McCauley, 1990).

a. Planning for implementation

Because of the close relationship between project plans and related water and land management technology, on the one hand, and the ease or difficulty of implementing projects on the other, it is necessary to make specific and detailed plans for the implementation of projects during the plan formulation stage. Typically, such an implementation plan will be a package of implementation tools, consisting of regulatory measures, monetary incentives, technical assistance and extension education, to insure that the land and water users and managers take appropriate actions to achieve project success (Easter, 1986b). As discussed in more detail below, the water users and land managers who will play key roles in implementing the project should participate in the combined project design and implementation planning. Of course, any initial implementation plan can only be a first draft, subject to change as experience is gained during implementation.

Any implementation plan will be developed initially in terms of an existing set of institutional and organizational arrangements. Where these arrangements are found to be inadequate or constraining the implementation plan may propose changes in these arrangements.

b. Local participation

Plan formulation involves local participation in two ways: First, farmers, fishermen, villagers, lake shore residents, and others who will use the water resources or will be affected by development projects should be involved in the planning and design of projects. Second, the implementation plans that are developed should have specific roles or tasks for the water users and affected people. For example, an implementation plan for an irrigation project would define the roles and responsibilities of water users in canal management, water distribution, operation and maintenance and financial management. According to a recent study of medium-scale irrigation systems in Northwest Thailand: "The (government) should adopt the concept of farmer involvement at all stages of irrigation development, from site design through O & M. The concept should be institutionalized in a Standard Operating Procedure, which establishes clear rights and responsibilities for farmers at all phases of system rehabilitation and operation (Johnson et al., 1989).

An outstanding example of local involvement in water resources planning is the Yahagi River basin whose local agricultural, fisheries and water supply groups continue to participate actively in the planning and policy process (Naito et al., 1989). Local citizens are also actively involved in water management decisions on Lake Biwa, especially as they concern water quality (Imai et al., 1989). On the other hand, community participation in planning and decision-making for Laguna de Bay is still in an embryonic stage. Its weakness is seen as a challenging problem facing the Laguna Lake Development Authority (Fellizar et al., 1989).

c. Multidisciplinary planning team

Formulating water resource management plans is far more than a technical exercise involving the services of hydrologists and civil engineers. In fact multiple objectives -- economic, social and environmental -- multiple purposes -- irrigation, hydroelectric power, domestic water supply -- multiple options -- demand-side and supply-side management options -- and multiple elements -- physical measures, implementation tools, and institutional and organizational arrangements -- are all involved in planning. Effective performance of planning tasks requires the services of people with training and experience in the social and biological sciences as well as in engineering and the physical sciences. Perhaps as important as the services of people covering the full range of these fields of knowledge and experience is the interdisciplinary composition of the leadership of the planning activity.

The Cisadene-Cimanuk Integrated Water Resources Development study is a good example of effective use of a multidisciplinary planning team (Delft Hydraulis and Indonesian Ministry of Public Works, 1988). The Delft Hydraulics team leader was a multidisciplinary-trained water resource planner. His team represented a broad spectrum of engineer/planners and natural and social scientists, including a system analyst, computer modeller, civil engineer/planners, hydrologist, economist, sociologist, water quality scientist, fisheries scientist, agronomist and irrigation engineer.

3.1.6 IMPLEMENTATION

The planning activities discussed above are directed toward assuring that an integrated water resource plan is prepared that meets the economic, social and environmental objectives of the society.

There remains, however, the challenging task of implementing the plan. As shown in Figure 3.1.5, implementation is generally divided into three stages: 1) Construction or installation of projects, 2) operation of the water resource system, and 3) maintenance of the physical facilities and natural elements of the water resources system.

These stages are usually sequential, as shown in Fig. 3.1.5, although at any one time, installation or construction, operation, and maintenance may be under way on different projects of the plan or program. As implementation proceeds, monitoring and evaluation of activities and results are undertaken, and the results are fed back to the water resources managers, as shown in Fig. 3.1.5.

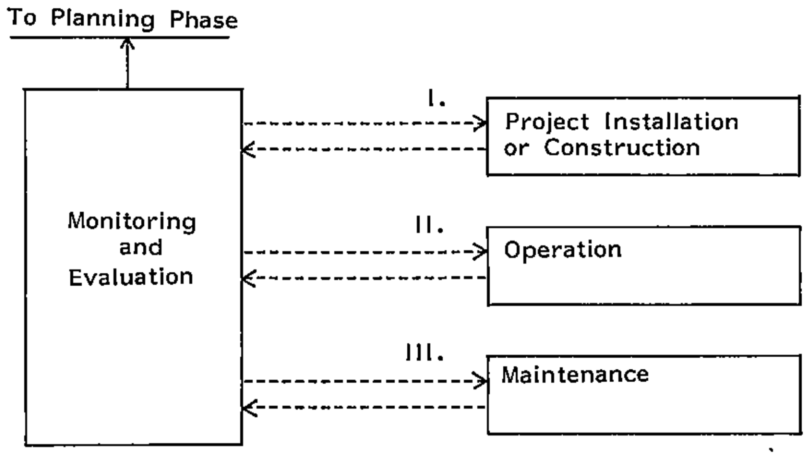

Figure 3.1.5 The Water Resource Implementation Process

In the following discussion of implementation, five major factors of management are advanced as of special importance at the implementation stage. These are: 1) integrated financial plan, program and budget, which is important not only at the construction or installation stage, but also for operation and maintenance; 2) local involvement in implementation; 3) implementation tools; 4) effective operation and maintenance; and 5) monitoring and evaluation.

Integrated financial program and budget

The integrated water resource plan which is the output of the planning stage typically will consist of a number of individual physical projects to be built or installed and individual management activities to be carried out by different agencies.

Whether this integrated financial program and budget is to be provided as a lump sum to a single ministry or department for allocation among individual agencies, or as separate appropriations to individual ministries or departments, it is necessary that the integrity of the programs and budgets be maintained throughout the budgetary and appropriation process. This can best be done if 1) the multi-year programs and annual budget are prepared jointly by all relevant agencies, 2) the basin-wide or region-wide programs and budget are kept intact as identifiable categories throughout the budgetary and appropriation process, and 3) administration of the program and budget during the implementation stage is a shared task of the relevant agencies.

Local involvement in implementation

The scope, form and method of local involvement in implementation will vary from case to case, and these factors, in turn, will affect the relevant strategy for public involvement. In some cases, such as irrigation, rural water supply, fisheries, and watershed management, the water or land users play key roles in project operation and maintenance. In other cases, where project construction and operation involve temporary or permanent displacement of people from the project site, or otherwise adversely affect local people, these people have an obvious stake in how the project is built and operated. Also, in some river/lake basins the general public, although not directly affected by project activities, will have an interest in how the water resources are managed because of indirect or secondary effects on environmental, social and economic conditions in the region.

Appropriate strategies for public involvement for these cases range from direct involvement in project construction and operation, as for irrigation water distribution and on-farm water spreading facilities, and close consultation and collaboration, as in the relocation of displaced people, to a strong advisory role on implementation in general, as in the case of citizens groups organized on a river/lake basin basis.

As summarized by Howe (1986), water resource implementation should involve sufficient public participation at regional and local levels so that "(a) valuable local information and technical inputs are identified and utilized, (b) the interests of all affected groups are identified and taken into account, and (c) local water users feel a part of the river basin program and accept their responsibilities for operation and maintenance."

The key role that public participation plays in implementation of watershed management is discussed by Easter (1986b). Important issues of concern identified by Easter, Hufschmidt and McCauley (1985) are 1) how to build local capacities for implementation; 2) the need to pinpoint the obstacles to effective participation in water management at the policy, agency and local levels; 3) importance of examining the lessons of successful participatory approaches used in other areas of natural resource management and rural development; and 4) finding out what can be learned from traditional systems of resources management that could be applicable to modern water resources management.

Implementation tools

The importance of appropriate tools in an implementation strategy has been discussed under Planning for Implementation above. What is appropriate depends upon the individual situation or case and is often a function of 1) the kinds of physical management measures of concern, e.g. farm terraces, irrigation canals, and 2) the institutional setting, e.g. land tenure, water rights. In theory, there is an appropriate set of implementation tools for each specific combination of management options and insitututional arrangements. Sometimes, in the pr6cess of implementation, it is necessary to change the mix of management options or the institutional arrangements to attain a workable combination of these with the implementation tools.

There are four general classes of implementation tools: regulatory "command and control" arrangements, monetary incentives or disincentives, technical help, education and research, and direct public installation and operation (Easter, 1986b). Most implementation strategies will use a combination of these classes. Each has its advantages and disadvantages. Direct "command and control" methods, involving regulation of land uses, forest harvesting, water withdrawals or polluted effluents, although potentially effective, often do not work well, especially on privately owned lands in rural areas. Economic incentives, in the form of grants or subsidized loans, are often expensive, and, once incentives are stopped, the desired management actions also stop. Economic disincentives, such as effluent charges are most effective for industrial water users, especially when used in conjunction with appropriate pollution control regulations. Technical help via extension services, supported by education and research, for water and land use and control practices have great potential for long- range effectiveness, but the immediate pay-off is usually disappointing. Direct construction and operation by public agencies is most appropriate for large-scale multiple-purposes such as dams, reservoirs, levees and canals. But such projects are often very costly, and in many cases still require the participation of irrigators and other water users, such as fishermen, in operation and maintenance to achieve project outputs.

In the Lake Dianchi Basin, China an attempt has been made to provide an integrated package of management measures and implementation tools through the "Ordinance for Lake Dianchi Protection" passed by the Kunming Municipal Government in May 1988 (Zhang and Liu, 1989). Included are provisions for regulations, effluent charges, water use fees and public construction and operation of facilities for water supply, water pollution control, watershed management, erosion and sedimentation control and fisheries management.

Operation and maintenance

A major weakness in the implementation of many water resource plans in developing countries is the failure to provide adequately for the operation and maintenance of projects once construction or installation is completed. Where projects are funded by loans or grants from international development banks or bi-lateral aid agencies, funds are provided only for construction, with the project sponsor -- usually a national water resources agency -- expected to provide for on-going operation and maintenance. With few exceptions, water user fees and assessments are not adequate to pay for operation and maintenance of projects; in many cases, water services are provided free to users; in other cases, where fees are levied, as for irrigation water, the rate of collection is very low. As a result, operation and maintenance activities must seek funds in national water resource agency budgets -- a difficult task when competing against more politically appealing projects.

In addition to being underfunded, operation and maintenance activities suffer from the low professional prestige accorded to the staffs who undertake what are considered to be mundane tasks. In some cases, unprofessional performance in the operation of irrigation systems, especially in the allocation of water, is prevalent (Chambers, 1988).

According to Howe and Dixon (1985) operation and maintenance problems stem from a series of distortions that start with project formulation and selection in the planning stage and continue through the project design, construction and operation stages. These distortions have their roots in decisions by donor/lenders and host countries and include adoption of inappropriate technology, highly capital intensive systems that are difficult to operate and maintain, little or no involvement of affected local people in project planning and implementation, and inadequate funding and lack of staff incentives for good operation and maintenance.

To overcome these deficiencies it is necessary to develop and carry out an operations and maintenance plan which has for its objective the continued production of the outputs of the project on a sustainable basis. This requires that adequate funds be provided on a sustained basis, in the integrated multi-year financial program and annual budget. To the extent practicable, funding should be provided from user charges and assessments on project beneficiaries. In addition, water users should participate in project operation and maintenance, especially for irrigation, rural water supply and watershed management activities. Special attention should be given to the effectiveness of project operation and to the adequacy of maintenance staffs, including those involved in monitoring and evaluation, and to participating water users. Incentives could be in the form of professional training, technical guidance, pay increases, professional recognition, higher status in the management agency, and security of tenure.

Monitoring and evaluation

As implementation proceeds, from construction to operation and maintenance, as shown in Figure 3.1.5, monitoring and evaluation of the performance of the water resources plan and program is an essential management activity. As pointed out by Easter (1986a) monitoring and evaluation is a continuous process designed to inform project or program managers what has happened or is happening while a project is being implemented. Accordingly, an effective monitoring and evaluation system will provide the kind of information that managers need in time to enable them to make necessary changes in project operations.

According to Easter (1986a) important components of an effective monitoring and evaluation system are: 1) carefully designed baseline studies of physical and socio-economic conditions; 2) strong support of the system by project and program managers; 3) realistic targets for project inputs, activities and outputs; 4) local participation in the monitoring and evaluation, especially of outputs and impacts affecting local people; 5) appropriate measures of effectiveness; 6) timeliness and accuracy of information generated by monitoring and evaluation; and 7) effective communication of results to planners, managers and decision-makers.

3.1.7 INSTITUTIONS AND ORGANIZATIONS

Because proper institutions and organizations are so important to successful water resources management, they are given separate treatment in this Section. Here we distinguish between institutions and organizations. Institutions as used here are the formal and informal rules of a society which define property rights to land, water and other natural resources, and spell out the rights and obligations of individuals and groups. As such, the definition also includes the rules under which organizations operate. Organizations are ordered groups of people in administrative or functional structures, such as private firms, non-profit public entities, and governmental agencies (Gibbs, 1986).

Institutions: Desirable characteristics

In general terms, water resource management institutions should promote or, as a minimum, not constrain the achievement of the multiple objectives of the water resource management plan -- in particular, the economic development, equity, environmental quality and sustainability objectives. More specifically, the rights and obligations of water, land and related resource users should be clearly defined and consistently administered so as to allow efficient and equitable use of resources on a sustainable basis, with appropriate account taken of unavoidable adverse environmental and social consequences. These essential characteristics of clarity of definition and consistency in administration may take somewhat different forms for streams, lakes, estuaries, groundwater, fisheries, forests, grasslands, rainfed and irrigated agricultural lands.

Turning first to agricultural lands: In general, security of tenure is the prime institutional characteristic contributing to productivity of agricultural lands on a sustainable basis. High security can take the form of outright private ownership of land as in Japan or the United States or long-term leasehold tenancy arrangements, with rights of renewal, whether with private owners or with the Government, as in many developing countries. Less secure are short-term tenancies with or without renewal rights, and customary land use rights, with no legal ownership or tenancy status. For rainfed agricultural lands, secure rights to land is the important requirement but for irrigated lands, security of water rights is needed as well.

As pointed out by Nickum and Easter (1989) difficulties arise in achieving security and transferability of water rights because of: 1) interdependencies among water users, 2) high degree of variability of supply, 3) economies of scale of large water projects, 4) high social value of agricultural water supply relative to economic value, 5) conflicting social values concerning use, and 6) high transaction costs where many water users are involved. Given these difficulties, water markets for irrigation will be severely constrained by governmental action. One type of government-issued water use right is a permit to withdraw a specific quantity or proportion of available water. Also irrigation water users pumping from a common groundwater pool may have restrictions placed on their pumping rates which depend upon groundwater recharge rates.

Fisheries in freshwater lakes present a special type of open access problem. As shown in the Laguna Lake case (Fellizar et al., 1989) some form of government regulation of fishery sites and rates of use was required to control adverse externalities and limit overall fish takes to sustainable levels. Here too the problem of "government failure" to regulate effectively an open-access resource becomes an important issue. The example of fishing rights in Tokyo Bay, described in Dixon and Hufschmidt (1986, Chapter 6) is a case where government acted effectively to 1) provide rights that were specific and transferable, 2) restrict access to members of user organizations (the fishery unions), and 3) vest decision-making rights in the fishery unions, with full participation by the users. In contrast, the Laguna Lake case is a less fortunate example of ineffective government and user performance (Fellizar et al., 1989).

In cases of market failure involving spillover effects such as water pollution, erosion and sedimentation, salinization, and flooding, government will usually intervene with regulations or economic incentives to correct such distortions. As pointed out by Nickum and Easter (1989), bargaining among affected private parties could, in theory, lead to a socially optimal level of cleanup. However, when, as is usually the case, many actors are involved or information on technical relationships is faulty, the transaction costs of bargaining are so high that this method becomes unfeasible, and government intervention is resorted to.

In the case of water pollution from urban areas, industry and agriculture, regulation can take various forms: effluent standards and ambient streams or lake standards. Economists advocate the use of effluent charges or tradeable permits as means of achieving economically efficient outcomes. Banning the use of chemicals in areas where water leaches quickly to the groundwater may be necessary.

Control of erosion and sedimentation from watersheds composed largely of agricultural, grazing and forest lands presents special problems. Except in special situations, government regulation is not an effective approach, in part because of high transaction costs. Promotion of institutions that foster collective action and internalize off-site impacts, along with strong tenure arrangements, are more appropriate actions. These, along with technical help and economic incentives to landowners and tenants, can lead to successful watershed management programs (Easter, 1986b; Gibbs, 1986).

Organizations: Desirable characteristics

The United Nations report on Integrated River Basin Development (1970) concluded:

There certainly is no single correct way to organize and administer a river basin programme. The plan of organization must in each case be fitted into the general governmental structure and into the cultural patterns and political traditions of the countries and regions which are involved.

This is still the case today. Accordingly, in developing the organizational dimension of a water resource management strategy, a good approach is to look at a number of desirable characteristics that an organizational arrangement should have. How to fit these characteristics into an existing or proposed organization for a specific river/lake basin or other management region is a separate and challenging task that is beyond the scope of this Chapter.

Following are four important desirable characteristics for organization:

a. Regional or river/lake basin focus

The organizational structure should have an appropriate regional focus. This is obviously the case with a river basin authority such as the Tennessee Valley Authority in the United States, the Damodar Valley Authority in India, and the Lake Victoria Basin Development Authority in Kenya. Regional focus can also be achieved by establishing a strong regional or river/lake basin coordinating mechanism such as an inter-agency committee, preferably with independent leadership, or alternatively with leadership by a sectorial agency.

b. Integration of objectives, purposes and means

Along with a strong regional focus, organization for water resources management must achieve effective integration of the various multiple objectives, multiple purposes and multiple means that are part of management. Even where a river/lake or regional authority exists, achievement of such integration is far from a routine exercise and requires sophisticated administrative skills. The problem is especially difficult in the usual case where responsibilities for water resources activities are divided among many sectorial agencies. Whatever the particular form or mechanism for integration, it is important that it be in place at the early stages of planning when some of the crucial decisions concerning scope, objectives and purposes of the water resource plan will be made.

c. Management effectiveness

Regardless of the particular organizational structure for management, the basic components, such as sectorial agencies, must have the legal authority and administrative capability to perform effectively the management tasks within their areas of responsibility. This is particularly important during the implementation phase of management. Management of open access resources such as lake fisheries, as in the Lake Laguna and Saguling Reservoir cases, groundwater aquifers, and communal forestlands and grasslands requires rigorously fair and consistent enforcement of restrictions on use. Otherwise, regulatory failure can lead to inequities and conflicts among resource users, widespread evasion, and deterioration of the resources. Government administration of regulations and economic incentive systems for control of water pollution, erosion, sedimentation, salinization and flooding must also be equitable and consistent. Almost always, effectiveness of administration is enhanced if the local resource users are closely involved in the administration, often through water user organizations.

d. Decentralized management via local user organizations

Although a considerable degree of centralization of activity is appropriate at the planning stage of management, a high degree of decentralization is usually desirable during implementation, especially when many water and land resource users are involved. Such decentralization of sectorial agency staffs to the project or sub-watershed levels is most effective when combined with devolution of responsibility to water user organizations, as in the case of irrigation projects, watershed management and lake fisheries. Administration of water rights, and economic incentives or regulations on pollution, sedimentation and groundwater withdrawals are often best accomplished through such water or land user organizations.

REFERENCES

Bangladesh Ministry of Irrigation, Water Development and Flood Control. 1986. National Water Plan. Dhaka.

Bower, B.T. and Hufschmidt, M.M. 1984. A Conceptual Framework for Water Resources Management in Asia. Natural Resources Forum 8(4).

Chambers, R. 1988. Managing Canal Irrigation. Chapter 6. Oxford and IBH Publishing Co.. New Delhi.

Delft Hydraulics and Indonesian Ministry of Public Works. 1988. Cisadene- Cimanuk Integrated Water Resources Development (BSTA-155) Volume 1 - Executive Summary. Ministry of Public Works. Jakarta.

Dixon, J.A. and Hufschmidt, M.M. 1986. Economic Valuation Techniques for the Environment: A Case Study Workbook. Johns Hopkins University Press. Baltimore.

Dixon, J.A. and Easter, K.W. 1986. Integrated Watershed Management: An Approach to Resource Management. Chapter 1 in Easter, K.W., Dixon, J.A., and Hufschmidt, M. Watershed Resources Management: An Integrated Framework with Studies from Asia and the Pacific. Westview Press. Boulder, Colorado.

Easter, K.W. 1986a. Monitoring and Evaluation for Integrated River Basin Development and Watershed Management. Proceedings of the Workshop on Integrated River Basin Development and Watershed Management, Vol. II. Ministry of Public Works, Government of Indonesia, in Cooperation with Environment and Policy Institute. East-West Center. Honolulu. pp. 301-321.

Easter, K.W. 1986b. Program Implementation. Chapter 8 in Easter, K.W., Dixon, J.A. and Hufschmidt, M.M. Watershed Resources Management: An Integrated Framework with Studies from Asia and the Pacific. Westview Press. Boulder, Colorado.

Easter, K.W., Hufschmidt, M.M. and McCauley, D.S. 1985. Integrated Watershed Management Research for Developing Countries: Workshop Report. Environmental and Policy Institute, East-West Center. Honolulu, Hawaii.

Easter, K.W., Dixon, J.A. and Hufschmidt, M.M. 1986. Watershed Resources Management: An Integrated Framework with Studies from Asia and the Pacific. Westview Press. Boulder, Colorado. pp. 4-9.

Fellizar, F.P.Jr., Pacardo, E.P., Francisco, F.R., Espaldon, V.O., Nepomuceno, D.N. and Espaldon C.F. January 1989. Policy Responses to Fishery Conflict in Laguna Lake. Paper presented at Second Expert Group Workshop on River/Lake Basin Approaches to Environmentally Sound Management of Water Resources, Focus on Policy Responses to Water Resources Management Issues and Problems. Bangkok and Hat Yai, Thailand.

Gibbs, C. 1986. Institutional and Organizational Concerns in Upper Watershed Management. Chapter 6 in Easter, K.W., Dixon, J.A. and Hufschmidt, M.M. Watershed Resources Management: An Integrated Framework with Studies from Asia and the Pacific. Westview Press. Boulder, Colorado.

Haimes, Y.Y., Hall, W.A. and Freedman H.T. 1975. Multiobjective Optimization in Water Resources Systems. Elsevier Scientific Publishing Co. Amsterdam.

Hamilton, L.S. 1985. The Watershed as a Unit for Planning Rural Development Projects. Unpublished Background Paper for the Workshop on Integrated Watershed Management. Environment and Policy Institute, East-West Center. Honolulu, Hawaii.

Hamilton, L.S. and King, P.N. 1984. Watersheds and Rural Development Planning. In Hanks, J., ed. Traditional Life-styles, Conservation and Rural Development. IUCN. Gland, Switzerland. pp. 80-86.

Holmes, B.H. 1972. A History of Federal Water Resources Programs, 1800- 1960. U.S. Department of Agriculture Misc. Pub. No. 1233. Washington, D.C.

Howe, C.W. 1986. The Institutional Framework for River Basin Planning and Management: Principles and Case Studies. In Proceedings of the Workshop on Integrated River Basin Development and Watershed Management, Vol. II. Ministry of Public Works, Government of Indonesia, in cooperation with Environment and Policy Institute, East West Center. Honolulu, Hawaii: 251.

Howe, C.W. and Dixon, J.A. 1985. Distortions in the Identification, Design, Construction and Operation of Development Projects: An Economic Perspective. Unpublished manuscript. Hufschmidt, M.M. 1986. A Conceptual Framework for Watershed Management. Chapter 2 in Easter, K.W., Dixon, J.A. and Hufschmidt, M.M. Watershed Resources Management: An Integrated Framework with Studies from Asia and the Pacific. Westview Press. Boulder, Colorado.

Hufschmidt, M.M., Dixon, J., Fallon, L., and Zhu, Z. 1988. Water Resources Policy and Management for the Beijing-Tianjin Region. Joint summary report of the State Science and Technology Commission of Beijing, China and the East-West Center, Honolulu.

Hufschmidt, M.M. and McCauley, D.S. 1988. Water Resources Management in a River/Lake

Basin Context. Water Resources Development 4(4): 224-231.
Hufschmidt, M.M. and McCauley, D.S. 1989. Institutional and Organizational Mechanisms for Integrating Land Use Decisions with Water Resources Management. Paper presented at Second Expert Group Workshop on River/Lake Basin Approaches to Environmentally Sound Management of Water Resources: Focus on Policy Responses to Water Resource Management Issues and Problems. Bangkok and Hat Yai, Thailand.
Hufschmidt, M.M. and McCauley, D.S. 1990. Strategies for Integrated Water Resources Management. Paper presented at the Third Expert Group Workshop on River/Lake Basin Approaches to Environmentally Sound Management. Otsu, Japan.

Imai, K. et al. 1989. Lake Biwa Case Study: Evolution of the Lake Biwa Water Resources Management and Environmental Conservation Policies. Paper presented at Second Expert Group Workshop on River/Lake Basin Approaches to Environmentally Sound Management of Water Resources: Focus on Policy Responses to Water Resource Management Issues and Problems. Bangkok and Hat Yai, Thailand.

Johnson, S.H.III, Patamatamkul, S., Apinantara, A., Charoenwatana, T., Issariyanukula, A., Paranakian, K., and Reiss, P. 1989. Medium Scale Irrigation Systems in Northeast Thailand: Future Directions. ISPAN- Irrigation Support Project for Asia and the Near East. Arlington, Virginia.
Jorgensen, S.E. and Vollenweider, R.A., eds. 1988. Principles of Lake Management, Volume 1 - Guidelines of Lake Management. International Lake Environment Committee, and United Nations Environment Programme. Otsu, Japan.

McCauley, D.S. 1988. Overcoming Institutional and Organizational Constraints to Watershed Management for the Densely Populated Island of Java. Paper presented at the Fifth International Soil Conservation Conference. Bangkok, Thailand.
Milliken, J.G. and Taylor, G.C. 1981. Metropolitan Water Management. Water Resources Monograph Series No. 6. American Geophysical Union. Washington, D.C. Naito, R., Sano, A., Harashima, R. and Niki, Y. 1989. Consideration of Management System and Consensus Forming in River Basin Management: An Analysis of the Roles and Functions of the Yahagi River Methods. Paper presented at Second Expert Group Workshop on River/Lake Basin Approaches to Environmentally Sound Management of Water Resources: Focus on Policy Responses to Water Resource Management Issues and Problems. Bangkok and Hat Yai, Thailand.

Nickum, J.E. and Easter, K.W. 1989. Institutional Arrangements for River/Lake Basin Management with Emphasis on Managing Conflicts. Paper presented at Second Expert Group Workshop on River/Lake Basin Approaches to Environmentally Sound Management of Water Resources: Focus on Policy Responses to Water Resource Management Issues and Problems. Bangkok and Hat Yai, Thailand.

United Nations. 1970. Integrated River Basin Development. United Nations. New York.
U.S. President's Water Resources Policy Commission. 1950. A Water Policy for the American People, Vol. 1. U.S. Government Printing Offices. Washington, D.C.

White, G.F. 1969. Strategies of American Water Management. University of Michigan Press. Ann Arbor, Michigan.

Zhang, J. and Hongliang, L. 1989. Institutional Analysis for Water Resources Management in Lake Dianchi Basin. Paper presented at Second Expert Group workshop on River/Lake Basin Approaches to Environmentally Sound Management of Water Resources: Focus on Policy Responses to Water Resource Management Issues and Problems. Bangkok and Hat Yai, Thailand.

SECTION 3.2

EFFECTIVE MONITORING OF LAKE WATERS

by Asit K. Biswas

3.2.1. INTRODUCTION

Monitoring has always been an integral component of all planning and management processes, and thus, in this sense, monitoring has been as old as management itself. No sustainable water resources system can be efficiently planned, designed and managed without adequate and reliable data on the system parameters, and lakes are no exception to this rule.

With ever-increasing human and animal populations, more and more water is required for their survival and maintaining a certain quality of life. Lake waters are therefore coming under direct pressure in terms of their availability and use for domestic consumption and for agricultural, industrial and navigational purposes. In addition, lakes are often used for waste assimilation, directly through point sources for domestic and industrial waste discharges and/or indirectly through non-point sources like agricultural and urban runoff. Lakes, especially in developing countries, are also an important resource for fish production. Optimum management of any lake thus requires careful balancing of all these demands, many of which are contradictory. For example, use of lakes as waste assimilators means that water quality continues to deteriorate, which could seriously restrict the use of water for domestic, agricultural and industrial purposes and reduce fish productivity.

Signs of stresses on lake management are becoming increasingly evident in many countries, both developed and developing. Lake managers are thus faced with the complex task of devising and implementing appropriate strategies which would optimize the use of lake waters to satisfy the needs of the human population but simultaneously ensure that this could be done without endangering such resources for continuing use in the future. The art and science of properly balancing the various possible uses of lake waters on a sustainable basis can be termed as lake management.

Lakes can only be managed efficiently if the information on which management decisions can be based is available to the decision-makers on a regular and timely basis. Unfortunately, however, for a majority of the lakes of the world, managers still have access to surprisingly limited information on which sound decisions can be based. The only way to ensure that managers have ready access to the information they need is to institute a functional monitoring system, which will regularly provide them with the data which they so badly need.

3.2.2 LAKE MONITORING

In the context of the present chapter, lakes include both natural and man-made lakes, and monitoring is defined as the continuous or periodic collection, collation and analysis of data and information for purposes of effective management of lake waters. Data includes both physical and socio-economic data which are required for proper management and optimum use of lake resources. Since the primary purpose of monitoring is to achieve efficient and effective management of lakes, it should be considered as an integral part of the management information system. Accordingly monitoring should be a regular internal activity of any institution responsible for managing lakes.

It should be clearly recognized that monitoring by itself will not be enough. Data collected must be used in a timely manner to get a clear picture of the status of any lake, both in terms of quantity and quality of its water, its availability and use, and overall effective management. Periodic evaluations need to be carried out. Evaluation in this context may be defined as a process which determines systematically and objectively to the extent prossible, the impact, effectiveness and relevance of lake management in terms of their agreed objectives.

It can be persuasively argued that if the existing performance patterns of lake management in terms of achieving their objectives are to be improved significantly, it would be essential to ascertain that monitoring and evaluation become an integral component of the management process in order first to determine their achievement levels and then to identify what adjustments and corrective actions may be necessary to ensure that the future stream of benefits accrue to the appropriate users and target groups.

Some form of monitoring and evaluation is often carried out for many lakes. For example, if the water of a lake is used for human consumption, agriculture or navigation, its water level is generally monitored frequently. Often some limnological paramenters are also monitored. However for a vast number of lakes, regular monitoring of essential water quality parameters is not generally carried out, or if carried out, the data are not available to planners and managers on a regular and timely basis. Reliable infomation on fish productivity (both total amount of fish caught annually and their types) is available only for a few select lakes. When one moves from physical factors to socio-economic factors, the status of their monitoring usually gets worse. One would indeed be hard-pressed to identify more than a handful of lakes anywhere in the world where their impacts on the lifestyles of the intended beneficiaries like farmers, fishermen and domestic water consumers have been properly evaluated at regular intervals.

It should be noted that regular and reliable monitoring of lakes is not an easy task under the best of circumstances. There are methodological problems which need to be resolved in order to find a cost-effective and reliable approach that can be used for monitoring within the resources and expertise available to the institutions responsible for lake management. Ready availability of funds and trained manpower are generally critical issues for nearly all developing countries. Even when such methodological issues and resource problems can be overcome, there are other important barriers like institutional inertia, which have to be effectively overcome, before a regular monitoring and data management system can be established, which could become an integral component of the management process.

It should be noted that the various reasons for instituting proper lake monitoring are generally not mutually exclusive since they are often interrelated. Equally it is not enough to identify and monitor the various technical, social, environmental and economic parameters; it is essential to review institutional arrangements and constraints, since it is the institutions concerned which in the final analysis have to develop and implement appropriate policies for lake monitoring and then use the information obtained for sustainable lake management.

On the basis of reviews of monitoring of lakes in many countries, it is clear that very few people are satisfied with the present status. The problems appear to be many-faceted, among which are the following:

Decision-makers often claim that they have no clear idea as to the total real benefits accruing from lakes, nor do they have precise information on the anticipated beneficiaries from the resources of the lakes or even on the nature and extent of the real beneficiares.

Planners point out that they have no objective information on how past planning of the use of lake resources has fared, and without any reliable feedback they cannot improve the existing planning process to any significant extent.

Managers state that they cannot make appropriate timely decisions since the information they receive is often somewhat general, and as such unusable and of little assistance (too little, too much, irrelevant, unreliable or too late).

People who monitor feel that their works do not receive proper attention, and what is more they are not given enough resources or time to carry out their tasks efficiently.

A realistic assessment of the current status of monitoring of lakes would indicate that virtually everyone associated feels that monitoring is essential and beneficial, but in reality the rhetoric overwhelmingly exceeds actions. Organizations, especially in developing countries, appear to embark more upon pilot exercises and training programmes on monitoring rather than carry them out properly on a long-term basis. This unsatisfactory situation must be improved.

3.2.3 MONITORING AND EVALUATION REQUIREMENTS

There are some fundamental requirements for designing any monitoring and evaluation system for an irrigated agriculture project. Among the primary requirements are the following:

1) timeliness;
2) cost-effectiveness;
3) maximum coverage;
4) minimum measurement error;
5) minimum sampling error;
6) absence of bias; and
7) identification of users of information.

Timeliness

Most management decisions have a time dimension, even though the timeliness of making some decisions may be more important than others. For example, if the water of a lake is of inappropriate quality for drinking or for use in agriculture, or if the fish production deteriorates for whatever reasons, it is necessary that these problems be identified as soon as they begin to surface and then necessary remedial measures are undertaken to rectify such problems. If not, the health of the people depending on lake waters would suffer, and the income foregone by the farmers due to the loss of agricultural productivity will never be recovered. Thus, it is essential that information collected from monitoring reaches the appropriate decision-makers on time, so that rational decisions can be made in time based on the data monitored. Accordingly, for a rational management system, monitored information should be channelled in a timely fashion so that it can be converted into decision and action.

It should be noted that the management success depends not only on the timeliness of the information but also on the quality, extent and the form in which the information is channelled into the decision-making process. A problem often arises because even if the required information has been collected, it could not be channelled into the decision-making process since it is either in a diffused or inappropriate form or could not be obtained and analysed within the timeframe by which decisions should be made. If information from lake monitoring does not reach its potential users in time, monitoring can at best only have a limited impact on overall lake management.

The danger is that if monitoring information does not reach the managers on time, it is likely that one or more of the following consequences, which are not mutually exclusive, may occur:

- wrong action may be taken;
- decisions taken may not be optimal on a long-term basis;
- no action may be taken when one is desirable;
- decisions taken may result in irreversible damage; or
- decisions taken may unnecessarily increase the cost and timeframe required for the resolution of a specific problem.

It is therefore essential that a lake monitoring programme be set up in such a fashion that relevant information in usable form reaches the people who need it on a continuing and timely basis.

Cost-effectiveness

Information collection, processing, analysis and scaling requires financial resources, expertise, manpower and equipment. Since the ready availability of all these resources is limited, especially in developing countries, any monitoring system designed for lakes should be cost-effective. This essentially means a sensible trade-off between the depth and context of information to be collected as well as between amount, relevance and accuracy. As a general rule, it can be said that the overall value of information collected in terms of use should exceed the cost of obtaining that information.

For most projects, from a management viewpoint at any specific time, the value of information generally increases with the increasing extent and the accuracy of information available. Value of information, however, for most decisions generally approaches a plateau at a certain stage, beyond which it increases only marginally. In contrast, the cost of obtaining information continues to increase with more coverage and higher accuracy. This is diagrammatically shown in Fig. 3.2.1.

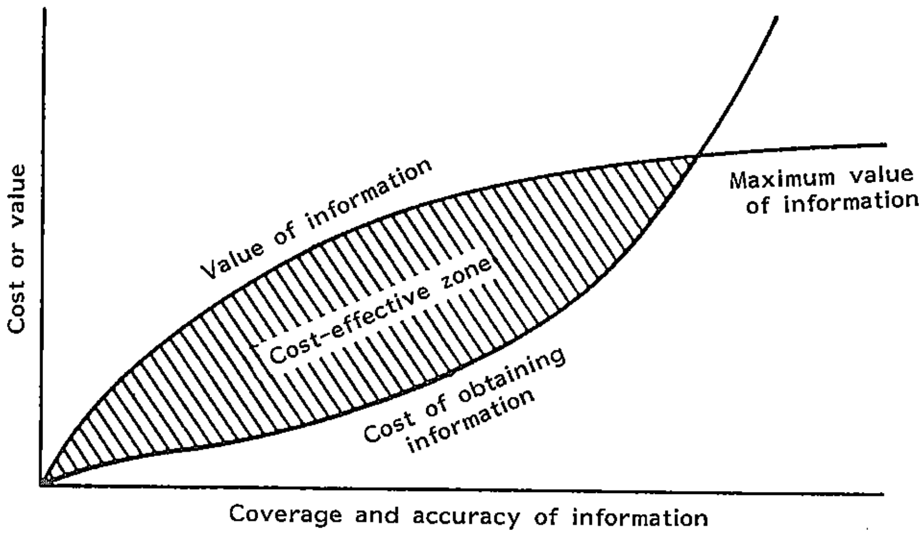

Figure 3.2.1 Cost-effectiveness of Monitoring and Evaluation of Information

The shaded area in Fig. 3.2.1 is the cost-effective zone, beyond which the cost of obtaining information will rapidly exceed its intrinsic value. Exactly where within a shaded area a decision should be made depends on a variety of factors such as type of projects, management experience and potential impact, but such trade-off considerations are often made on the basis of value judgements.

There is often a tendency to collect more data than necessary. For any monitoring and evaluation process to be efficient and cost-effective, it is essential to have a clear idea about who is going to use the data, what types of data are necessary, how the information would be used, and when and in what form they should be made available. Without such a clear focus, unnecessary and non-essential data may be collected, which is an expensive luxury all countries can do without.

While data collection processes need to be carefully integrated within the monitoring framework, consideration and desire for scientific rigour should be balanced with the need for timely information. This in reality often translates into a trade-off between accuracy and reliability with cost. In the final analysis, the value of information for the management process becomes the key factor in resolving this trade-off.

Maximum coverage

For monitoring of lakes, especially large ones, a major difficulty arises from the fact that a wide area may need to be covered, including the lake catchment area, since land use patterns and other human activities will have a major impact on water reaching a lake as well as its water quality. Thus, maximum coverage taken literally may prove to be an expensive, complex and time-consuming process.

As a general rule, sociologist and anthropologists prefer to have as much breadth of coverage as possible. However, given the high resource costs of manpower, time, transportation, and other related factors, as well as high opportunity costs, a decision may often be necessary to have limited coverage of selected variables, and then use the balance of available resources to obtain more detailed information on specific aspects and/or areas that are critical from a management viewpoint. Accordingly, maximum coverage in the present context should be interpreted to mean colection of maximum data that are necessary and will be used for management purposes, subject to resources (funds, manpower, expertise, equipment and time) availability.

Minimum Measurement Error

The level of accuracy and reliability of any data that will be collected is an important consideration for any monitoring process. Generally engineers and physical scientists are more concerned with the accuracy of measurements and data collected than sociologists and anthropologists. For example, if the presence of certain toxic chemicals in lake waters is to be considered, often these are to be measured in terms of parts per billion. Under these circumstances "minor" errors could have significant implications.

Minimum sampling error

Since it is neither necessary nor desirable to monitor all possible developments in the project area, sample surveys are essential. Lake management covers numerous issues and diverse disciplines, and accordingly there is no straightforward or uniform solution as to what may constitute suitable sample size. For example, for analyses of rainfall, one rain gauge per square kilometer will be considered to be a very dense network, and thus totally unnecessary unless very exceptional circumstances warrant it. In contrast, the identical sample size would be totally unacceptable to sociologists. In the final analysis, determination of sample size will depend upon the type of information to be collected, and the use that will be made of it.

Absence of Bias

Monitoring of lakes often suffers from biases of people performing the task. This happens because monitors, often due to their disciplinary orientation, expertise and past experiences, may have the tendency to concentrate on specific issues at the cost of other issues which may be of similar importance. For example, a common bias often is to concentrate on limnological factors and not other issues.

It should be noted that in a real world, an issue is an issue. It is often labelled limnological, engineering, economic, social or legal depending upon an individual's discipline, experience, and ways and means of approaching it. Thus, ideally, monitoring should be carried out by multidisciplinary people, who may specialize in one discipline but are knowledgeable in other disciplines. They should be flexible, observant, sensitive, eclectic and constructive. They should be capable of intermixing freely and questioning sympathetically and inventively. Since, in reality, such qualified and experienced individuals are very difficult to find, one may have to depend on who is available. To a certain extent, the problem can be resolved by carefully choosing a multidisciplinary team, which may offset biases of individual members by the juxtaposition of the insights of various disciplines. However, it should be noted that past experiences indicate that use of multidisciplinary teams for monitoring of lakes, where team members are not familiar or do not have established working relationships with each other, generally do not produce an integrated multidisciplinary approach.

Identification of Users of Information

If the results of any monitoring are to be actually used, it is necessary to identify who are going to be the users of the information and their information requirements before designing a monitoring sytem. At the different levels of management, the hierarchy of information needs is different. For example, at a certain level of management, detailed information on a specific aspect of an irrigated agriculture project may be necessary, whereas at other levels (generally higher), aggregated information may be required. It is necessary that the right type of information is provided to the appropriate levels.

For any utilization-focused monitoring, after identification of relevant information users, it is desirable to 1) actively involve the users in ways that would increase their commitment to the utilitzation of evaluation finds; 2) train users to increase their understanding of evaluation and make it possible for them to play a useful role in the evaluation process; and 3) provide genuinely useful information to the users so as to reinforce their future commitments to evaluation.

Trade-off between the Requirements

The principal requirements discussed above should not be considered individually in isolation since some may reinforce each other and thus are mutually supportive but others may be in conflict. The quality of any monitoring system is determined by not any one of the requirements but rather how effectively all these factors are integrated in one system. For example, there is always a trade-off between maximum coverage, minimum sampling error and cost, and these trade-off decisions are generally case specific. There is no one single universal clear-cut solution.

3.2.4 FRAMEWORK FOR LAKE MONITORING

Monitoring of lakes is a complex process since a large number of regular and specific tasks have to be performed, both concurrently and sequentially, in a coordinated manner, by a variety of professions, within available expertise, time and resources. Thus, designing an efficient lake monitoring system, and making it work properly on a continuing basis is a complex task under the best of circumstances.

One important issue is worth pointing out here. This pertains to the physical boundary within which monitoring should be carried out. While lake boundaries may be comparatively easy to define, they may not be the boundaries within which all monitoring efforts should be confined for sound lake management. This is because what happens outside the lake boundaries may have direct impacts on the quantity and quality of water available and lake productivity. For example, if land use patterns around a lake change, and increasing emphasis is given to agricultural activites, part of the runoff which normally used to reach the lake, may have to be diverted for irrigating crops. Equally, water from the lake may have to be used for irrigation. This could mean that the water balance of the lake would change radically. In addition, increasing agricultural activities around a lake would mean accelerating use of fertilizers and pesticides, a significant part of which may leach to the lake water. This could increase the eutrophication problem, and water use for domestic consumption may have to be curtailed. This type of information, which is from outside the lake boundary, is necessary for sustainable lake management. Thus, it is not an easy task to define the boundary within which lake monitoring should be confined.

In terms of rational lake monitoring, no one single system can be proposed that would be valid for all lakes anywhere in the world. It is thus essential that an effective monitoring system be desigend for each specific lake based on the requirements discussed earlier. Overall, however, four interrelated levels of a monitoring framework can be proposed, which naturally would have to be somewhat general. Within this conceptual framework, managers of each lake should develop their own specific monitoring system in terms of identification of the parameters that need to be monitored, and frequencies and locations of monitoring each parameter.

Within this overall context, the following four levels of lake monitoring should be considered:

1) water quantity monitoring;
2) water quality monitoring;
3) biological monitoring; and
4) environmental monitoring.

Three important aspects should be noted. First, the four levels of monitoring are not sequential: they are generally simultaneous. Second, these levels are interrelated. For example, quantity of water has a direct bearing on water quality, and water quality parameters are likely to have direct impact on biological and environmental factors, and vice versa. Third, for many parameters, there could be seasonal, or in some cases even diurnal variations. It is thus essential that the monitoring system designed should be able to specifically consider such variations.

Water quantity monitoring

For both natural and man-made lakes, monitoring of appropriate variables like inflows to a lake, outflows, water withdrawals and losses from the lake, and water levels need to be monitored. A clear knowledge and understanding of the lake water balance is essential for its sustainable management.

Of all the four levels, water quantity monitoring is generally the most simple and straightforward. The number of variables involved is not only easily identifiable but is also limited. The monitoring techniques are fairly simple, which means that they can be carried out with limited expertise. Expensive equipment and a fully-equipped laboratory are not necessary. For these reasons, some form of water quantity monitoring for the most part is generally carried out for many lakes.

Water quality monitoring

Water quality monitoring is significantly more complex than water quantity monitoring for many reasons. First and foremost is the fact that the potential number of water quality parameters that could be monitored are numerous. Literally it is not possible to put an upper limit to the number of water quality parameters that could be monitored. This is because the number of man-made chemicals and other products is increasing exponentially. For example, if only pesticides are considered, prior to 1939, only a few natural products like derris, pyrethrum pand nicotine were used along with largely inorganic counpounds such as lead arsenate, sodium arsenite, copper in various forms, sulphur and mercury. In 1950, the British Ministry of Agriculture, Fisheries and Food had in its Approvals List of pesticies fifteen chemicals, used in nearly 300 formulations. By 1975, the number of chemicals used had increased to 200, and the number of formulations to just over 600. At present there are over 600 chemicals and more than 1800 formulations. Since pesticides would leach into any lake around which modern agriculture is practised, the number of pesticide parameters alone that could be monitored could theoretically run into hundreds. Monitoring such a large number of pesticides would undoubtedly be a very expensive and time-consuming task. Furthermore, such indiscriminate monitoring will not be a cost-effective process. Hence, considerable thought must be given to which pesticides should be monitored and how often. Some criteria have to be developed on the basis of which such rational decisions could be taken. For example, one criterion could be the identification of major pesticides which are used extensively around a lake. Thus, in contrast to water quantity monitoring, where the choice of parameters to be monitored are almost automatic, water quality parameters that should be monitored have to be carefully selected.

Secondly, there is a time dimension to the parameters that needs to be monitored. Because of the changing patterns of use of chemicals and other compounds, and since type of industry and effluents produced in an area generally vary with time, the list of water quality parameters that need to be monitored should be reviewed periodically. Often some new parameters have to be added to the list, and equally some old ones may have to be deleted. Thus, the water quality monitoring process is not as simple or automatic as water quantity monitoring: it requires significantly more thinking and deliberation.

Thirdly, collection and analysis of water quality data requires considerable expertise, resources and time. Expensive equipment in a functional laboratory is an indispensible requirement. This often becomes a serious problem in most developing countries, where availability of trained manpower, adequate resources and sophisticated equipment are serious constraints. Equally maintenance of complex analytical equipment due to lack of spare parts, foreign exchange and trained repairers is generally a serious problem, which often disrupts the continuity of the monitoring process.

There are certain water quality paramenters which need to be monitored for nearly all lakes that need to be managed. Among these are dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), pH, temperature, coliform, P and N.

Biological monitoring

Biological monitoring can provide information on the overall status of the aquatic ecosystem of a lake as a whole since aquatic organisms can integrate the various factors affecting their surrounding environment. Accordingly, biological monitoring, if carefully designed and carried out, could be an important component of any lake management information system.

There are, however, a wide range of organisms and communities which could be included in biological monitoring of lakes. For example, information on planktons could be important to assess the quality of lentic systems. Benthic macro-invertebrates are preferred for lotic systems since they have limited mobility and thus are comparatively easy to sample Equally they cover large number of species which are differentially sensitive to water quality.

Monitoring of fish populations should be an integral part of any effective lake management for two important reasons. First, both natural and man-made lakes are important sources of food in terms of fish catch, especially in developing countries where protein consumption is generally low. Thus, managing a lake efficiently often requires maximizing fish catch on a sustainable basis. Second, fish act as bio-accumulators of many undesirable contaminants, and thus could be used as a proxy for the overall problem.

In order to integrate various biological parameters, some indices like a diversity index have been proposed by some scientists. However, none of the indices proposed satisfactorily provide a summary of the biological parameters that are monitored in a lake. Accordingly, use of any index is of very limited value to lake management.

Environmental monitoring

Many environmental parameters may have to be monitored for a lake. The decision as to which parameters should be monitored can be taken in the context of only a specific lake. This would require identification of environmental parameters that are important for the management of the lake concerned.

For example, if the lake is in a geographical region where vectors of water-borne diseases like schistosomiasis, malaria, filariasis or onchocerciasis could be present, it would be essential to institute a monitoring system which will provide appropriate information to managers in order that disease incidents could be under control. Equally, if a specific health issue is not a concern in an area, there is not much point to using scarce resources for wasteful monitoring. For example, for any lake in India, it is totally unnecessary to have a monitoring system that considers schistosomiasis, since it does not occur in the country. However, if a monitoring system is to be designed for a lake in Kenya, Brizil or in southern Africa, where schistosomiasis is prevalent, it must be monitored.

3.2.5 CONCLUDING REMARKS

Monitoring is an integral component for management of any lake. However, this does not mean that if monitoring is carried out, efficiency of lake management will be automatically improved. In fact, on the basis of a review of lake monitoring carried out in many parts of the world, it can be said that the general situation appears to be that monitoring is having far less impact on lake management processes than expected or even possible.

There are many reasons for this unfortunate state of affairs. One of the main reasons for this is that often parameters that are monitored may not be the most important ones on which managers would like information. Scientists often monitor what they wish to monitor in terms of their need for scientific research, and not what the managers would like to see monitored. Equally, the managers may not receive the monitored information in a form that would facilitate decision-making, or may not receive required information in a timely and regular manner.

If a cost-effective monitoring system can be designed for lakes that specifically addresses the interests of managers, then unquestionably the present status of lake management can be improved substantially.

SECTION 3.3

INTEGRATED LAND-WATER SYSTEMS AND THEIR POSSIBLE MODERN APPLICATION

by Heinz Loffler

3.3.1. INTRODUCTION

Integrated land-water systems represent zones where interaction exists between terrestrial and aquatic components as represented, for example, by lake pastures where aquatic plants are grazed by cattle, horses and other livestock. Very often they are typical of the so-called ecotones which are the marginal zones of ecological units such as ecosystems and in this context very often for example the littoral zones of stagnant or running water. In a more sophisticated way they comprise the cycling of aquatic and terrestrial compounds as exemplified by the mulberry dike - carp pond resources systems in China.

Many of the integrated land-water systems have an old tradition and have developed along with irrigation, the culture of paddies (at least since 6,000 years B.C.) and marsh cultures like the most sophisticated one of the Marsh Arabs in the Shatt el Arab Region. Most recently many of the old integrated systems have increasingly attracted general interest and in addition new devices of integrated land-water systems have been established. In this section an overview of relevant activities will be given.

3.3.2 LAKE- AND MARSH-PASTURES AND THE MARSH ARABS

The use of aquatic plants for livestock has a long tradition in semi-arid and arid areas but has been given only little attention in recent times. A paradigmatic example of this kind is offered by the highly unstable Hamun Lake in the eastern Persian province of Seistan and expanding into Afghanistan. In this shallow lake, area of 4000km^2, and its catchment area, the culture of the "Gaw-dars" (cow-herdsmen) developed some thousand years ago. A variety of aquatic macrophytes, cattail (Typha sp.) presents the main source of nutrition for cattle (zebus). It is also used for the construction of huts, for thatching, rafts ("tutins"), mats etc. As fodder for livestock it is usually harvested and transported to villages by the rafts. On the other hand, the herds may at times be driven to the macrophyte stands (Loffler, 1956). In addition, fishery plays a major role in Hamun Lake with Schizothorax sp. being the main species (300 - 500 metric tons per year). At present the water budget of the lake is greatly affected by the use of water from its main inflow, the Hilmand-Rud, for irrigation.

Similarly the luxuriant submerged vegetation in the shallow lakes ("lagunas") of the Titicaca-area are an important pasture for cattle during the dry season when fodder resources are restricted to these aquatic sites (Loffler, 1968).

Most recently (Nörthcote et al., 1989) the socio-economic importance of the macrophytes in Lake Titicaca itself (Puno Bay and the shallow parts of Lago Pequeno) have been analyzed. The following section is an extract of the chapter on the socio-economic importance of macrophyte extraction in Puno Bay by Levieil et al. (in Northcote et al., 1989). Shore dwellers find the so-called "llachu" (mainly submerged macrophytes such as Elodea potamogeton, Myriophyllum elatinoides and Potamogeton strictus) most useful as livestock fodder and sometimes for handicrafts (e.g. mattress stuffing) or as fuel. Livestock may graze directly on "llachu" growing in water less than one meter deep from July to February (sometimes August to January) when there is no grazing left in the terrestrial pasture land.

Sometimes the "llachu" is harvested directly or from a boat. "Llachu" harvesting is open to all shore dwellers; however, the "llachu" beds are divided into zones and belong to different shore communities. Among "llachu", Elodea is considered the best fodder. Its dry matter contains 15-29% protein. Obviously the algae (periphyton) growing on them may contribute to its nutritive value. Apart from "llachu", the totora bulrush (Scirpus tatora) is used as "totora verde" for livestock fodder and harvested in much the same manner as "llachu" except that livestock are never allowed to enter the totora beds in order to avoid any damage by trampling. The exploitation of totora, unlike that of "llachu", is severely restricted and most totora plots are privately owned.

Transplanting and sowing of S. tatora takes place to a certain extent and may become intensified in the future. Due to its digestibility and protein content (9-15% of dry weight) totora verde is a good fodder which is easier to transport (e.g. as rafts) than "llachu". "Totora amarilla", the maturation stage of S. tatora, is used for the construction of boats ("balsas") similar to the "tutins" of Hamun Lake, for mattresses, mats and roofing. After its harvest and before its use it is left to dry in the sun for one or two weeks. Over the last decades, due possibly to the increased demand for "totora verde", "balsas" and mattresses it is increasingly difficult to find good quality "totora amarilla" in Puno Bay. In addition to totora verde and amarilla, the rhizomes of S. tatora ("sacca" and "siphi", young and tender and mature rhizomes respectively) as well as its stalk base serve as food resources for people at the end of the dry season. Finally, in dry years when the lake level is down, the exposed totora plots are tilled: the preparation of the rhizome areas for this procedure is usually done by pigs and the mixture of mud, rhizomes and decaying organic matter, called "kille", if dried, floats on the surface of the lake. Large chunks of "kille" are the raw material of the well known floating islands of the Uros. Otherwise "kille" serves as organic fertilizer.

Both "totora" and "llachu" contribute greatly to the productivity of Lake Titicaca. They provide a substrate and protection for eggs and young fish. Birds, particularly ducks, also consume several species of macrophytes and almost all feed on invertebrates that live in the "llachu" and "totora " beds. On the other hand, both fish and birds contribute to the economy and diet of shoreline communities, particularly that of the inhabitants of the Uros islands.

Aquatic pastures for terrestrial livestock of the kind described above exist in many regions but virtually nothing is known about their origin and traditional roots. Quite a few of them could have derived from Arab traditions (in the cases of Titicaca via the Spanish Conquistadors) but many probably came about accidentally. The Pulvar Lake marsh area in Southern Iran, a vast valley obviously dammed by a land-slide, may belong to the latter group. All these cases suggest that the improvement of existing technology at sites of this kind and the establishment of new aquatic pastures are highly desirable especially in semi-arid regions and at the same time, with respect to their construction, rather economic.

To some extent the large marshes of the lower Euphrates, Tigris and Shatt el Arab may also be considered as an aquatic river-lake pasture system used mainly for water buffaloes. In this region, however, it is the most sophisticated reed culture existing on our planet and created by the Marsh Arabs which dominates. With the design of different buildings such as the "raba", the "sarifa" and the "mudhif" built of reeds and matting (Thesiger, 1964) it is an example of an old and outstanding amphibic lifestyle.

Rice cultivation is believed to have originated in Southeast Asia 6,000- 8,000 years ago, dispersed independently in West Africa much later and only recently has developed in the temperate zones of Europe. At present the total area amounts to about 1.5 million km^2, and contributes to the cultivation of other aquatic plants, fish-ponds, ponds for recreation etc., as man-made wetlands. Obviously, from the earliest onset of these activities man took advantage of the animals which became abundant in these artificial ecosystems. These included certain insects (e.g. Dytiscus sp., Belostoma sp., etc.), shrimps, fish, amphibians, reptiles, birds and mammals. In particular, fishery (some thirty species are involved) in combination with rice cultivation was given increasing attention.

It is most likely that the so-called "Minipadi" system in Western Java has evolved to the highest level of such combined activities including dams for terrestrial cultivation (Ruddle, 1980). The concurrent cultivation of rice and fish results in two crops of rice and eight harvests of fish (mainly fry and fingerlings of carp (Cyprinus carpio) but also a few other species). This system is strongly linked with fish and pond production: six of the harvests resulting from rice field activities such as field preparation and flooding, including the repair of dikes and ditches for fish culture, serve for pool stocking whereas the last two harvests serve as table fish for both household consumption and sale. The latter fish harvests take place during the weeding processes and the first harvest of rice. The last fish yield amounts to about 80-100 kg-ha which corresponds roughly to US $ 80.

Another system in Indonesia, again in West Java, is the "Surjan". This system puts more importance on the dikes which here are wider, in order to support dryland crops such as beans, chili peppers, and cucurbits. In contrast to the minipadi, polycultural fish production is practiced in the surjan (Cyprinus carpio, Barbus goniotus, Oreochromus mossambicus, Clarias batrachus etc.) (Ruddle, 1980).

Ruddle (1980) claims that in addition to economic and dietary benefits to the farm household and the use of more available niches -- despite higher input costs -- the joint cultivation of rice and fish in paddies generally enhances both the yield of rice and fish.

The author also points out that there are certain aspects of rice technology which are inimical to fish raising, and vice versa some facets of fish cultivation that are detrimental to the rice crop. Among the risks for fish, pesticides of various kinds, high N application and the selection of fast-growing rice (105-125 instead of 160 days) may be mentioned. On the other hand, fish sometimes damage young rice plants though normally rice yields improve if fish are present and even more under polyculture of fish species (Ruddle, 1980). Among others, improved aeration and increased soil fertility enhanced by the decomposition of fish excrement contribute to increased rice yields.

At present, the principal constraints for fish cultivation in paddies are the toxic agricultural chemicals and of course -- very often so -- the provision of a regular water supply (Ruddle, 1980).

As a consequence of these constraints a decline in the area and productivity of rice field fisheries is observable throughout Southeast Asia. In response, and despite greater investment required, the importance of freshwater fishponds has been increasing although in many cases pond and paddy field culture of fish still play their complementary role (Ruddle, 1980). It is hoped therefore that in the future rice-fish-terrestrial plant systems will be given more adequate attention.

If the hydrological features of a river (low and high water levels) tend to be similar, the establishment of paddies within a floodplain is a common practice. A good example of this is the inner delta of the Niger where, before the impact of irrigation projects, the paddy yields amounted to 235 g/100 m3 of water (Drijver and Marchand, 1986). After upstream damming and increased irrigation, not only was the water volume available for flooding but also the timing and duration of floods profoundly changed. Although the paddy harvests went up to 5,000 g/100 m3 of water, other essential resources were lost. Cattle herds, which came from distances of more 200 km to survive on the former grassland available during the dry season in the floodplain, can no longer be supported there on a full scale. Likewise, the well-adapted floodplain agriculture no longer functions. Thus, for example, a special type of sorghum was planted at the end of the flooding: the fast-growing roots of this sorghum variety are able to follow the rapidly-receding water table down to 2.5m. The fishery suffered even more disturbance during the onset of the flooding and when the water was draining back. Fishing during these periods needed a minimum of effort and investment. Drijver and Marchand (1986) demonstrated impressively that, despite increased rice production, due to the loss of meat, milk (migrating cattle herds) and fish the net margin of profit per 100 m^3 was \$0.49, but due to the costs of construction and interest this value was distinctly less (- \$0.77). Moreover the increased paddy area attracted the immigration of people and therefore led to intolerable deforestation.

In 1953, a new type of integrated system was introduced in the area of Szarvas. In order to economically use the solontchak (salt-soil) plains, which were otherwise known for their high ecological value, large parts of them were flooded and stocked

with fish (Cyprinus carpio, Ctenopharyngodon idella, Hypophthalmichthys molitrix and a few Siluris glanis). The fingerlings are then put into ponds until fall when they are transferred to hibernation basins where they finally gain their selling weight of about 1 kg. In this way, 300-350 t/ha of fish can be produced annually. During the time when the ponds are stocked with fish, ducks and chickens are put into the ponds to attain their selling weight of 3kg after 48 days. The total amount of yield per year attains some 1,000 kg/ha.

After five years' use, the lakes are drained and the improved soil is now ready for an agricultural period of four years. During the first season it is used for corn, clover, etc., part of which is used for fish food and fertilizing. Afterwards three seasons serve for rice cultivation. The planting of young rice is performed under dry conditions during the middle of April. Afterwards the water level is kept at approximately 10 cm. After the drainage of the paddies, the harvest of rice is carried out at the beginning of September, and the yield may amount to 3 t/ha per year. After these agricultural activities another fish-duck season is introduced. Meanwhile this type of integrated system has also been successfully introduced in CSFR.

All of the integrated systems mentioned so far have been evolved in the Old World. There exists, however, a great variety of wetlands, one example of which is the tree swamp type in North America whose potential has not been fully used yet. Protein harvest, timber improvement of water quality as a consequence of slowly growing trees, and flood/storm absorption are only a few items which make those tree swamps extremely important sites (Odum, 1982; Day et al., 1982; Patten and Matis, 1982). Terrestrial and aquatic components abound in these systems, which in Europe have almost completely disappeared. However, the optimum strategy for ecological as well as economic design has not yet been achieved for most of these North American tree swamps, which present a valuable potential.

In contrast to the tree swamps of USA and Canada, the "Chinampa" system (derived from twigs, brushwood and faggots) was developed during the pre-Colombian time in Mexico, and not only still is in existence but has become one of the important MaB activities and is expanding at proper sites. The latter comprise mainly fens and generally minerotrophic wetlands very often in the neighbourhood of lakes and rivers. Small lots of land are confined by channels whose walls are consolidated with twigs, poles etc. The excavated material is to raise the level of the lots and at the same time fertilization is provided by the channel material. The channels provide for transportation and fishery whereas the chinampas serve for a variety of vegetables such as beans, spinach, corn and others. The yield of the different agricultural

products is generally high. Thus about 54 t/ha of celery could be harvested after 150 days. Some of the chinampas are located in wet tropical forests, which offer additional technologies; some others -- as already mentioned -- are close to the rivers which allows for additional irrigation. Obviously the chinampa system can be applied in any proper area within the tropics.

The last example is devoted to one of the most reknowned integrated systems, the mulberry dike - carp pond resource system of the Zhujiang (Pearl River) Delta in Southern China (Ruddle et al., 1983; Ruddle, 1985a; Ruddle, 1985b; Guangzhou Intst. Geogr., 1980; Chung Kung-Fu, 1979; Luo Kaifu et al., 1980).

In China different types of wetlands cover an area of approximately 100,000 km^2 (= 165 million mu) (Huang Xichou, 1980). Many of these wetlands still have their natural character, but quite a lot have been transformed into grazing land by means of drainage. In contrast to these simple types of reclamation the Zhujiang Delta of South China is an example of an old established and elaborated integrated system, which has evolved over the last two millennia and is operated on a geographic and economic scale unmatched elsewhere in the world (Ruddle, 1985). The system covers an area of approximately 1,600 km^2 and supports an estimated population of 1.3 million people. About 290 km^2 are occupied by fishponds and about 130 km^2 provide for plantations of mulberry trees, sugar cane, rice and others like vegetables and mushrooms. The fishpond system came into existence only shortly after the T'ang Dynasty whereas silk cultivation has existed at least since the Han Dynasty.

The size of the dams varies between 0.2 and 0.5 ha and their depth between 2-3 m. The dams rise above the pond level from 0.5 to 1.0 m and their breadth attains 6-20 m. Mulberry leaves are harvested eight or nine times during a year and their yield amounts to 30, sometimes even up to 75 t wet weight/ha/year. With this food for the silk worms (Bombyx mori) available 2-5t/ha can be collected annually. Wastes from the silk worm culture, agriculture and households are dumped into the ponds and excessive sediment from the ponds is returned as fertilizer to the dams. In order to achieve a maximum yield of fish the ponds are stocked with china carps and Cyprinus carpio, which prefer different food resources. For the upper layer of the pond mainly bigheads (Hypophthalmichthys) and striped bigheads (Aristichthys nobilis) are applied. In the deeper parts it is mainly grass carp (Ctenopharyngodon idella) whereas the bottom resources are mainly used by carp (Cyprinus carpio).

3.3.4 CONCLUSIONS

In summarizing, it becomes obvious that many of the old integrated systems (very often the ecotone type) have been almost forgotten or not given proper attention. The few examples mentioned are only a fraction of the integrated systems which will increasingly play an important ecological and economic role.

It should, however, not be forgotten that many of the integrated systems involve health risks. Thus in Puno Bay diarrhea diseases are of concern, and fishes of Puno Bay in general have rich parasitic fauna. A survey of 159 shore-dwelling families within the city of Puno showed that nearly a third of these were tested positive for intestinal helminthiasis (census March 1983; Sanchez et al., 1989). Much less is known about Lake Hamun, which sometimes becomes rather alkaline and consequently poor in vectors like snails. In paddies the increasing application of pesticides is a major obstacle with respect to the use of fish and other animals. Since, however, many of the integrated systems can be controlled with respect to waterborne diseases the variety of health risks may be reduced by chemical treatment of rice fields. Hopefully new and less harmful technologies may be developed in the near future.

REFERENCES

Auble, G.T., Patten, B.C., Bosserman, R.W., and Hamilton, D.B. 1982. A Hierarchical Model to Organize Integrated Research on the Okefenokee Swamp. Proceedings of the International Scientific Workshop 2 on Ecosystem Dynamics in Freshwater Wetlands and Shallow Water Bodies. Moscow. pp. 203-218.

Chung Kung-fu. 1979. Mulberry-dike-Fish-Pond on the Pearl River Delta, a complete artificial ecosystem of land-water interaction. Kwangchow Inst. Geogr. p. 18.

Day, J.W., Sklar, F.H., Hopkinson, C.S., Kemp, G.P. and Conner, W.H. 1982. Ecosystem dynamics in wetlands and shallow water bodies 2: 73-105.

Drijver, C.A. and Marchand, M. 1986. Taming the floods: environmental aspects of floodplain development in Africa. Nature and Resources 22: 13-22.

Levieil, D., Cutipa, Q.C., Goyzueta, C.G., and Paz, F.P. 1989. The Socio-Economic Importance of Macrophyte Extraction in Puno Bay. In Northcote, T.G., Morales, P.S., Levy, D.A. and Greaven, M.S. Pollution in Lake Titicaca, Peru: Training, Research and Management. Westwater Research Centre, The University of British Columbia. p. 262.

Loffler, H. 1968. Geo-Ecology of the Mountainous Regions of the Tropical Americas. Coll. Geogr.: 57-76.

Loffler, H. 1961. Beitrage zur Kenntnis der Iranischen Binnengewasser II. Int. Rev. Hydrobiol. 46: 309-406.

Luo, K., Gongfu, Z., Hanzeng, D., Houshui, W., Yuyou, D. and Daojin, C. 1980. Background to the Utilization of the dike-Pond Areas of the Zhujiang (Pearl River) Delta, China. Guangzhou Inst. Geogr.: 1-33.

Northcote, T.G., Morales, P.S., Levy, D.A. and Greaven, M.S. 1989. Pollution in Lake Titicaca, Peru: Training, Research and Management. Westwater Research Centre, The University of British Columbia.

Odum, H.T. 1982. Role of Wetland Ecosystems in the Landscape of Florida. Proceedings of the International Scientific Workshop 2 on Ecosystem Dynamics in Freshwater Wetlands and Shallow Water Bodies. Moscow. pp. 33-73.

Patten, B.C. and Matis, J.H. 1989. The Macrohydrology of Okefenokee Swamp. In Northcote, T.G., Morales, P.S., Levy, D.A. and Greaven, M.S. 1989. Pollution in Lake Titicaca, Peru: Training, Research and Management. Westwater Research Centre, The University of British Columbia. pp. 216-236.

Rivera, C.R., Levy, K.H., Chuquimia, H.E., Llanque, E., and Zavala, F. 1989. Sanitation and Public Health in Puno. In Northcote, T.G., Morales, P.S., Levy, D.A. and Greaven, M.S. 1989. Pollution in Lake Titicaca, Peru: Training, Research and Management. Westwater Research Centre, The University of British Columbia. pp. 207-218.

Ruddle, K. 1980. A Preliminary Survey of Fish Cultivation in Ricefields, with Special Reference to West Java, Indonesia. Bull. Nat. Mus. Ethnol. 5: 801-822. Ruddle, K. 1985. Rural Reforms and Household Economics in the Dike-Pond Area of the Zhujiang Delta, China. Bull. Nat. Mus. Ethnol. 10: 1145- 1174.

Ruddle, K., Furtado, J.I., Zhong, G.F., and Deng, H.Z. 1983. The mulberry dike-carp pond resource system of the Zhujiang (Pearl River) Delta, People's Republic of China: I. Environmental context and system overview. Applied Geog. 3: 45-62.

Temprosa, R.M. and Shehadeh, Z.H. 1980. Preliminary Bibliography of Rice-Fish Culture. Bibliographies 1. International Center for Living Aquatic Resources Management. pp. 1-20.

Xichou, H. An Outline of China's Marshes. Changchun Inst. of Geog. Acad. Senica. pp. 1-15.

SECTION 3.4

ECONOMIC ANALYSIS OF WATER RESOURCE DEVELOPMENT

J.A. Dixon

3.4.1. INTRODUCTION

Economic analysis of water resource development within the context of lake/reservoir management is concerned with the analysis of alternatives and the allocation of costs. Consider a dam and its reservoir. Economics plays a major role in the initial decision on whether or not to construct a dam, where to locate it, how to construct it, how big to build it, and how to operate the associated reservoir. The techniques of project analysis, usually some form of social benefit/cost analysis (B/CA) or cost-effectiveness analysis, are used to assess the initial design options.

Once built, however, a dam is a classic case of what economists call a "sunk cost"; the dam cannot be moved and probably has no alternative use other than impounding water. How the dam and reservoir are managed, however, is an important variable and economic analysis can play a useful role in this process.

A natural lake is also a fixed asset. Other than draining it, a lake is not easily changed, although its water can be polluted and degraded or used in various ways and at different rates.

However, whether man-made or natural, management of both lakes and reservoirs has many common features in terms of purpose of use and environmental effects. Although ex-ante economic analysis of major investments is primarily relevant to dams and their associated reservoirs, economic analysis of operation and maintenance is common to both reservoirs and lakes.

This section considers economic analysis of water resource developments including both dams/reservoirs and lakes. In particular, the environmental dimensions will be emphasized and how these aspects can be handled within an economic analysis. Broader issues of multiple objective analysis are covered in Section 3.1, Water resource management: planning and implementation.

3.4.2 ANALYSIS OF INVESTMENT DECISIONS

The economic analysis of major capital projects like dams is a well-developed technique. Whenever such major investments are undertaken it is important that careful estimates be made of expected benefits and costs. Dams are public investments made to serve multiple purposes including irrigation, water supply, flood control, navigation, and hydropower generation. Public decisions should be analyzed in a social benefit/cost analysis (B/CA) framework, rather than in a financial analysis of private return that is appropriate for individual decisions. The social B/CA uses measures of social costs and social benefits to analyze alternative projects, design formulations, or management strategies. This approach is therefore an integral part of the planning process as shown in Fig. 3.1.4 on planning and management activities. The mechanics of this approach are found in standard references including the UNIDO Guidelines (1972), Little and Mirrlees (1974), Squire and van der Tak (1975), Gittinger (1982), and Dixon and Hufschmidt (1986).

It is not possible to present the details of project analysis here. Dams are frequently mega-projects costing hundreds of millions, if not billions of dollars and often take years to plan, design and construct. Anticipated benefits may or may not be realized depending on changes in demand; prices of both inputs to the project and the desired outputs may change in the interval between analysis and project implementation.

Because of the long time horizon over which these projects are implemented, therefore, it is important that sensitivity analysis be carried out on key parameters to see how a change in a parameter will affect the economic viability of the project. For example, if a dam is designed primarily for hydropower generation, sensitivity analysis could be done on both the future price for electricity (higher? lower? than initially forecast) and on the future seasonal availability of water in the reservoir. These are commonsensical suggestions that are usually done as part of the analysis of any dam projects.

There may also be important environmental or resource effects associated with dams that need to be taken into consideration. These impacts can take place above the dam/reservoir, at the dam itself, or downstream. When they are beneficial these impacts should be included as benefits in the social welfare analysis of the project; when they are harmful they need to be included in the costs of the activity.

Environmental and resource impacts are important considerations both before construction begins, and in the management of existing facilities or lakes. A recent World Bank Technical Paper, Dams and the Environment: Considerations in World Bank Projects (1989), discusses the economic and environmental issues involved.

Fig. 3.4.1 presents the chain of main events related to storage dams and the environment. A number of upstream events are listed as "effect of the environment on the reservoir"; most of the impacts occur in the dam or reservoir/lake site or on the downstream "service areas", in this case irrigation, domestic and industrial water supply, and power.

Each of these effects or impacts has associated consequences (also indicated in Fig. 3.4.1). These consequences can frequently be valued in monetary terms, and hence economics enters the picture. The valuation of environmental effects of dams and their reservoirs is discussed next. Although some of these effects are unique to dams, many are also encountered in the management of lakes.

3.4.3 ECONOMIC ANALYSIS OF ENVIRONMENTAL EFFECTS OF STORAGE DAMS AND RESERVOIR/LAKE MANAGEMENT

A traditional economic analysis of a dam project includes the construction and operation, maintenance, and replacement (OM and R) costs as well as the expected benefits in terms of hydropower generated, irrigation water provided, flood damages averted, and water supplied for domestic and industrial use. In some cases, recreational and fisheries benefits may be important. In addition, there are associated environmental and resource costs and benefits that must also be taken into account.

The logic for a wider analysis has several dimensions. First, given the key position of a dam in a regional investment strategy and of a lake as a regional resource, it is prudent to safeguard such investments and resources by taking appropriate actions to prevent loss of direct project benefits -- the water and power provided by the dam or lake. Fig. 3.4.1 present environmental factors both caused by the dam and that affect its

S T O R A G E   D A M S   A N D   T H E   E N V I R O N M E N T

CHAIN OF MAIN EVENTS

EFFECT OF ENVIRONMENT ON THE RESERVOIR

EFFECTS	CONSEQUESCES
- Precipitation	- Run-off (for storage) with extreme events of floods & low flows
- Soil erosion	- Siltation of reservoir and outlet - Blockage.
- Pollutant & natural chemicals	- Deterioration of water quality
- Aquatic life & waterfowl	- Settlement on reservoir
- Evaporation	- Water loss
- Climate	- Low temperature water inflows
- Debris	- Outlet blockage.

RESERVOIR

EFFECT OF THE RESERVOIR AND ITS STORAGE FUNCTION ON THE ENVIRONMENT

EFFECTS	CONSEQUENCES
- Smaller variation in downstream streamflows	- More plentiful and reliable supplies of water; less flood damage; lower after-flood crop production; less flood plain fisheries; more/less estuarial salinity depending on topography. less bank erosion.
- Lower silt content of water	- Lower cost of water management; downstream erosion.
- Inundation of land	- Displacement of settlers; damage to fauna & flora, archaeology, and infrastructure; loss of land.
- Creation of lake/pond	- Recreation; new fisheries; better animal watering but disruption of migration routes; eutrophication.
- Creation of gravity head	- Command of irrigable land; potential power production.
- Lower flows downstream	- More esturarial salinity (in extreme cases).
- Temperature	- Better conditions for users (warmer water, less frazzle ice).
- Interception of river	- Interference with fish migration.
- Inundation of forests	- Poor water quality for potable purposes.
- Induced seismicity	- Induced landslides.
- Reservoir drawdown	- Dry season cropping/grazing.
- Subterranean leakage	- Rise in groudwater.
- Construction activity	- Economic development; environmental change.

SECONDARY EFFECTS ON "SERVICE AREAS" AND SYSTEMS DOWNSTREAM

IRRIGATION

EFFECTS	CONSEQUENCES
- Lower silt content in water	- Lower DAM cost; better water management leading to less water logging. - Changes in fauna and flora.
- More regular supply of water	- Adoption of perennial in place of non-perennial irrigation with better crop production. - Expansion of irrigated area. - Better control of some pests and diseases; less control over others.
- Additional water supply	- More waterlogging but, with good management, better salinity control.
- Gravity supply to irrigation system(where feasible)	- Lower energy consumption.
- Regulated river flows	- Lower pumping costs.

Note: Almost all storage dams supplement water supplies to existing run-off-river systems.

DOMESTIC & INDUSTRIAL WATER SUPPLY

EFFECTS	CONSEQUENCES
- More reliable supplies **	- Less failures and less rationing hence better public health control. - Better repulsion of salt intrusion in estuaries giving more sustainable rural water supplies.
- Lower biological quality *	- Higher treatment cost.
- Higher chemical quality *	- Lower treatment cost.
- Wider spatial availability of water **	- Less concentration of urban areas and industries.
- Poorer taste* **	- Higher treatment cost.
- Lower silt content **	- Lower treatment cost.

Note: * compared with groudwater
** compared with run-of-river

POWER

EFFECTS	CONSEQUENCES
- Non-thermal energy production	- Displaces fossil fuel and nuclear power and their associated environ-mental effect.
- Renewable energy source	- Sustainable production
- Lower cost of production	- Permits special industries such as smelting - Provides low cost domestic amenities.
- Simplicity of operation	- Less failure in regions with few skilled human resources.
- Lumpy investment	- Debt burden.

Note: Treats fossil fuel and nuclear power as the alternative sources to hydroelectric (excludes tidal wave, and other sources.)

Figure 3.4.1 Chain of Main Events for Storage Dams and the Environment (from Dixon, Talbot and Le Moigne, 1989) functioning. A number of these are adverse, such as a high rate of soil erosion in the upper catchment leading to sedimentation of the reservoir or lake, and degradation of water quality. There may also be second-order effects such as soil salinization or waterlogging in newly irrigated areas or the proliferation of human parasites in perennial irrigation areas made possible through water storage. These environmental impacts directly affect the generation of project benefits over time. Since most of these are costs they reduce the financial and economic attractiveness of the project.

Similarly, any direct environmental benefits, such as a new reservoir or lake fishery, a tourism industry, or the reduction of the suspended matter content of the water, should be counted as benefits.

Second, there may be important indirect effects created by the operation of the dam and associated reservoir/lake and associated environmental impacts. Fisheries, both downstream and in coastal areas, may be hurt by changes in water quantity and quality including a lowering of water temperature. If there are migratory fish species within the river (e.g. salmon, sturgeon), their productivity or very survival may also be affected. There can also be significant indirect environmental benefits of dam/reservoir or lake operation. Changes in stream flow after dam construction can result in reduced saltwater intrusion in coastal areas, depending on how water releases are regulated. When environmental benefits occur, they should be included in the economic analysis in the same way as environmental costs.

Third, there are important social impacts chiefly associated with dams. These include the major problem of involuntary resettlement for those people living in the reservoir area and the spontaneous voluntary movement of settlers into the watershed (reservoir basin) above the dam. In-migration is often accelerated by the improved access provided during dam construction. (There are even reports of new settlement in the proposed reservoir area in hopes of receiving compensation when it is flooded.)

Other social impacts are caused by changing economic patterns as a result of dam-induced developments, both upstream and downstream. The net effect of these factors may be to increase or decrease the economic returns from the dam project.

In order to conduct a wider, more environmentally sound appraisal of dam/reservoir or lake management projects, several conditions must be met. First, it must be accepted that environmental costs and benefits are real costs and benefits that must be included in the economic analysis. Under-estimating or ignoring environmental costs is no longer acceptable. Second, the identification of the likely environmental impacts requires the skills of a mix of disciplines.

Fourth, environmental effects change over time and monitoring is required, both to evaluate on-going activities and to identify potential problem areas and take appropriate action. Ideally, monitoring must start before construction to establish baseline data. See UNEP (1989) for a discussion of monitoring and evaluation for water resource development projects.

The tools of economic analysis are well developed for carrying out standard financial and economic evaluations of dam and lake management projects. In the past two decades, much work has also been done on applying economic analysis to environmental effects of development activities (Hufschmidt et al., 1983; Dixon et al., 1988). For some categories of effects, the analysis is quite straightforward; for others, the appropriate techniques are still evolving.

Consider the case of soil erosion and reservoir/lake sedimentation. The physical processes have been extensively studied; it is know that soil erosion and sedimentation are the result of both natural and man-made processes. The costs due to lost reservoir storage capacity are also very large if live storage is curtailed. (Most dams have dead storage built into the reservoir design for storage of sediment. In fact, sediment usually affects both live and dead storage. The important question is the distribution of sediment between the two.)

In a recent World Bank technical paper on reservoir sedimentation, K. Mahmood (1987) estimated the replacement cost for lost reservoir capacity of major world dams at some $6 billion per year. While part of this lost capacity is due to natural erosion, part is created by human activities. In addition, this annual cost is expected to increase over time. As Mahmood point out, "in many basins, additional sites are hard to find, and in general, remaining sites for storage reservoirs are more difficult, and, hence, more expensive to develop."

Environmental impacts may also be a major contributing factor to construction delays or even outright cancellation of projects. Just as a heavily sedimented reservoir imposes large costs on society, a delayed or canceled project can be equally costly in terms of project benefits foregone and lost capital investment.

A proper environmental and social analysis, therefore, can help assess whether or not the benefits are larger than the costs (including environmental damages). With this analysis, some proposed projects may not prove to be socially desirable. In that case, alternative projects or management strategies should be considered in the search to find the best way of supplying the desired water and power benefits.

3.4.4 ANALYTICAL TECHNIQUES

Recent work has expanded the list of environmental or resource impacts that can be evaluated in tangible (monetary) terms and included in the economic analysis. Many of the most useful approaches rely on changes in productivity that can be valued using market prices. Table 3.4.1 lists some of the environmental aspects of dam/reservoir projects, their economic impacts (both benefits and costs) and selected valuation approaches that can be used to value them. The table does not present an exhaustive list; it is merely indicative of where one can start.

As seen in Table 3.4.1, many of the environmental effects and their economic impacts can be valued using change in productivity techniques or preventive costs or replacement costs approaches. All of these approaches rely on use of actual expenditures (or in some cases potential expenditures) valued at market prices. With proper identification of the cause-effect relationships, there is little doubt that these impacts reflect real welfare changes -- either positively, in the case of benefits, or more commonly negatively, in the case of costs.

Other approaches used to value environmental benefits and costs rely on "surrogate markets" such as the travel cost and property value approaches. Health care costs and loss of earnings techniques may be used to value health-related effects. In all cases the aim of the analysis is the same, - to properly identify likely environmental benefits or costs arising from the dam project and incorporate them into the overall economic analysis of the project. The actual process of valuation of environmental effects requires their translation into monetary terms. Considerable literature exists on the valuation process; discussion of techniques and examples are found in Sinden and Worrell (1979), Krutilla and Fisher (1982), Hufschmidt et al. (1983), Dixon and Hufschmidt (1986), Dixon et al. (1988), and Dixon et al. (1989).

Table 3.4.1
Selected Environmental Effects and their Economic Impacts

Environmental Effect	Economic Impact	Benefit (B) Cost (C)	Representative Valuation Technique
Environment on Dams			
1. Soil erosion - upstream sedimentation in reservoir	Reduced reservoir capacity, change in capacity, change in water quality, decrease in power	B,C	Change in production, preventive expenditures, replacement costs
Dams on the Environment			
1. Chemical water quality - changes in reservoir	Increased/reduced treatment cost, reduced fish catch,	B,C	Preventive expenditures, changes in production.
2. Reduction in silt load, downstream	Loss of fertilizer, reduced siltation of canals, better water control	B,C	Replacement costs, preventive expenditures avoided.
3. Water temperature changes (drop)	Reduction of crop yields (esp. rice)	C	Changes in production.
4. Health - water related diseases (humans and animals)	Sickness, hospital care, death; decrease in meat and milk production	B,C	Loss of earnings, health care costs.
5. Fishery - impacts on fish irrigation, spawning	Both loss and increase in fish production	B,C	Changes in production, preventive expenditures.
6. Recreation - in the reservoir or river	Value of recreation opportunities gained or lost, tourism	B,C	Travel cost approach,
7. Wildlife and biodiversity	Creation or loss of species, habitat and genetic resource	B,C	Opportunity cost approach, tourism value lost, replacement costs
8. Involuntary resettlement	Cost of new infrastructure, social costs	B,C	Replacement cost approach, "social costs", relocation costs
9. Discharge variations, excessive diurnal variation	Disturbs flora and fauna, human use, drownings, recession agriculture	C	Relocation costs, changes in production.
10. Flood attenuation	Reduces after flood cultiva tion, reduces flood damage	B,C	Changes in production, flood damages avoided.

Source: Dixon, Talbot, Le Moigne (1989)

3.4.5 STARTING THE ANALYSIS

Among the hardest tasks for the economist or project analyst is to decide which of the environmental and resource impacts are important and how to measure them and include them in monetary terms. There is no "cookbook" answer; the analyst must think through each problem, identify important impacts, make decisions, and make all assumptions explicit. Among the various environmental effects of dam projects some general guidelines that should be of help in setting up the analysis follow:

Start simply with the most obvious, most easily valued environmental impacts. This may mean looking for impacts on the environment that result in changes in productivity and that can be valued using market prices. (Sometimes market prices are distorted and one has to make appropriate adjustment via use of shadow prices.) Table 3.4.1 listed categories of major effect dams/reservoirs and their economic impacts. Secondary effects may be very important, both ecologically and economically, but the analyst would do best to start with the effects that have directly measurable productivity changes that can be valued by market prices. Secondary effects can then be incorporated to the extent knowledge, data and resources permit.

There is a useful symmetry in benefits and costs: a benefit foregone is a cost while a cost avoided is a benefit. A reduction in dam height, for example, may mean that fewer people need to be resettled from the reservoir. This reduction in resettlement costs is a benefit of the decision. Of course, the reduced height also creates "costs" due to reduced hydropower, irrigation or flood control benefits.

All assumptions should be stated explicitly. This is particularly important in valuing effects on the environment because other analysts may wish to critically review the results and can only do so if the assumptions and the data are clearly presented. The analysis should be carried out in a with-and-without-project framework. That is, the analysis must compare the likely future situation without the project with what is expected to occur with the project. In many areas, existing forces are leading to growing environmental degradation (and poverty) and this process would continue or even accelerate without the project. In this case, the with-project situation must be compared to a deteriorating without-project scenario.

Given the wide range of potential valuation techniques, some of which are listed in Table 3.4.1, this section cannot present any in detail. Rather, brief reviews of two commonly used approaches are presented. The change in productivity approach uses market prices to value a change in production while the replacement cost approach is a cost analysis technique that uses estimates of potential expenditures to value an impact on the environment.

Changes in productivity

Techniques using changes in productivity as the basis for measurement are direct extensions of traditional benefit-cost analyses. Physical changes in production are valued using "economic" or accounting prices, usually based on market prices for inputs and outputs or, when distortions exist, appropriately modified market prices (i.e. shadow prices). The monetary values thus derived are then incorporated in the economic analysis of the dam or lake management project. This approach is based directly on neo-classical welfare economics. The benefits and costs of an action are counted regardless of whether they occur within the project boundaries or beyond them.

Several steps must be taken in order to use this technique:

1. Changes in productivity caused by the project have to be identified both on-site and off-site. In the case of dams, in addition to direct project outputs (e.g. hydropower, irrigation, water supply, flood control) there may be other indirect on-site effects such as the benefits of a reservoir fishery or a tourism/recreation industry. Changes off-site (both positive and negative) include various environmental or economic externalities. These off-site effects must be included to give a true picture of project impacts. Various lake management regimes may also result in impacts that can be measured using this approach.

2. Assumptions will also have to be made about the time over which the changes in productivity must be measured, the "correct" prices to use (e.g. shadow prices) and any future changes expected in relative prices.

The change in productivity approach can be used for various on-site and off-site effects: fisheries and draw-down cultivation in the reservoir or lake area, changes in crop production, and changes in fishery production, both in-stream and in affected coastal areas. Upstream environmental effects, such as changes in land use patterns and associated soil erosion/sedimentation will also affect the economic productivity of the reservoir or lake. These latter impacts may be difficult to measure for the "without project" scenario due to rapidly changing rural settlement patterns. These costs can also be valued by the change in productivity approach.

Replacement cost approach

The basic premise of the replacement cost approach is that the costs incurred in replacing productive assets damaged by a project can be measured, and that these costs can be interpreted as an estimate of the benefits presumed to flow from measures taken to prevent that damage from occurring. The approach can thus be interpreted as an "accounting procedure" used to work out whether it is more efficient to let damage happen and then to repair it or to prevent it from happening in the first place. With the assumptions given below, it gives an estimate of the upper limit of damages that can be ascribed to the project but does not really measure the benefits of environmental protection per se.

The assumptions implicit in this type of analysis are:

1. The damages are measurable;

2. The replacement costs are calculable and are not greater than the value of the productive resource destroyed, and therefore it is economically efficient to make the replacement. If this assumption is not true, it would not make sense from an economic perspective to replace the resource lost (although there may be social or political reasons to do so); and

3. Any secondary benefits (i.e. benefits other than those for which the project or management action was undertaken) associated with the preventive expenditures should be included as benefits in the analysis. For example, reforestation of an upper watershed to control erosion may result in development of a tourism industry or a new wildlife habitat.

In dam and reservoir projects this approach can be used to evaluate various environmental effects and alternative mitigation measures. The simplest example is the problem of resettlement. Resettlement of people displaced by a reservoir and construction site, whether rural farmers, residents of small villages, or inhabitants of larger urban areas, is a costly and difficult process. The costs of replacing lost facilities and recreating viable economic-social systems in another location are calculable. These are a form of replacement cost and should be considered in assessing the overall profitability of the project. The impacts of alternative dam heights and associated reservoir levels on replacement costs must be considered as well as the implication of dam height and reservoir levels on construction costs and generation of power, irrigation or flood control benefits. Although lakes are usually less variable in level, in some cases management actions can result in lowering or raising the lake level resulting in similar effects.

An instream fishery may be threatened by a dam that intercepts a natural migration path. In this case the replacement cost to protect and maintain the fishery may consist of fish ladders and other means to permit some degree of migration and natural biological cycles. These costs are then compared to the cost of allowing the fishery to disappear or suffer reduced productivity. In this example the dam project is debited with the amount of the replacement costs (if these are less than the value of the fish that would be lost) or the value of the lost fish (assuming replacement costs are larger than this).

In general, the replacement cost approach can be useful when an effect on the environment has caused, or will cause, resources to be spent on replacing a physical asset. When that asset is a road, dam or bridge, the technique is straightforward. When it is soil, water or aquatic life its application is the same but the problems of measurement are greater. The change in productivity approach can also be useful in these cases. When impacts on the environment result in measurable changes in the level of goods and services produced this approach can frequently be used to bring these "economic externalities" into the analysis.

3.4.6 ANALYSIS OF MANAGEMENT OF RESERVOIRS AND LAKES

In addition to pre-construction decisions and the explicit inclusion of environmental impacts, economic analysis serves a useful function in the analysis of management options. Whether a lake or a reservoir, there frequently is more than one user of the water (joint users), and decisions must be made on how to allocate costs over the various users (allocation of joint costs). This issue is discussed in some detail in Section 3.5.

Management to serve one purpose may well impose costs on another user. In the case of a reservoir that both generates power and provides irrigation water, it may not always be possible to meet both needs 100% throughout the year. If there has been a drought and the reservoir level is down, does one use the stored water to generate electricity or meet irrigation needs? There is no simple answer. Saving the water for one use rather than the other will impose economic costs on the affected sector. An economic analysis can compare expected productivity effects from shortfalls of either electric power or irrigation water. Depending on the economic situation, one option may be clearly preferred.

In Egypt several years ago, a major drought reduced inflows to the reservoir of the Aswan High Dam. In this case the decision was made that irrigation supplies were of prime importance and the reservoir was managed to meet agricultural needs. Power generation was reduced as a result of this action, but this decision was made after weighing the benefits and costs (social and political as well as economic) of each alternative.

Lakes present similar situations, particularly when there are several competing users for the available water. Recreation (including swimming) may be one important (if seasonal) use while lakes are also commonly used as a source of potable water, for cooling or power plants, for fishing, for navigation, and as a receptacle for industrial, agricultural or urban wastewater. Obviously conflicts arise and not all uses can be accommodated at their maximum level.

Economic analysis can be used to examine the implications of alternative scenarios. In general, the larger the lake, the more complicated the analysis. With increasing size of the water body there usually is an increasing number of inputs and outputs and increasingly complex ecosystem interactions. Knowledge of the physical system and of cause-effect linkages decrease rapidly with increased size and complexity.

Still, economic analysis may be useful to eliminate certain options. For example, if a lake (or a reservoir) is to be used for a potable water supply but is presently contaminated by industrial wastewater inflow (or natural run-off from agricultural or urban areas), two major options are possible. One is to reduce contamination of the water body by imposing stringent effluent control standards or by using physical means to prevent, or redirect, inflows. Alternatively, one can examine the costs of treating the water abstracted from the lake (or reservoir) to meet potable standards. As a result of an initial analysis the economically efficient option may become quickly apparent. If pollution control costs, for example, would be $100 million over a 10-year period and water purification costs were $10 million over the same period, one would probably choose purification. If the numbers were reversed, then control would be preferred.

Of course, the analysis becomes more complicated when the number of uses and users increases as well as the number of potential sources or pollution. In addition, even if the economic analysis points out the least-cost alternative, it does not specify whether that option is socially desirable or politically feasible. A multiple-objective analysis may be required to determine this. Governments frequently become involved as both analysts and regulators; taxes, fines or subsidies are commonly used to influence the actions of individuals and firms.

Economic incentives (and disincentives) can be powerful management tools in promoting changes in water use or water resource development. Pricing of water resources can help promote more efficient allocation of water. Although the traditional approach to water quantity problems has been supply augmentation, the use of economic policies to manage demand can be equally effective in helping reach a water supply/water demand equilibrium. (The use of economic analysis and water pricing to manage demand may have the additional benefit of raising revenue!)

3.4.7 CONCLUSIONS

Economic analysis of water resource development plays a useful role both in making investment decisions on design and construction of dams and reservoirs as well as in developing management options for existing lakes and reservoirs. Environmental and social impacts are associated with both project design and resource management and these impacts need to be taken into account in the economic analysis.

The theory and techniques of economic analysis are the same whether they are used for guiding investment decisions on new water resource developments, or developing management plans for lakes or reservoirs.

REFERENCES

Dixon, J.A.and Hufschmidt, M.M., eds. 1986. Economic Valuation Techniques for the Environment: A Casestudy Workbook. Johns Hopkins University Press. Baltimore.

Dixon, J.A., Carpenter, R.A., Fallon, L.A., Sherman, P.B., and Manopimoke, S. 1988. Economic Analysis of Environmental Impacts of Development Projects. Earthscan Publications. London.

Dixon, J.A., Talbot, L.M. and Le Moigne, G. 1989. Dams and the Environment: Consideration in World Bank Projects. Technical Paper No. 110. World Bank. Washington, D.C.

Gittinger, J.P. 1982. Economic Analysis of Agricultural Projects. Published for the EDI of the World Bank. Johns Hopkins University Press. Baltimore.

Hufschmidt, M.M., James, D.E., Meister, A.D., Bower, B.T., and Dixon, J.A. 1983. Environment, Natural Systems, and Development: An Economic Valuation Guide. Johns Hopkins University Press. Baltimore.

Krutilla, J.V. and Fisher, A.C. 1985. The Economics of Natural Environments. Resources for the

Future. Washington, D.C.

Little, I.M.D. and Mirrlees, J.A. 1974. Project Appraisal and Planning for Developing Countries. Basic Books. New York.

Mahmood, K. 1987. Reservoir Sedimentation: Impact, Extent, and Mitigation. World Bank Technical Paper No. 71. The World Bank. Washington, D.C.

Sinden, J.A. and Worrell, A.C. 1979. Unpriced Values: Decisions Without Market Prices. Wiley. New York.

Squire, L. and van der Tak, H.G. 1975. Economic Analysis of Projects. Published for the World Bank. Johns Hopkins University Press. Baltimore.

UNEP. 1989. Sustainable Water Development and Management: A Synthesis. Water Resources Development 5(4). December.

UNIDO. 1972. Guidelines for Project Evaluation. United Nations. New York.

SECTION 3.5

COST SHARING FOR LAKE/RESERVOIR MANAGEMENT: ISSUES AND PRINCIPLES

K. William Easter and John J. Waelti

3.5.1. INTRODUCTION

Among the perennial questions arising in public endeavors such as water resources development and management is "who pays for it?" In his classic article on cost allocation, Ciriacy-Wantrup (1954) reminds us that issues such as repayment are among those intricately connected to the allocation of costs. Cost allocation refers to the apportioning of costs (particularly, joint costs) of multiple purpose projects to individual project purposes. In contrast, cost sharing (which we use as synonymous with "repayment") refers to the division of responsibility for the climate burden of furnishing real resources used in building, operating and maintaining a given project.

To clarify the relationship (and difference) between cost allocation and cost sharing, consider the following example. A public water development project may have costs allocated between water supply and flood control purposes as a basis for determining the rate of return for each purpose. Yet it may be decided that the beneficiaries of water supply share in paying for the project, but the beneficiaries of flood control do not. The allocation of costs to a specific purpose does not necessarily imply sharing of the costs by the beneficiaries of that purpose.

Who should pay for the lake/reservoir development and management? The objective of this section is to delineate key issues, and offer some rationale and policy guidelines for answering this perennial controversial question.

The Social Criteria

Reservoirs, lakes and streams are generally considered to be public resources. Consequently we begin with the premise that these resources should be used for the maximum net benefit to society, rather than with criteria such as maximum net monetary profits to a private entity, or maximum net benefit to a local government unit. While use of the broader criterion of net social benefit entails measurement problems, this complication does not warrant changing the criterion for mere convenience.

While economists are concerned with efficient resource allocation to maximize net social benefits, they also consider equity -- fairness in the distribution of income -- to be important. In a representative democracy, equity is reflected, however imperfectly, in the political process. Thus, social economic efficiency and political feasibility (the latter as a proxy for equity) are the criteria on which we base the policy guidelines suggested for cost sharing.

Efficiency, Equity and the "Benefits Received" Principle

A good starting point is Ciriacy-Wantrup's 1954 contention that: "It appears economically justified and politically equitable that beneficiaries from public resource development pay for the benefits received -- provided such benefits are practically assessable and provided that enough incentives is left for beneficiaries to participate in resource development" (p. 116).

In some cases, this may mean that beneficiaries repay more than the share of total costs allocated to "their" project purpose, such as irrigation or hydroelectric power. However, the point that beneficiaries pay something is paramount. In practice, there may be cases where it is administratively unfeasible or otherwise impractical to assess beneficiaries for some specific purpose. Cases may also occur where the repayment should be extracted indirectly so that the repayment does not have unwarranted impacts on the incentives to more fully use the resource.

3.5.2 IDENTIFYING BENEFICIARIES

If cost sharing is to be based primarily on benefits received, then we must be able to identify beneficiaries and measure the benefits they receive. For many goods or services, this is not a problem. Consumers pay x amount for goods or services and consume them. The benefits they receive are equal to or greater than the amount they pay, and they have exclusive use of the good or service. Problems arise in valuing goods or services when they are either not exchanged in the market, or there is no exclusive use.

Non-exclusive/Exclusive Goods

A difficult problem arises in the case of non-exclusive goods, i.e. where no one can be excluded from using the good or service (see Table 3.5.1 for discussion of terms). Since by definition people cannot be excluded from use, it is also likely to be very difficult to directly collect user charges or fees. If you cannot exclude people from using the good or service, how can you collect fees for such use? Consequently, these goods or services, in most cases, must be financed by the public sector or private foundations. The only question usually involved is that of the level of the public sector to share the costs (local, state or national). Many types of recreation and some commercial fishing fall in this category, particularly if the costs of exclusion and/or user fee collection are considered.

Non-rival/rival goods

Many of the goods or services which are non-exclusive are also non-rival goods (sometimes called public goods), where one person's use of the good or service does not decrease its value to others who use the good or service (Randall, 1987). Flood control is a good example of a non-rival and non-exclusive service. Rival goods or services are just the opposite (my use precludes your use). They include most of the normal market goods as well as water supplied from a lake/reservoir for domestic or industrial users.

Since non-rival goods are not consumed (in the traditional sense) when used, they can continue to provide the same benefits to everyone as long as they are not damaged or congested. Thus, the more they are used, the larger is the benefit stream they produce. As long as there are no costs to society for added use, then use should not be discouraged. This suggests that the economically efficient user price would be zero because the marginal cost of serving another user is zero. However, this does not mean that the beneficiaries of a non-rival good should not make some payment for the good. A payment scheme can be devised which is unrelated to the amount of service obtained, so that the payments will not influence the consumption decision. The marginal price will still be zero.

This is an efficient policy as long as there is no congestion or other costs associated with increased use, i.e. too many people at a recreation site or added management costs. Once congestion costs occur, user fees need to be charged, based on the congestion costs that one or more user imposes on the other users. The marginal cost is no longer zero for another person to use the resource. The marginal costs is equal to the marginal congestion costs, plus any added management costs.

Table 3.5.1
Types of Goods or Services and Cost Sharing Rules [1] (Randall, 1987)

	Non-exclusive goods[2]	Exclusive goods
Non-rival goods	Lump sum payments by the government unit closest to beneficiaries.	Lump sum charges to beneficiaries.
Rival goods	Charges based on amount of good or service provided and paid by user-group or government unit closest to beneficiaries.	Fees charged to beneficiaries based on amount of services or goods received.

1) The cost sharing rules assume no congestion. If congestion occurs, the user charges need to include this cost.

2) Definitions:
Non-rival, non-exclusive goods: goods for which one person's consumption does not reduce or subtract from the value obtained by others consuming the same good. In addition, users cannot be excluded from consuming the good.
Rival, non-exclusive goods: goods for which consumption by one person precludes consumption by others. However, individuals cannot be excluded from its use.
Non-rival, exclusive goods: again, goods for which one person's consumption does not detract from any other person's consumption of the same good. However, if one so desires, individuals can be excluded from using the good.
Rival, exclusive goods: this is the typical good that is best provided by the private market. One person's consumption precludes consumption by other consumers and individuals can be excluded from using the good.

Lumpy benefits

A closely related problem involves the provision of many non-rival goods in large lumpy units. In such cases, the consumer does not have the opportunity to purchase different levels of the good or service. Usually, only one level is provided. The user cannot be charged based on quantity consumed, because only one quantity is provided. It is also likely to be difficult and expensive to determine how much each individual benefits. Flood control is an example of such lumpy goods. A given area is provided with a set level of potential flood protection. This can be varied somewhat by providing more or less reservoir storage through control of the lake/reservoir level, but the range of flood control is constrained by the physical storage capacity of the lake/reservoir and its other uses for storage.

3.5.3 DISASSOCIATION OF BENEFITS AND COSTS

Another area of concern involves cases where the benefits from a management activity accrue in a location removed from where the activity (cost) takes place. In other words, one group's or individual's activities create externalities for others. Soil conservation activities in the watershed above a lake/reservoir is a classic example. If upstream farmers or foresters implement soil conservation practices, many of the benefits accrue to those using the lake/reservoir downstream. To get the upstream resource users to apply the socially optimum amount of soil conservation, the downstream interests must develop ways to share in the cost of the practices. Otherwise, sedimentation and pollution levels are likely to be high in the lake/reservoir.

The problem is one of sharing the costs between the pollutee and the polluter. If the rights are clearly specified, it may not be a difficult task. When the users of the lake/reservoir have the rights to clean water, then the polluter must pay to prevent the pollution. In contrast, if the polluter has the right to discharge soil into the lake/reservoir, then the pollutee must pay enough of the costs of pollution control to get the polluter to stop or reduce discharges. The polluter may receive some benefits from increased future production, due to reduced soil erosion, and be willing to pay some of the costs while society, or those damaged, pay the rest.

When the rights are unclear, then cost shares among pollutees and polluters should be based on the benefits received. This assumes that the benefits can be estimated. Measuring downstream benefits from reduced soil erosion is not easy, but methods for measuring these benefits, such as contingent markets, travel costs and changes in productivity, are available (Hufschmidt et al., 1983; Easter et al., 1986).

3.5.4 COST ALLOCATION

Recall that cost allocation and cost sharing (repayment) for project costs are related, but separate, issues. Cost sharing for a specific purpose, while dependent in some measure on cost allocation, may well exceed the costs of a project attributable for that purpose. To illustrate this relationship, consider an example of a multi-purpose water development project costing $100 million for irrigation, hydroelectric power, and flood control. The project includes features which are directly attributable to irrigation, such as the distribution canals. It also includes features, such as the generator and turbines, which are directly attributable to power generation. However, a major part of the project, such as the dam, and the opportunity costs of the land flooded by the reservoir, are necessary for all three purposes, and hence are not assignable exclusively to either of the three purposes. This is essentially a problem of joint production, and there is no single theoretically best way in which to assign these costs to specific purposes. If beneficiaries anticipate that they will pay for the project in proportion to costs assigned to specific purposes, they have an incentive to apply political pressure to apportion costs to other purposes.

How might such joint costs be apportioned? One method which is fairly consistent with principles of equity and efficiency, and is reasonably simple and operational, is the "separable costs - remaining benefits" method of cost allocation. One of the basic ideas behind this approach, when used for cost sharing, is that repayment and ability to pay are related to benefits received (see Easter and Waelti (1980) for more detail).

In this method of cost allocation, the first step is to calculate the costs of the project *without* each of the individual purposes. This process yields the *separable costs* which are assignable to each purpose. In our example of a project costing $100 million, assume that $20 million is directly attributable to irrigation, and $40 million is directly attributable to hydropower generation. This leaves $40 million for joint costs -- costs which, for purposes of cost allocation, must be assigned with some degree of arbitrariness to the specific project purposes of irrigation, power generation, and flood control.

Under this method of cost allocation, the separable costs for each purpose are subtracted from the benefits for each purpose to attain what are called *remaining benefits*. (These benefits are estimated as a part of the initial economic feasibility study.) To illustrate the method, assume that the benefits are $40 million for irrigation, $80 million for power, and $40 million for flood control, for a total of $160 million. Subtracting the separable costs for each purpose leaves ($40 - $20), $20 million for irrigation; ($80 - $40), $40 million for power; and ($40 - 0), $40 million for flood control, for a total of $100 million in remaining benefits. The proportion of remaining benefits for each purpose to total remaining benefits is then used as the proportion to be allocated the $40 million in joint costs: in this case, (.2 x $40), $8 million to irrigation, (.4 x $40), $16 million to power, and (.4 x $40), $16 million to flood control. The amount of the joint costs, plus the separable costs for each purpose, constitute the total costs of the project allocated to each purpose, i.e. $28 million for power and $16 million for flood control.

Another approach would be to allocate costs so as to minimize distortions caused by cost sharing requirements that total revenues equal or exceed total costs of a purpose, rather than marginal benefits equal marginal costs (Eckstein, 1958). This method involves allocating costs in inverse proportion to the elasticity of demand for outputs of each purpose. The rationale for this method is that those outputs with the smallest elasticity (steepest demand curve) will have greater price flexibility without causing much change in the quantity demanded. For "a given price change to cover project costs, those outputs which have the least elastic demand will be purchased in the least diminished quantity relative to those with higher elasticity. This suggests that those outputs having low elasticity can be allocated a greater proportion of the costs and priced accordingly for repayment purposes" (Easter and Waelti, 1980, p.45).

This method might be difficult to implement, since the elasticity of demand would need to be estimated for each purpose involved in the cost sharing. Furthermore, if the cost sharing is also used to allocate the resource rather than just for repayment, one may want to change levels of use. If this is the case, then allocating costs to purposes with the smallest elasticity may not be as desirable.

Again, we stress that the *allocation* of costs to a specific purpose does not necessarily imply that the beneficiaries of each purpose should be assessed for benefits received. In some cases, beneficiaries may not be directly assessed at all, while in other cases, beneficiaries might be asked to repay considerably more than the costs allocated to a specific purpose of the project. In fact, in the U.S., repayment has varied widely over time by project purpose (Waelti, 1984).

What factors, other than pure politics and political pressure, might account for what could be construed as different repayment obligations for various purposes? The apparent discrepancy is accounted for by factors discussed earlier in this section -- namely, differences in the ease of identification of beneficiaries, and the differences in the efficacy and practicality of collection from beneficiaries of various project purposes.

3.5.5 ALTERNATIVES FOR COLLECTING COST SHARES

Once the cost shares have been decided by purpose or type of good, the next question is how should the shares be collected. The method most frequently discussed in the literature is that of user charges. They can be used primarily to collect some of the economic rents (benefits) users receive, or to pay all or some of the project costs. The user charges can also be employed as a means to regulate or limit use of the good or service. The type of user charge best suited for a particular situation will depend on which of the above functions is most important. If regulating use is important, then the user charge must be tied in some matter to the quantity used. As more is used, the amount paid by the user must go up. This increase in payment creates an incentive for users to conserve the resource.

On the other hand, if we are dealing with a non-rival good and no congestion, and the main function of user charges is repayment, then there is no economic efficiency reason to tie charges to quantity used. All users might be charged the same amount, or the charge might be a percentage of their land or property tax. The users still pay, but the quantity used would not influence the payment directly. For flood control, large scale land owners could pay more land taxes than the small scale owners, but the payment would not be directly tied to the amount of flood protection provided.

In some cases, either because the good is non-exclusive or the cost of collecting from users is too high, user charges are not imposed. For these situations, some level of government and/or some community group must pay for that management service. When most of the benefits are very local in nature, then local governments are best positioned to decide on the level of service and to pay for it. In contrast, when the service provides benefits for users over a wide area, the state or provincial governments should pay some or all of the costs. Again, the share which each level of government pays could be based on the relative share of the benefits which accrue to local users as compared to users from the rest of the state or country.

Local user groups might also pay a share of the costs for non-exclusive goods that mostly benefit a given area, such as an area protected by a flood control project. A flood control district or a soil conservation association are good examples of such groups that could pay their share of costs.

3.5.6 COST SHARING FOR SPECIFIC PURPOSES

What does all this mean in terms of specific management purposes for lakes/reservoirs? It is clear that the products and services provided by lakes/reservoirs vary from rival goods to non-rival goods, some of which are more or less exclusive, whereas others are non-exclusive. But how can the general rule concerning rival and non-rival goods be applied to lakes/reservoirs? To answer these questions, we will examine products and services provided by lakes/reservoirs in more detail, including water supply, irrigation, hydropower, navigation, recreation, fisheries, environmental quality and flood control.

Water Supply

Water supply for municipal and industrial purposes is a rival good from which others can be excluded from use. The product can be precisely measured and sold in discrete units. A charge can be levied and collected, and the system can be designed so that service can be cut off if payment is not forthcoming. The major exception occurs in cities where open taps or stand pipes are provided for anyone to use free of charge, or where meters have not been installed.

Since beneficiaries may continue to receive a valuable product long after the project costs are repaid, there is no reason not to continue assessing for the product after the costs allocated to water supply are repaid. There will continue to be operation and maintenance (O&M) costs associated with water delivery, and funds collected in excess of O&M can be used as a sinking fund for major new investment which may be required. This may be especially important for developing countries where capital is in short supply. Finally, in cases where both the demand for water and the marginal cost of new supplies are increasing, economic efficiency indicates that users should be charged the long-run marginal cost of supplying water (Seagraves and Easter, 1983).

Electric Power

Many of the above conditions for water supply apply to the sale of electricity. Beneficiaries receive a quantifiable product for which a charge can be levied and collected. In fact, the record in collecting from electric power users is generally much better than those from direct water users. The counterpart of stand pipes does not exist for electricity, so it is more difficult to get free electricity. Also, since electricity is generally not considered a basic right as, in some countries, is water supply, it would be easier than it would be for water to charge users the full long run marginal costs of new supplies.

Irrigation Water

Some of the same conditions for municipal and industrial purposes also apply to irrigation water, since it is basically a rival good as long as return flows are not important. What makes irrigation water different, particularly large gravity flow systems from lakes/reservoirs, is the difficulties involved in monitoring water delivered to the numerous users, and in excluding others from illegally using the water. The water delivery system can be designed, at a cost, so that the product can be measured and sold in discrete units. A charge can be levied and collected, based on amounts received, if the appropriate measurement and institutional arrangements are made. Finally, the system can be designed so that the product can be cut off if payment is not forthcoming. however, for large gravity flow irrigation systems from lakes/reservoirs, water deliveries and charges are very difficult to monitor and enforce. With many small scale farmers, as one finds in developing countries (1 ha average), it is expensive to design a large system that allows the control and measurement of water delivered to each farmer's field. Consequently, it is difficult to assess water users according to quantities received. The case is quite different, however, for small systems, particularly those supplied by wells.

To get around these monitoring and enforcement problems, new institutional and organizational arrangements may need to be established so that measurement and control is done at a higher level of aggregation than the individual farm. Ideally, water user organizations can take control of the water and enforce water delivery schedules and payments. In many developing countries, this may be essential if irrigation officials expect irrigation users to repay their cost share.

Navigation

Navigation is a less clear cut situation, since it is a non-rival good unless congestion exists. The output is easily identifiable as generally lower cost transportation. Beneficiaries include producers who can ship at lower costs, and consumers who may benefit through lower product prices. In developed nations, to the extent that shipping is done by a few large firms, it is feasible to help pay for public navigation projects through a fuel tax or a charge per vessel or amount of cargo. In developing countries, if beneficiaries are widely dispersed, such means may be impractical. Further, broadly dispersed benefits resulting from lower cost transportation, and its non-rival nature, may mean that no attempt should be made to collect costs from shippers. However, as soon as congestion occurs, fees for use of the navigation channels are justified as a means to reduce congestion costs. Also, if locks and dams are involved, then the cost of an additional vessel is positive, and fee collection can be done at the locks. Furthermore, the existence of locks provides a means of exclusion for those who do not pay.

Flood Control

As discussed earlier, flood control is a non-rival and non-exclusive good provided in large lumpy units. The benefits of a particular flood control project are the real resources saved, and the increased production resulting from a reduction in flood damages. Some of these benefits will accrue to land and other property owners through increased productivity, which is capitalized into land and other property values. Thus, a tax on land and real estate is one means of capturing some of these gains if repayment of project costs is an important objective. If the fees are based on the value of land and buildings, then payments will be directly related to benefits received, since increases in property value are dependent on the degree of flood protection provided.

Two aspects of flood control deserve mention. First, given that flood control is provided for a specific area, it becomes available to every one in that area. Provision for one person cannot be accomplished while excluding someone else in the area. A fee for service on a voluntary basis is, therefore, impossible. In addition, if economic activity increases in areas outside the flood plain because of the flood protection, a land and property tax in the flood plain would miss these beneficiaries. It may also miss some other beneficiaries in the flood plain.

Second, provision of flood control for the purpose of reducing flood damages can have perverse effects. The mere existence of increased flood protection may increase economic activity in the "protected" region. Since no flood control measure is absolute, the occasional (and inevitable) "record flood" might cause more damage than before "protection", because of the increased level of economic activity induced by the perceived protection. The net result is that if investment in flood control is to achieve its intended goal of reduced flood damages, other policy tools will be needed. The so called "non-structural" tools such as zoning will be required to restrict economic activity in the flood plain. This is especially important if beneficiaries of flood protection are not asked to share the costs, in full, of benefits received. If the general public has to pay most of the costs for flood protection in a given area (with the predominant share of benefits going to beneficiaries in the protected area), it is reasonable for that same public to insist that the area not be placed at greater risk through increasing economic activity in the protected area. This is particularly important when the general public is expected to provide disaster aid for flood victims.

In practice, beneficiaries seldom share fully in costs of flood protection, probably through a combination of political pressure and the difficulties involved in collection. Greater efforts at restricting economic activity in the flood plain that usually accompanies flood control projects would, in our view, move in the direction of improving both economic efficiency and equity.

Recreation, Fish and Wildlife

With these goods and services, we move into a group which vary considerably both in ease of identifying beneficiaries and ease of fee collection. Certain recreation activities are non-rival in nature, while others are rival. Some are non-exclusive, and congestion is a big problem for many popular recreation activities, particularly during peak vacation time periods (weekends and holidays).

For activities such as power boating, it is relatively easy to identify beneficiaries and to exact payment through a boat license of other forms of user fees. With sport fishing and hunting, exclusion and fee collection is more difficult except through a hunting or fish license fee collected by the state. A portion of such fees could be allocated to a specific project to help finance it. Similarly, it may be possible to collect fees for maintaining public camping facilities. For activities such as hiking, biking, bird watching, or swimming, it may be impractical to collect fees. Even if beneficiaries can be identified, the costs of collection may not be justified in light of anticipated revenues from fee collections. Further, the efficacy of collecting fees for such activities may be circumscribed by local custom and tradition and the fact that they are non-rival. For example, the father taking his son fishing is celebrated in American folklore. Similarly, in many parts of the world, the idea of collecting fees for certain activities relating to water and land use may run counter to cultural values.

Yet, fees can be charged for using areas that are set aside for recreation, such as national, state or local parks. As long as entrance can be restricted and fees can cover the costs of collection, a user fee for lake/reservoir recreational services is feasible. The implementation depends on management objectives, the demands for repayment and the level of congestion.

Commercial Fishing

If there is only a small amount of recreational fishing in a lake or reservoir, then it is relatively easy to identify the beneficiaries of commercial fishing. Once the commercial fishing interests have been identified, charges can be imposed through boat licenses or catch fees. The former would be the easier of the two to impose and collect, but has the disadvantage of being indirectly related to benefits received. Boat licenses could also be varied by size of boat to account for differences in potential catch rates.

Charging fees based on fish caught has the advantage of relating payments directly to benefits received by fishing firms. Fee collection would require close monitoring to determine how much each firm was catching at different points in time. The task would be much easier if only a few ports exist on the lake or reservoir. Monitoring and collection costs could be high if there are numerous small fishing firms and ports, and if the fishing firms do not cooperate. Such cooperation is most likely when firms know that the fees are used to help pay for the lake or reservoir management, including fish management and improvements in the fishery.

Environmental Protection

In environmental protection, we approach the classic case of the non-rival good, where its provision to one party automatically includes provision to all parties. One person's use within the protected area does not exclude another's use. In addition, the beneficiaries are, in most cases, not those who cause the pollution. However, for many lakes, pollution by lake shore owners will eventually damage all users of the lake. The pollution is not carried downstream as it is in a river. Thus, lake shore owners would receive some benefits from reducing their own pollution discharges.

Examples of environmental protection include watershed protection through enhanced vegetative cover or reforestation, and preservation or enhancement of species of fish, plants and wildlife. These benefits may be difficult to measure in a quantitative, scientific sense. However, inconvenience in measurement neither diminishes the importance nor the magnitude of such benefits where they exist. And, as pointed out above, improved techniques for estimating these benefits are available (Hufschmidt et al., 1983).

Since much of the environmental damage, particularly in the case of soil erosion, occurs downstream or downwind, there is a disassociation of benefits and costs. A prime example of this is the high sedimentation rates in many Asian reservoirs coming from upstream watersheds (Easter et al., 1886, Ch. 15). If the upstream land users are to use conservation practices, cost sharing arrangements must be provided or regulations imposed. Otherwise, the pollution will continue. This means devising institutional arrangements that allow cost sharing by society or by those being damaged. In some cases, this might even involve outright management of upstream watersheds by downstream groups. For example, a downstream community might rent or purchase an upstream area and reforest it. This is a means of internalizing the external costs and should lead to an optimum level of soil conservation. Those damaged by the erosion would have an incentive to reduce the erosion to a level where the marginal benefits from reduced damages is equal to the marginal costs of added protection.

A number of approaches have been tried to internalize upstream erosion externalities. Before 1920 in Japan, "irrigation associations and municipalities downstream were very active in improving the deteriorated watersheds at their own expense... The most common measures taken by the water users downstream were the acquisition of critical watersheds and profit sharing plantations on alien lands" (Kumazaki, 1982). Later on, municipalities and power companies shared the costs of upland plantation projects. As water use increased, however, prefectural governments took over more responsibility and "leased the privately owned watersheds and planted tree(s), with financial cooperation for the water users downstream, who in turn enjoyed a certain share of the revenues from the plantations" (Kumazaki, 1982).

Thus collective action and cost sharing by all beneficiaries of lake clean-up efforts can be an important way of improving lake water quality and quantity. The level of a country's economic and institutional development, and the degree of pressure on the resource, appear to play major roles in determining the organizational and institutional forms adopted. Early on, formal and informal private and collective actions may be the primary impetus for water quality improvement. As government agencies become technically more capable and efficient, they can play a larger role in protecting water resources.

One of the key components of such collective action is a good understanding by downstream water users of the benefits they receive from conservation activities upstream. Given this knowledge, then institutional arrangements need to be in place that allow them to assist in conservation activities. If they are cost sharing, then they need to know that the funds will be efficiently used for the desired purposes. When they want to have more direct control, they need to have the option to lease or purchase easements in the upper watershed.

Cost sharing by downstream interests would be considered fair by upstream land owners, since the downstream interests get many of the benefits. These activities may even encourage upstream land owners to engage in more conservation practices. This would be an application of the principle of reciprocity (Sugden, 1984). Since downstream users are installing and cost sharing on conservation practices, the upstream owners may feel they should do their share.

3.5.7 CONCLUSION

In summary, the general principle of the "the beneficiary pays" is usually compatible with both efficiency and equity goals of public lake/reservoir management. However, it is more practical to collect on a "benefits received" principle for those goods approximating "rival goods". For goods which more closely resemble non-rival goods, or for which beneficiaries are more difficult to identify and assess on a "benefits received" basis, there are good theoretical grounds as well as a strong "common sense" basis for financing them from other sources or with indirect taxes. These sources would include state or local governments, water user organizations and the central government if the lake/reservoir generally benefits the whole community.

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REFERENCES

Ciriacy-Wantrup, S.V. 1954. Cost Allocations in Relation to Western Water Policies. Journal of Farm Economics 36(1): 108-129.

Easter, K. W. et al. 1986. Watershed Resources Management: An Integrated Framework with Studies from Asia and the Pacific. Westview Press. Boulder, Colorado.

Easter, K.W. and Waelti, J.J. 1980. The Application of Project Analysis to Natural Resource Decision. 1980 Water Resources Research Bulletin 103. University of Minnesota.

Eckstein, O. 1958. Water-Resource Developments: The Economics of Project Evaluation. Harvard University Press. Cambridge, Mass.

Hufschmidt, M.M. et al. 1983. Environment, Natural Systems and Development: An Economic Valuation Guide. The Johns Hopkins University Press. Baltimore.

Kumazaki, M. 1982. Sharing Financial Responsibility with Water Users for Improvement in Forested Watersheds. In The Current State of Japanese Forestry (II), Its Problems and Future. The Japanese Forestry Economic Society. Tokyo.

Randall, A. 1987. Resource Economics: An Economic Approach to Natural Resource and Environmental Policy. John Wiley and Son. New York.

Seagraves, J.A. and Easter, K.W. 1983. Pricing Irrigation Water in Developing Countries. Water Resources Bulletin 19(4): 1663-1672.

Sugden, R. 1984. Reciprocity: The Supply of Public Goods through Voluntary Contributions. The Economic Journal 94, December: 772-787.

Waelti, J.J. 1985. Cost Sharing for Federal Water Projects: Trends and Implications. Water Resources Research 21(2): 153-158.

PROFILE C:

THE MANAGEMENT OF LAKE DIANCHI - CHINA

Liu Hongliang and J. Zhang

Lake Dianchi is a fresh water lake located within the jurisdiction of Kunming Prefecture, the capital of Yunnan Province in southwest China. Approximately 100 years ago, it was recorded that the lake surface was more than $500km^2$. Nowadays, this has been reduced to $307km^2$. This decrease in surface area has been caused by deforestation in the upper stream catchment area, which resulted in soil erosion and siltation. Another cause of the reduction of the lake capacity can be directly blamed on the misleading policy in the period from the 1950s to the 1970s which overly emphasized grain production. This resulted in government-organized land reclamation from the lake and the surrounding marsh for grain farming. The same policy overly stressed economic growth, promoting the development of heavy industry and ignoring the environment's capacity for recovery. The rapid development of industry and the expansion of the urban population without consideration for pollution control resulted in a drastic increase in untreated wastewater discharged into the lake. Land reclamation and deforestation affects the storage capacity of the lake and weakens the function of rainfall collection and storage in the whole catchment area. Water shortage is therefore a vital problem in Kunming Prefecture, which is complicated by the deterioration in water quality in general.

Past experience shows that the neglect of environmental factors in economic planning may cause irreversible damage to the natural system, which may in turn restrict further development.

This chain of events has gradually slowed down since the establishment of environmental agencies at all government levels in the late 1970s and the setting up of a monitoring and inspection system of the entire water system including ditches and pipes for wastewater discharge. The accumulation of environmental data through monitoring and various research projects has improved the understanding of the entire water system. This has encouraged the establishment of a basin-wide eco-management strategy, which was legislated in early 1988 as the Ordinance for Lake Dianchi Protection.

In order to implement the ordinance, the Outline of the Comprehensive Plan for the Renovation of Lake Dianchi was formulated one year later. The outline presents the objectives of the renovation plan in three stages for a period of 20 years. At the end of this period, the water quality of the lake should achieve grade 3 of the national surface water standards through ambitious pollution control programs including a total discharge control program, the implementation of effluent standards and effluent fees, construction of five sewage treatment plants, and dredging. With respect to water supply, the outline proposes various water resource development projects and a large scale afforestation project in order to meet the projected demand in the year 2010. Institutional arrangements are also specified. Up to 10 sectorial plans with strong environmental considerations shall be drawn up; 17 regulations and measures for the enforcement of the ordinance are to be formulated; and a new organization named the Lake Dianchi Protection Commission directly subordinate to the prefectural government is to be established to achieve the unified management of the water system. Consequently, it is expected that the coordination between sectors related to water use and protection will then be strengthened. On the demand side, the new policy promotes metered water fees and will set water quality standards and water use permits. Even tradeable water rights and effluent rights are under consideration.

Some of the above-mentioned renovation projects have been accomplished, and many others are in the planning stage. Although large major efforts are still required, the management of Lake Dianchi has been substantially redirected in a positive way.

PROFILE D:

LAKE BIWA

N. Nakamura

Lake Biwa, the largest lake in Japan, is located in the uppermost reaches of the Yodo River Basin in central Honshu island and occupies one-sixth of the of Shiga Prefecture. In the downstream reaches of the basin are the metropolises of Kyoto, Osaka and Kobe and other smaller municipalities in Kyoto, Osaka and Hyogo Prefectures, with a total population of 13 million, for which the lake supplies water for domestic, industrial, hydroelectric and irrigation purposes.

The lake measures 63.5 km in the north-south direction and is divided into two subbasins at the constriction point approximately 16 km from the southern end. It has a total surface area of 674 km^2, a volume of 27.5 billion m^3, and a shoreline length of 235 km. Its catchment area is 4.7 times the lake itself, which corresponds closely to the prefectural boundary. The catchment area consists of forest-covered hills and mountains (60%), paddy fields and other farmlands (25%) and urban and industrial areas. The prefectural capital, Otsu, has an approximate population of 240,000 and is located at the southern end of the lake.

Throughout history, there have been conflicts in water use and managment between upstream Shiga and downstream areas, first with respect to flood control and then to water resource development and more recently to water quality management.

As for flood control, the communities in the immediate surroundings of Lake Biwa suffered from many severe floods for centuries before the central government finally agreed, approximately a century ago, to carry out major dredging work in the Seta River, the only outflowing river from the Lake. Seta Weir, the only artificial water flow control facility of the lake outflow, was also constructed at about this time. With these and other flow control measures introduced over the past century, flooding is no longer a major threat either for Shiga or for downstream areas.

As for water resource development, the demand for lake water by the downstream megalopolises in the 1960s led to the Lake Biwa Comprehensive Development Plan in 1972, in which development of a new water resource amounting to 40 m^3/sec was agreed upon by Shiga and downstream prefectural and municipal governments, as well as by the National Government. This additional amount of water is to be made available upon completion by 1992 of all the lakeshore reinforcement works and other compensatory public works projects for Shiga Prefecture. There is uncertainty, however, whether the projects will be completed on time and whether the water can in fact be made available in time, despite the claim by the downstream governments.

In the meantime, the lake water quality has been worsening over the past several decades due to population growth and various development activities within the catchment area. Some environmentalist groups have blamed the Comprehensive Development Project itself. Shiga Prefecture is now under pressure to improve the lake water quality through various wasteload reduction measures as well as in-lake clean-up attempts. It has also been airing its frustration recently by arguing that the downstream governments should bear, in addition to the amount paid within the framework of the Comprehensive Development Project, part of the cost incurred for improving the lake water quality, since most of the benefit accrues to the downstream users. It has received so far a rather cool response to this unofficial proposal.

SECTION 4

SOCIAL AND ENVIRONMENTAL PROBLEMS OF LAKE/WATER RESOURCE DEVELOPMENTS

SECTION 4.1

LOCAL SOCIAL AND ENVIRONMENTAL IMPACTS OF WATER RESOURCE DEVELOPMENTS

Antoine Sendama Mulashi

4.1.1. INTRODUCTION

To the majority of people, large dam-construction and associated man-made lakes conjure up an image of unleashed potential for socio-economic development. They see in this a quick and guaranteed source of clean and cheap hydro-electric power, a means of controlling flooding in regions downstream of the dam, a source of abundant fish supply and a national status symbol symbolizing wealth, power and feats of technological achievements.

Rarely do people associate the construction of a man-made lake with such undesirable consequences as extensive cultural destruction, increased diseases and costly environmental damage. Seldom indeed does it seem to occur to people that unless stringent environmental considerations are taken into account, those for whom the dam is said to be built are bound to suffer unnecessarily, and that the huge investments ploughed into the project may never be recovered.

This paper, which draws on current information and data on man-made lakes in Africa, examines the social and environmental impacts of the lakes on the local population living in the immediate environs of the lake.

4.1.2 LOCAL SOCIAL AND ENVIRONMENTAL IMPACTS OF WATER RESOURCES

Displacement of Population

Ideally, dams ought to be constructed only in areas that are either uninhabited or that are sparsely populated. Clearly this often cannot be possible. Therefore prior to flooding, the people who live in earmarked dam sites have to be moved and resettled elsewhere. As Table 4.1.1 shows, it can be seen for example that establishment of six African lakes has led to thousands of people being displaced.

Though such a displacement has its inherent unwelcome aspects, it also carries with it (if well planned) an opportunity for the authorities concerned to make available to the relocatees better housing and social amenities that would improve their lives. However, this can only be possible if resettlement of these people is thoroughly planned, not carried out in haste, and if the necessary financial and human resources are available. The evidence available suggests that in most cases to date, the resettlement process has been anything but well planned.

For instance, with the construction of Lake Masinga on the Tana River, an estimated 4,000 to 6,000 persons were displaced (Rogerri, 1985). These suffered different fates depending on which side of the river they had been living on before the flooding. Those on the left bank of the Tana River had been living on government trust lands; prior to the construction of the Masinga dam they were moved by the government to new lands; an evaluation was made of their crops in the fields and the improvements made to the land and they were compensated for these losses. However, they were not compensated for the land since this was state land. As for those on the right bank of the river -- which was freehold land -- they received compensation for their land and were also compensated for the crops in the field and for the improvements made to the land. But how and where to settle was for them to handle. One would have expected that those settled by the government on new lands would have been helped to establish new homes but this was not the case. The displaced had to organise themselves in order to find or build new homes.

Table 4.1.1
People Displaced by the Construction of Six African Lakes
(Rogerri, 1985; Goldsmith, 1986)

Lake	Country	Number of people displaced
Masinga	Kenya	4,000 - 6,000
Kariba	Zambia/Zimbabwe	86,000
Volta	Ghana	80,000
Cabora Bassa	Mozambique	about 25,000
Masser	Egypt	120,000
Kainji	Nigeria	50,000

What was clear was that though the construction of the dam brought about the displacement of thousands of people, the authorities responsible for the construction of the dam did not plan any resettlement programme worthy of the name (Roggeri, 1985). This is disappointing given the fact that by the time of the completion of Masinga dam (1961), abundant information existed relating to the problems of forced displacement of people by man-made lakes and clearly detailing mistakes made in the past. Therefore, the replication of similar mistakes could have been easily avoided.

If those displaced by Masinga Lake seem to have gotten off lightly this was not the case with those displaced by the creation of Lake Kariba almost two and a half decades before. The creation of Lake Kariba caused the displacement of 86,000 people, mainly of the Tonga tribe. They violently protested and struggled to keep their homelands, but in vain. They were made to abandon their rich alluvial valley and were resettled on less fertile upland soil which was hardly enough for them. In addition, during the process of their relocation, due consideration was not given to existing cultural differences between the relocatees and host communities. Displaced communities were simply split up and people from different ethnic backgrounds and speaking different languages with different social customs were lumped and settled together without due regard for these differences. Thus the resettlement caused resentment and conflict between the two communities because of these differences (Linney and Harrison, 1981).

Following this disastrous resettlement programme, it emerged that in actual fact no detailed study had ever been undertaken to assess the best areas for resettlement of the displaced persons (Goldsmith and Hildyard, 1984). Thus again, inept planning subjected tens of thousands of displaced persons to sufferings and relocation stress that could have been otherwise avoided.

Though the constraint of space does not allow a more detailed examination of this question, it is a fact that elsewhere on the continent where large man-made lakes have been constructed the scenario remains much the same. It is characterized by little or no attention being paid, by the authorities responsible for dam construction, to the social impacts of the lake on the local people.

Even in the few instances where the relocation of the displaced persons had been planned for to some degree, other factors mitigated against this. One such interesting example is Lake Volta. In this case, thorough advance planning through the Volta Lake Preparatory Commission had been done prior to improvement. Hence there was no reason why the 80,000 persons displaced by the creation of the lake should not have been properly resettled. Yet this is exactly what happened. It had been envisaged that the displaced persons were to be resettled in 52 resettlement sites over a period of 3-4 years before the closing of the dam. However, a hitch developed as the cost of resettlement had been grossly underestimated and by the time of resettlement, only 2 years were available for doing so. The siting of the settlement had taken the wishes of the people into consideration and located the resettlement towns on their traditional lands (Linney and Harrison, 1981), but not enough good land was available for the farmers. Land disputes and outbreaks of violence became increasingly common as the resettlement scheme got under way (Goldsmith and Hildyard, 1984).

The picture that emerges from these limited examples suggests that the hundreds of thousands of people forcefully displaced by the construction of dams in Africa, have had to endure undue hardships and sufferings occasioned in the main by poorly planned resettlement programmes. Further, even where thorough resettlement programmes had been worked out, underestimation of the cost of resettlement and bad timing have negated the gains that would have been otherwise made. Given the extensive knowledge gathered from the mistakes of the past, there was no justification for repeating them.

It should therefore be the policy of donor agencies and recipient governments to ensure that, in all cases of dam construction, comprehensive resettlement programmes constitute an indispensable facet of the project.

4.1.3 DRINKING WATER SUPPLY AND SANITATION

The most obvious effect of dam construction is the creation of a reservoir of water; yet surprisingly, information related to dams' impact on the drinking water supply of local communities in the environs of man-made lakes, and on sanitation, is almost non-existent. This absence of such information could lead to the assumption that the provision of safe water and adequate sanitation to local communities has always constituted an integral part of all dam-construction projects and thus need not be dwelt on at length.

However, available evidence suggests that certainly this has not been the case. On the African continent for example, major man-made lakes like Volta, Kariba, Cabora Bassa, Nasser, Kafue and Kainji were either constructed for hydro-electric power production or for flood control and use in irrigation. In general there are no drinking water supply networks constructed on the sites of these lakes (Rogerri, 1985). In addition, as already indicated, even the people displaced by the construction of the lakes and relocated elsewhere, are inadequately supplied with drinking water supply networks. Hence, the local communities living around these lakes have to supply their water themselves; they do so by using water obtained directly from the lakes for their drinking and other domestic needs.

It can therefore be seen that in general the establishment of man-made lakes in Africa has not helped improve the water supply to the local communities living around the lakes. This becomes even more evident given the fact that the lakes are built on permanent rivers.

What may not be clear is that several factors tend to render a large water reservoir unsuitable for human use without treatment. For example, dam construction severely reduces the rate at which water flows; this tends to encourage the proliferation of micro-organisms, many of which are injurious to human health. In addition, dam water tends to be polluted with all kinds of pollutants like human excreta, chemical fertilizers and solid matter particles brought in by the river.

The creation of a man-made lake without the corresponding provision of clean and adequate water to the local population living around the lake not only loses a great opportunity, but also exposes the population to the risk of all sorts of water-borne and water-related illnesses. Yet dubious economic considerations seem to have made those responsible for dam projects in Africa do just that. Rarely have steps to reduce the risk of the spread of diseases, and to better the lives of those who live in the areas around the lakes (for example by supplying them with drinking water supply networks and sanitary facilities), been incorporated in the construction of dams on the continent.

4.1.4 HEALTH

If planned correctly, the construction of a large dam can have beneficial effects on the health of the local population. However, it could also render a region more vulnerable to disease. The large mass of water created can carry many communicable diseases serving both as a transfer-medium and as a habitat for vectors and intermediate hosts. Diseases which did not previously exist in an area may appear with dam construction, while the prevalence and intensity of some that appeared only at low levels may increase.

Unfortunately, the current record of African dams indicates that dam construction has largely had only detrimental effects on the health of the local population. For instance, the construction of the Aswan High Dam led to a sharp increase in schistosomiasis (bilharzia). Schistosomiasis is a water-related disease transmitted by aquatic or amphibious (living both on land and in water) snails. After the completion of the Aswan Low Dam, the number of persons attacked by bilharzia in the local community rose from 21 to 75 percent; with the completion of the High Dam this rose to 100 percent in some areas (Lanoix, 1958). Nor were these isolated pockets infested with the disease. Four carefully selected areas for study indicated that with completion of the dam the number of persons attacked by bilharzia had risen from 10 to 44 percent; 7 to 50 percent; 11 to 64 percent, and 2 to 75 percent (Biswas, 1980). To date bilharzia remains endemic in vast areas of Egypt even where it was unknown before the construction of the Aswan Dam (Linney and Harrison, 1981).

The creation of Lake Volta, like that of Lake Nasser, largely had negative effects on the health of the local population. Its construction was followed by the escalation of schistosomiasis brought about by a combination of factors. Abundant nutrients in the young lake led to a bloom of aquatic weeds that provided a habitat for the vector snails. In addition, fishermen, many of whom were already infected, migrated to the lakeshore with the completion of the lake. Despite this, the increase in the incidence of the disease would have been limited if the people resettled with the construction of the lake had been provided with adequate drinking water supplies. Since this had not been the case, most of them had to resort to lake water for their needs. This increased human contact with water caused infection rates to increase greatly. In different areas around the lake, the infection rate rose from 1% and 5% to 60% and 100% (Rogerri, 1985).

The experience of Lakes Nasser and Volta is by no means unique; the construction of Kariba in Zambia/Zimbabwe, Kainji in Nigeria, Cabora Bassa in Mozambique, Masinga in Kenya, Kafue in Zambia, and Kossu in Ivory Coast have all led in some degree to a marked increase in the incidence of bilharzia in the local community. In many of these cases the prevalence of some other water-borne or water-related diseases, for instance malaria, elephantiasis, dysentery and at times river blindness, has also increased.

The cause of this increase is easy to appreciate. Dam construction creates conditions favourable for the proliferation of mosquitoes that transmit malaria and elephantiasis. Further, as already seen, the construction of man-made lakes leads to the displacement and relocation of thousands of people. Yet rarely is the relocation thoroughly planned for and properly implemented, with the relocatees supplied with adequate sanitary facilities. This lack of adequate sanitation facilities in the vicinity of the lake leads to the contamination of the lake water with human excreta and a consequent increase in the water-related diseases like dysentery. In the case of Kariba Lake, its construction also led to increases in the prevalence of sleeping sickness within the Tonga community who on displacement were relocated to an area infested with the tsetse fly.

Large dams have more often than not had deleterious effects on the health of the local population by bringing about a sharp increase in the prevalence of water-borne and water-related diseases in the local populations. Yet measures to combat the spread of the diseases were largely ignored even where pre-impoundment studies had clearly shown that such an increase was likely to occur.

Due to "economic" considerations, basic preventive measures such as improving the lakesides, mounting information and education campaigns, and implementing basic sanitation programmes, all of which would have shielded the local population from much suffering, were neglected. This therefore brings into contention the claim that large water-development projects are aimed at the improvement of the local peoples' well-being. Those involved in the planning, design, financing and construction of large man-made lakes in Africa would do well to ensure that the projects actually serve to uplift the peoples' well-being.

4.1.5 AGRICULTURE AND FOOD SUPPLY

Every nation strives to achieve food sufficiency for its people, but for many countries in Africa this goal has remained elusive with the increase in food production failing to keep pace with population growth. The reasons for this failure are complex; however, one important hindrance to the expansion of agricultural production is lack of sufficient moisture in the soil. Therefore, since a dam makes it possible to irrigate land lacking in moisture, it can have far-reaching effects on the food security of a region or country.

A dam can exert influence on an area miles away from its site, but in this paper only its impacts on agriculture and food supply in its surroundings will be examined. As Table 4.1.2 shows, the most dramatic impact of dams on agriculture has been the loss of vast areas of land submerged under water and the displacement of thousands of those who worked it. When this loss is followed by resettlement on less fertile and insufficient land, as has often been the case in Africa (Section 4.1.2), agricultural productivity and local food supply is adversely affected.

Silt entrapment within the dam has considerable impact on agricultural productivity as well. Before the construction of the Aswan dam, the Nile floods spread tonnes of silt downstream. The silt was a renewing source of fertility and riverine agricultural productivity was high. With the construction of the dam, artificial fertilizers now have to be used to maintain the fertility of the soil downstream at a staggering cost of about $100 million (Goldsmith and Hildyard, 1984).

Table 4.1.2
Land Submerged and People Displaced by the Construction of Four African Lakes

Lake	Hectares submerged (approximate)	Number of people displaced
Nasser	400,000	120,000
Volta	848,200	60,000
Kariba	510,000	66,000
Cabora Bassa	380,000	25,000

However, some increase in local agricultural productivity has at times been achieved with the construction of dams. A case in point is Lake Volta where farming has improved and diversified around the lake shores. The shores of the lake are seasonally flooded and then exposed; this has enabled farmers to grow a number of crops such as maize, seat potatoes and vegetables, even at times when lack of rainfall makes farming impossible elsewhere.

But this is in contrast with the area surrounding the lakes of River Tana in Kenya (Masinga, Kamburu and Kindaruma). The purpose of these lakes is simply to produce electricity. Nevertheless, it would be expected that the areas around the lake should be well provided with water so that crops can grow normally irrespective of seasonal changes. But in a study conducted there (Rogerri, 1985) it became clear that the ground water is at levels well below the reach of the root system and thus this dam has had no beneficial effects on agricultural production.

With regard to fish production, dam construction has led to increased fish yields, though this increase has been inconsistent. As is characteristic of new man-made lakes, the bloom of nutrients in the first few years of impoundment led to a rapid increase in the fish population, then with the stabilization of the lakes productivity decreased and the fish population dropped until it stabilized at an equilibrium generally well below the peak.

Thus, for instance, five years after the formation of Lake Kariba, 3,628 tons of fish per year were being caught. Besides being a source of protein to the local population, this was important to about 2,000 fishermen working the lake. However, with time this yield declined and ten years after the closure of the dam only 907 tons of fish were being caught. By 1978 the fish catch had fallen so much that only a small section of the local population was engaged in fishing (Goldsmith and Hildyard, 1984).

On the Volta Lake the pattern was similar; the 1968 estimated catch was 60,000 metric tonnes, but the level has now dropped off to 42,000 tonnes, a level well below the peak, though still several times more than the catch from the rivers (Obeng, 1977). The decline in fish yield in the man-made lakes in Africa is at times also associated with poor management of the fishing industry besides the decline of nutrients in the lake. For instance, the decrease in the fish caught in Kamburu Lake (Kenya) within a year after the completion of the dam (-37%) seemed to have occurred as a result of improper and uncontrolled fishing; fishermen in the region operating unhindered used very fine nets and even poison to increase their catch (Rogerri, 1985). Understandably, this had a devastating effect of the fish population in the lake.

Storage of large quantities of water by dam construction may make it possible to bring land downstream under irrigation and hence, if well-handled, increase a region's agricultural production. However, for the local people to substantially benefit, irrigation projects at the lakes must be implemented and the supplementary funding required for this budgeted for. These expenditures, measured against the total cost of the dam, and the fact that they would enable the local communities to obtain their food throughout the year regardless of the climatic conditions, are negligible. Nonetheless, where irrigation forms part and parcel of the dam project, necessary measures have to be taken to protect soils and the local populations from its destructive impacts.

With the construction of man-made lakes, the fishing industry viewed as a whole seems to have made some gains. But when these are weighed against the overall social, economic and ecological destructions occasioned by the dams, they pale into insignificance.

4.1.6 PLANT COVER, EROSION AND SEDIMENTATION

Soil erosion commonly takes place in an area where forests have depleted, plant cover is inadequate, soils are organically poor, farming methods are improper and the rains are heavy. When erosion takes place, the run-off water carrying the soil particles may end up in a river. If the rains are heavy and rivers flooded, these sediments -- usually rich in nutrients -- carried by the river are deposited in its flood plains. This is of agricultural importance since it helps the soil renew itself.

The damming of a river therefore prevents the sediments and other solid matter carried by the river from flowing downstream. This makes the sediments accumulate in front of the dam. Consequently, soils situated downstream are deprived of the nutrient-rich sediments and their fertility has to be maintained by use of fertilizers. Further, due to this impeded flow of sediments, the dam's reservoir gradually fills up with the sediments. This not only affects the quality of its water but also reduces the period during which it remains usable. By filling, or silting up, a dam's usefulness with regard to flood control, water supply, navigation and hydro-electric power production is diminished.

Given the present level of deforestation in Africa due to the usage of wood for fuel and the need to increase available land with increasing population, dam siltation poses a serious problem. Thus the construction of Kariba dam and its trapping of silt from the river's catchment area have caused the recession of the delta 80-100 km below the dam (Linney and Harrison, 1981).

The Akosombo Dam on Lake Volta retains even more sediments and the effects of this are more pronounced. Before the construction of the dam, the Volta River, which flows into the Gulf of Guinea,used to carry sediments from its catchment areas right up to the Ghanaian coast. The sea spread these sediments along the coastline right up to Togo, thus making up for erosion by sea waves. With the completion of Akosombo Dam much of the silt is retained in the lake and the coastline has been significantly eroded.

The effect of siltation of Lake Nasser on the fertility of the soil downstream, and the huge sums of money that this costs Egypt, has already been mentioned and needs no further elaboration (Section 4.1.5). But even relatively smaller dams -- for instance Lake Kamburu (Kenya) -- are not immune from this danger of siltation. Lake Kamburu now gets 5.6 million tonnes of sediments -- eight times as much sediments as had been assumed in working out its useful lifespan at its conception (Odingo, 1979). Clearly this indicates the degree of the erosion of the catchment area and of the bank of the River Tana. Despite the magnitude of the problem and the fact that the authorities are quite well aware of the problem, no reforestation or embankment policy has been established in the areas through which the river and its tributaries run (Linney and Harrison, 1981).

One other impact of man-made lakes in Africa that cannot be ignored is the submersion of forests and vegetation which indeed are sometimes difficult to replace (Ahmad, 1962). Although figures are not available for the total loss of forests and vegetation in Africa to dam projects, these have caused the drowning of thousands of acres of forests and vegetation. Thus, for instance, the area now submerged by Lake Volta was mainly under the cover of riverine forests of varying width and savannah woodland. Given that approximately 848,200 hectares of such vegetation was submerged under the lake the impact of dams on forests and vegetation becomes clear.

Lake Volta was no isolated case. Others, like Cabora Bassa,which submerged about 360,000 hectares of land, or Lake Kariba, which led to the submerging of 510,000 hectares of land, illustrate the point further.

To a certain extent each man-made lake on the continent is under the threat of siltation. This has serious implications since the construction of man-made lakes involves the expenditure of large, usually borrowed, sums of money. Furthermore, being such a costly undertaking with far-reaching social, economic and environmental impacts, maximum benefits ought to accrue if their construction is to be at all justified. Yet siltation can bring a dam's useful life to a quick premature end, reducing the time in which the dam has to pay for itself.

Since soil erosion and especially the erosion of the river's banks and catchment area greatly affects the rate of siltation of the lake, it would make good economic sense to include programmes for soil conservation and re-afforestation into dam construction projects. However, this can only be achieved if donor agencies and recipient governments consult more and arrive at decisions related to dams jointly.

Sound economic and environmental considerations call for the integration in the dam schemes of those measures that increase the chances for the recovery of the funds invested in the project and conservation of the continent's basic natural resource, its soil.

4.1.7 HYDRO-ELECTRIC POWER

The primary purpose of large dams in Africa has usually been for hydro-electricity production; in 1980 Africa was producing 3,207 billion KWh and had an estimated 3,210 billion KWh in the process of development or soon to be developed (Biswas, 1983).

To begin with, from the 70's onwards, the price of oil has been sharply rising, and thus a number of countries have been looking for ways of reducing their dependency on oil, as it consumes a large portion of their hard currency earnings. However, water being a national resource, hydro-electricity production ensures that a country has a reliable and stable source of energy produced locally. Further, relative to diesel, steam or nuclear forms of energy, the cost of producing electricity is low.

Unfortunately, the hydro-electricity generated is generally used to supply towns or industries at the expense of the rest of the country. In fact, whereas electricity is seen as an essential form of energy in the developed countries, in most African countries it is a luxury (Wabulengo, 1989).

There are several reasons why rural electrification has not taken off in Africa despite the fact that the electrification of these areas has been the declared intention of many African countries for many years. To begin with, rural areas of Africa are not usually densely populated; settlement areas are scattered widely and are not industrialised. This makes it difficult to supply electricity to these areas at a reasonable price. Further, since rural people are to a large extent poor, the agencies supplying electricity fear that they would not recover their investments easily if they were to embark on a programme of rural electrification.

In general, therefore, electricity generated as a result of the construction of the major dams in Africa is channeled to the national grid and then distributed to towns and other electrified areas. For instance, the electricity produced at Akosombo Dam in Ghana is used by Kaiser aluminium mines and also exported to neighbouring countries; that from Lake Kariba is used for coal and copper mines in Zambia; that from the Inga Dam in Zaire is meant for the Shaba mine; and the 174MW of electricity from the lakes on River Tana is supplied mainly to towns.

In terms of electricity, as in most other aspects, the local population stands to benefit little. Governments in most cases opt to supply the urban centres and industrial towns with electricity, since these consumers can be reached easily and are able to pay installation and maintenance costs. This is in marked contrast with some developed countries where the areas around lakes are supplied with electricity free of charge, or according to preferential rates (Rogerri, 1985).

4.1.8 CONCLUSION

It is not possible in the confines of this paper to fully examine the impacts of dams on their immediate environments and on the communities living around them. Nonetheless, the picture that emerges from this brief study merits the attention of donor agencies, recipient countries and other interested parties such as local communities and NGOs.

To begin with, it is evident that the local community benefits little from the presence of such man-made lakes. This is true, be it a matter of availability of drinking water, electricity, sanitary facilities, or the improvement of housing and agricultural production. Furthermore, where families were displaced, they were in most cases improperly resettled, and the regions in which they were resettled had or came to have high incidences of bilharzia, malaria and other water-borne or water-related diseases.

Yet these problems could have been anticipated. Indeed, in many cases the problems were known both to donor agencies and recipient governments, but it was expedient not to deal with them.

What this points to is a need for a more realistic approach to cost-benefit analysis -- one that includes both social and environmental conservation measures and impacts at the local level in the dam project appraisals. If man-made lakes are to be of benefit to the local communities as it is purported, and if their record of disaster with regard to their impacts on the environment is to be curbed or minimized, the way in which they are planned, developed and maintained is of fundamental importance.

Failure to give adequate recognition to the need to integrate social and environmental factors in the implementation of the dam projects will continue to be a recipe for disastrous consequences.

REFERENCES

Ahmad, J.Y. 1982. Irrigation in Arid and Semi-Arid Areas. United Nations Environment Programme. Nairobi.

Alexis, L. 1984. The Damnation of Paradise. The Ecologist 14(5/6). December.

Anonymous. 1985. To irrigate or not to irrigate is Kenya's question. The Weekly Review. 1 Feb. 1985. Kenya.

Balon, K.E. 1978. Lake Kariba. Ambio 7(2).

Biswas, A.K. 1980. Water Management for Arid Lands in Developing Countries. Oxford.

Chambers, R. 1970. The Volta Lake Resettlement Experience. Pall Mall.

Goldsmith, E. and Hildyard, N. 1984. The Social and Environmental Effects of Large Dams.
Goldsmith, E., and Hildyard, N. 1986. The Social and Environmental Effects of Large Dams, Volume 2: Case Studies. Wodebridge Ecological Centre. U.K.

Hort, D. 1980. The Volta River Project: A Case Study in Politics and Technology. University Press. Edinburgh.

Lanoix, N.J. 1958. Relation between Irrigation Engineering and Bilharizias. Bulletin of the World Health Organisation.
Linney, W. and Harrison, S. 1981. Large Dams and the Developing World: social and environmental costs and benefits - A look at Africa. Environment Liaison Centre. Nairobi.

Obeng, L.E. 1969. Man-Made Lakes. The Accra symposium. Ghana Academy of Sciences. Ghana.
Obeng, L.E. 1981. Man's impact on tropical rivers. In Lock, M.A. and Dudley, W.D., eds. Perspectives in Running Water Ecology. Plenum Press. New York.

Rogerri, H. 1985. African Dams Impacts in the Environment. The social and environmental impacts of dams at the local level: A case study of five man-made lakes in Eastern Africa. Environment Liaison Centre. Nairobi.

Smolowe, J. and Colton, E.O. 1985. Reassessing the Swan Dam. Newsweek, 25 February l985.
Symoens, J., Burgis, M. and Goudet, J. 1981. The Ecology and Utilization of African Inland Waters. United Nations Environment Programme. Nairobi.

Walubengo, D. 1969. Rural Electrification Issues and Options from a Southern Perspective. Ecoforum 14(2). December. Environment Liaison Centre International. Nairobi.

PROFILE E:

THE SOCIAL IMPACTS OF THE CREATION OF LAKE KARIBA

C.H.D. Magadza

1. INTRODUCTION

The social impacts of the construction of Lake Kariba can be divided into those that immediately became manifest in the early stages of the project, and those that have taken a much longer time scale to unfold.

Prior to the inundation of the Gwembe valley, the Valley Tonga lived astride an international border as a single social group, making extensive year-round use of the flood plain of the Zambezi River (Scudder, 1971). Their population was estimated at 86,000 people, with 55,000 in Northern Rhodesia and 31,000 in Southern Rhodesia.

Lake Kariba divided the Tonga into two separate political populations. There were no provisions to give the Tonga families choice as to which side of the lake they would prefer to settle on so as to retain the coherence of their family groupings.

2. PRIMARY IMPACTS

The resettlement areas to which the Tonga were moved consisted of mosaics of Karoo sandstone derived soils and alluviums with a high frequency of sodicity and poor rainfall. In these areas only one rain-fed crop per year could be raised. The frequent occurrence of droughts and uneven seasonal distribution of the rain resulted in unreliable production systems.

In addition, the remoteness of their settlement from central services meant that there were limited state services. The Gwembe Valley has endemic diseases such as malaria (plasmodium), sleeping sickness (Tyrpaosoma rhodesiensis), and filarial elephantiasis (Filaria bancrofti).

The combination of these factors led to famine, whose severity has been reconstructed by Weinrich (1977). Thus the immediate impact of the displacement of the Tonga were:

1. Disruption of social structure by separation of closely related family groups, leading to the collapse of peer support systems. Colson (1971) records suicidal deaths among young wives due to lack of elder support in crises.

2. Loss of a flexible flood production system which minimized famine risk.

3. Lack of alternate employment to offset the losses incurred by the displacement, coupled with a lack of state support services, leading to a general psychological despair.

The overall effect was to produce an embittered national minority that, above all, possessed neither the institutional nor the political facilities through which to seek redress.

3. SECONDARY IMPACTS

It is not possible here to give a comprehensive account of the second generation social impacts of Lake Kariba as these are still unfolding. Two major factors have been responsible for the shaping of the secondary social impacts of Lake Kariba. First is the eradication of the tsetse fly, Glossina morsitans, in the belief that this would remove a major constraint to food production by enabling the introduction of cattle for draft power. The second factor was the unpredicted entrepreneurship opportunities the lake would create for those with disposable incomes to invest in exotic ventures such as tourism.

The eradication of the tsetse flies from the Zambezi valley not only enabled the Tonga to keep livestock, but opened opportunities for land-hungry communities on the plateau to move into the valley, thus intensifying environmental stress in this fragile ecosystem (Magadza, 1986). The use of DDT in the control of tsetse flies and mosquitoes has resulted in the accumulation of this pollutant in the Lake Kariba aquatic ecosystem (Magadza, 1989; SEMG, 1987).

The transmigration into the valley also abruptly introduced a cash economy, resulting in a sudden increase in the cost of living (FGU-Kronberg Consulting and Engineering GMB, 1988), all of which has gone into making the Tonga an alienated minority in their own areas. The relatively high unemployment rate has also led to an upsurge in sexually transmitted diseases.

The overall impact of these factors is that thirty years after the creation of Lake Kariba the original inhabitants of the Zambezi valley are still an impoverished people, accounting for the greatest proportion of malnutrition related morbidities reported at Kariba District Hospital.

Furthermore, the destruction of the plant cover by uncontrolled fires as well as clearing for cultivation has resulted in high silt loads in the rivers flowing into Kariba, as well as converting perennial streams to seasonal ones.

REFERENCES

Colson, E. 1971. The Social Consequences of Resettlement: The Impact of Kariba Resettlement upon the Gwembe Tonga. Manchester University Press.

FGU-Kronberg Consulting and Engineering GMB. 1988. Land Use Study of the Tsetse Fly Infested Omay Communal Lands. FGU-Kronberg Consulting and Engineering GMB, Sondener Strasse 6, Postfach 1266, 6240 Koningstein, West Germany.

Magadza, C.H.D. 1989. Synopsis of the SAREC sponsored project on Ecology of Lake Kariba. In **Magadza, C.H.D., ed. U.L.K.R.S. Bulletin No. 1/89**: Ecology of Lake Kariba. The University Lake Kariba Research Station, University of Zimbabwe.

Magadza, C.H.D. 1986. Conflicts of Resource Use on Lake Kariba Environs. Nature and Resources 22(4).

Regional Tsetse and Trypanosomiasis Control Programme, Malawi, Mozambique, Zambia and Zimbabwe. 1987. Environmental monitoring of tsetse control operations in Zimbabwe. 1986: Impact of spraying and odor-baited targets on treated ecosystems. Scientific Environmental Monitoring Group Report. 5th EDF Account No. 5100.35.94.269. Saarbrucken.

Scudder, T. 1971. Gathering among African Woodland Savannah Cultivators: A Case Study of the Gwembe Tonga. Institute of African Studies, University of Zambia, Lusaka.

Weinrich, A.K.H. 1977. The Tonga People of Southern Shore of Lake Kariba. Mambo Press.

SECTION 4.2

PROBLEMS AND ISSUES IN COMPENSATORY MEASURES RELATED TO WATER RESOURCE DEVELOPMENTS

Saburo Matsui

4.2.1. PROBLEMS AND ISSUES

Among the various types of water resource development projects, dam and reservoir construction have perhaps the most significant social and environmental effects. These projects often create problems of involuntary resettlement due to the inundation of houses as well as land. People dislocated by a large project may lose a variety of assets such as properties, employment opportunities, fishing waters, irrigation works, standing crops, and trees. In the case of the very poor, even the loss of assets or opportunities that are not normally evaluated as an economic value may be disastrous. Such opportunities include the collection of roots, berries or leaves for dietary supplement or sale.

The adverse consequences of displacement can be summarized into the key dimensions of the improverishment risk model: 1) landlessness, 2) joblessness, 3) homelessness, 4) marginalization, 5) food insecurity, 6) morbidity, and 7) social disarticulation (Cernea, 1990). The key dimensions often interact with each other and even tend to reinforce each other. It is therefore necessary to find solutions which avoid the unnecessary displacement of people or reduce the number of people who are displaced to a minimum. In cases where displacement is unavoidable, it is necessary to find ways of mitigating the adverse effects on the displaced people.

Government laws and regulations relating to expropriation of property by the state are generally used to define the procedures for valuation of, and compensation for, the property lost in cases of forced resettlement. However, such national laws and regulations governing compensation are sometimes outdated, or lacking in precision or appropriate mechanisms, and therefore very often do not prevent serious hardship and suffering of the dislocated people.

The World Bank guidelines point out that "experiences with the resettlement of large populations tend to show that payment of cash compensation alone is often a very inadequate strategy for dealing with the dislocated; in some instances, the entire compensation has been used for immediate consumption purposes, leaving the dislocated with nothing to replace their lost income-generating assets and opportunities." The World Bank concluded that the "land for land" approaches are to be firmly supported instead of "cash compensation" (Cernea, 1988; Cernea, 1987).

In resettlement planning, housing at new sites, sanitary facilities, drinking water supply systems, schools, health care facilities, etc. are another major component in addition to compensation for private assets. When the population of the dislocated group is large, the compensatory measures to the group as a whole become complex. Depending on the situation, a variety of measures to provide infrastructure are needed to support reconstruction of a new social organization in the new place.

Another essential component of the resettlement planning process is the need to provide support program for the host community. In the situation where the ratio between the incoming resettled population and the host population of the receiving areas is high, the host population may face increased pressures on its society as well as on the area's natural resources. Compensatory measures to the host population are also necessary in this case.

4.2.2 JAPANESE EXPERIENCE OF COMPENSATORY MEASURES FOR SOCIAL AND ENVIRONMENTAL EFFECTS OF WATER RESOURCE DEVELOPMENTS

It may be worthwhile to begin by briefly reviewing the history of Japanese water resource development in terms of compensatory measures and to try to analyze the problems.

First of all, historically the New Constitution and the Imperial Constitution established the rights of private property which are at the foundation of the compensation system. In water developments projects there have always been conflicts between new and existing water rights. Thus the construction of a new inevitably creates new conflicts and the new for conflict resolution. This conflict resolution in relation to water rights is usually a long and protracted process involving a number of bureaucratic systems of central and local governments, and various water users. Only after the settlement of these conflicts can the water development project be initiated.

In parallel with the history of the development of water resources in Japan, institutional and organizational compensatory measures began with irrigation projects and gradually expanded to water supply and hydroelectricity projects in the period from about 1870 to 1920s. The industrialization of Japan increased the demands for electricity, which in turn fostered the development of water resources projects. The need to coordinate the competition among various water demands led to comprehensive planning of water resource developments, including compensatory measures for social and environmental effects, in many river basins.

At the end of World War II, Japan implemented programs to try to restore its infrastructure, farm lands and for flood control and afforestation. The ensuing water resource development projects followed the example of the Tennessee Valley Authority (TVA) development projects, introducing multi-purpose dams. During the 1960s and 70s, rapid industrialization and urbanization in many cities created new large-scale demands for water resources. However, many cities faced water shortages due to the delay of water resource development projects. Utilization of groundwater for industry induced subsidence of ground levels in many cities which still continues to date.

Japanese society has developed in a number of complex stages which in part explains the present complexity of laws and regulations. The organisation responsible for undertaking a particular water development project, in addition to its efforts to deal with the conflict resolution process, must clear many hurdles related to these laws and regulations before construction can begin. Furthermore, the project undertaker must negotiate a compensation deal with those people who may lose their property of livelihood as a direct consequence of the development project. In the past, the negotiation period was normally less than 20 years. But more recently, 20 years or more is the norm with further delays expected in future.

Table 4.2.1 shows the number of dams constructed during different periods by different organizations for water resource development. Suitable catchment areas for the construction of new dams have recently become very difficult to find.

Table 4.2.1
Number of Dams Constructed under Water Resource Development Projects in Japan (Takebayashi, 1981)

Organization	pre-1950	51-60	61-70	71-80	Total
National Government	1	19	16	16	52
Water Resources Development Public Corporation	0	0	4	9	13
Local Governments and others (multi-purpose dam)	8	29	34	49	120
Local Governments and others (flood control dam)	0	2	7	35	44

4.2.3 NEED FOR SOCIAL AND ENVIRONMENTAL MEASURES FOR THE DEVELOPMENT OF RESERVOIR AREAS IN JAPAN

Construction of new reservoirs created the following problems in Japan:

1. Development of large-scale reservoirs often involved the involuntary resettlement of people, and the loss of their property as well as their community structure, which in turn affected various socio-economic conditions of neighbouring communities.

2. The communities which are involuntarily resettled are usually mountain or farming villages which suffer from depopulation and an aging population. It was difficult to find new land and employment opportunities for the relocated people.

3. Benefits from the construction of new reservoirs usually accrued to the people who live downstream, while those who lived in the catchment area bore most of the costs. Those upstream people called for more reasonable compensation measures to offset their sacrifices.

The Ministry of Construction in Japan has developed the following approach to measures related to reservoir development:

1. prevention of the depopulation of the communities in reservoir areas;

2. financial aid for the local governments which care for the resettled and host populations;

3. coordination between the costs on upstream and the benefits for downstream populations; and

4. special compensatory measures for re-establishing dislocated people by national and local governments (Takebayashi, 1988).

4.2.4 CLASSIFICATION OF VARIOUS COMPENSATORY MEASURES PRACTICED IN JAPAN

Various compensatory measures for reservoir areas practiced in Japan can be classified into three major categories as follows:

1. re-establishing dislocated people;
2. provision of infrastructure around reservoir areas; and
3. aid to local governments.

Each category can be further sub-divided into different levels.

1. Re-establishing dislocated individuals is supported at three different levels:

- Dam enterprises are required to directly support those affected individuals through compensation, as defined in the General Compensation Order (1962), and/or by special funds, depending on the situation.

- Local governments in the reservoir's catchment area and the downstream organizations which obtain benefits from the construction of the reservoir should support those individuals by various direct and indirect methods, including the provision of new land, new jobs, attracting enterprises to areas downstream of the reservoir, and providing low interest loans to assist those individuals to obtain new land. The "Fund for Special Measures for Reservoir Area Development" has been established recently.

- Reduced taxes on the compensation money.

2. Provision of infrastructure around reservoir areas is conducted at four different levels:

- Dam enterprises should compensate for infrastructure destroyed by the construction of the reservoir as defined by the Infrastructure Compensation Order (1967), and/or should conduct direct replacement construction, and provide necessary infrastructure around reservoir areas.

- Provision of infrastructure defined by the Act for Special Measures for Reservoir Areas Development, and the Act for Provision of Infrastructure Around Regions of Power Generation Facilities.

- Local governments in the catchment area and the downstream organizations which obtain benefits should also provide various types of infrastructure, if necessary. They can use the "Fund for Measures for Reservoir Areas Development" for necessary infrastructure construction.

- Local governments can support various undertakings initiated by the dislocated people based on, for instance, the Act to Promote Mountain Villages Development, the Act for Special Measures to Promote the Development of Depopulated Areas, and various other acts related to the development of local areas and exploitation of forest resources owned by the national government.

3. Financial and taxation aids for local governments are conducted by the following two levels:

- Local governments (cities and towns) in the reservoir areas can put a fixed assets tax on a dam enterprise.

- Prefectural governments can charge an electric enterprise for utilization of stream water.

The above-stated measures can be grouped and compared based on the amount of money used, as shown in Figure 4.2.1.

Key to Figure 4.2.1

1. Money supported by dam enterprises
2. Money supported by national government, local governments, and downstream organizations
3. Money calculated according to the General Compensation Order
4. Money calculated according to the Infrastructure Compensation Order
5. Money prepared according to the Act of Special Measures for Reservoir Areas Development, and the so-called "Three Acts for the Development of Power Resources"
6. Money provided according to various acts relating to local development and exploitation
7. Money supported by the Fund of Measures for Reservoir Areas development and various taxation systems

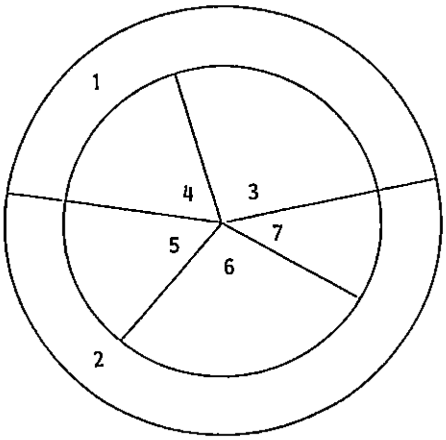

Figure 4.2.1 Classification of Money used for Social and Environmental Measures for Reservoir Areas Development in Japan, according to sources and responsible organizations (from Cernea, 1987).

Key to Figure 4.2.1

1. Money supported by dam enterprises
2. Money supported by national government, local governments, and downstream organizations
3. Money calculated according to the General Compensation Order
4. Money calculated according to the Infrastructure Compensation Order
5. Money prepared according to the Act of Special Measures for Reservoir Areas Development, and the so-called "Three Acts for the Development of Power Resources"
6. Money provided according to various acts relating to local development and exploitation
7. Money supported by the Fund of Measures for Reservoir Areas development and various taxation systems

4.2.5 THE ACT FOR SPECIAL MEASURES FOR RESERVOIR AREAS DEVELOPMENT

The Act for Special Measures for Reservoir Areas Development (ASMRAD) was enacted in 1973. It was the first act in Japan with which effective measures could be provided to cover various problems arising from water resource development projects, such as the construction of dams and the regulation of lakes and marsh water levels.

The aim of ASMRAD is to promote special measures to stabilize the life and promote the welfare of people affected by the construction of dams and water level regulation facilities, through the preparation of infrastructure around the reservoir areas and with a plan for the protection of the reservoir's water quality.

The application of ASMRAD involves the designation of reservoir construction projects or regulation facilities according to conditions described by ASMRAD. Any reservoir construction project which will cause the inundation of more than 30 houses or 30 ha of farmland (in Hokkaido Prefecture, 60 ha farmland) can be designated. Any project to construct a facility for regulating water levels which will benefit more than two prefectural governments by creating large reservoir surface areas can also be designated.

Since enaction, 65 projects have been designated under the law, including the Lake Kasumigaura Comprehensive Development Project and the Lake Biwa

Comprehensive Development Project. The designated reservoir areas are located in more than 33 prefectures. The development undertakers include the Ministry of Construction; Ministry of Agriculture, Forestry and Fisheries; prefectural governments; Water Resources Development Public Corporations and Power Resources Development Corporations.

Various types of infrastructure were constructed with the support of ASMRAD, including forestry conservancy, flood control, land improvement, road construction, water supply, sewerage systems, night soil treatment facilities, solid waste treatment facilities, land creation, public housing health centers, nursery schools, elementary schools, junior high schools, civic centers, fire stations, sport facilities, public gardens, and cable broadcasting facilities.

Of these infrastructure provision investments, the largest amount of money was allocated for road construction (about 50%), followed by afforestation and flood control (about 12%), land amelioration, afforestation and forest roads (about 19%).

It was argued that ASMRAD's coverage needs to be expanded to include joint management facilities for the modernization of farming, afforestation and fisheries, museums of folklore and archaeology, homes for the elderly, children's homes, children's gardens, recreation facilities, and radiotelephone facilities. ASMRAD was amended to expand its coverage to meet the above points in 1978.

ASMRAD was also amended in 1979 to increase the amount of subsidies for the construction of infrastructure when the size of a project becomes larger than the following limits. When the construction of a reservoir or a water level regulation facility is expected to cause more than 150 houses or 150 ha to be inundated, the subsidy must be increased. Likewise, when more than two prefectural governments downstream obtain benefits from a project, and more than 75 houses or 75 ha of land are inundated, the subsidy by ASMRAD is also increased.

Thus ASMRAD has been amended to meet new problems arising from projects of construction of reservoir areas.

4.2.6 THE ACT OF TAXATION FOR THE DEVELOPMENT OF POWER RESOURCES,THE SPECIAL ACCOUNT ACT OF MEASURES FOR THE DEVELOPMENT OF POWER RESOURCES, AND THE ACT OF PROVISION OF INFRASTRUCTURE AROUND REGIONS OF POWER GENERATION FACILITIES

"Three Acts for the Development of Power Resources" were established to promote the development of electric power generation in Japan. These are the Act of Taxation for the Development of Power Resources (ATDPR), the Special Account Act of Measures for the Development of Power Resources (SAAMDPR), and the Act of Provision of Infrastructure around Regions of Power Generation Facilities (APIRPGF).

ATDPR authorizes spending of a portion of electric power rates for the promotion of projects for power resource developments so that the national government can charge consumers a tax on power rates for the development of power resources (500 Yen / 1000 kWH). Based on the tax, the national government can set up special accounts within the national budget for measures to develop power resources authorized by the SAAMDPR.

A portion of the accounts is allotted for local governments which receive power resource development projects related grant support. Local governments can use the grant support to set up infrastructure in the regions of power generation facilities authorized by APIRPGF. Local governments which have power generation facilities inside their administrative boundary providing excess electric power beyond the boundary, can also accept additional grants which can be used to create jobs for the people around the power generating facilities Local governments which have hydro-power generating facilities within their administrative boundary in operation for more than 15 years, can accept grant support when conditions meet the requirements set by the Ministry of International Trade and Industry. The grant-in-aid can be used to mitigate social and environmental effects arising from the hydro-power facilities.

It is obvious that good coordination must be arranged between the measures supported by the ASMRAD and the APIRPGF. The arrangement of the acts obviously needs the following considerations:

1. The area in which ASMRAD-supported infrastructure is built should be as small as a group of several lot numbers, which can meet various small demands of infrastructure by local residents. Instead, APIRPGF supports rather large infrastructure construction conducted by local governments.

2. The projects supported by ASMRAD must be decided prior to any decision on the projects by APIRPGF.

3. When projects supported by ASMRAD are planned, a combination of other national grant support can be introduced, depending on the type of infrastructure. APIRPGF projects cannot be combined with other national grant support for the construction of

infrastructure.

4.2.7 THE FUNDING OF MEASURES FOR RESERVOIR DEVELOPMENT AREAS

Water resource development projects create, to a greater or lesser degree, so-called "upstream and downstream problems". In order to resolve these problems, financial devices need to be created in addition to the measures supported by the national government. Coordination of benefits and costs between upstream and downstream areas has been practiced in the past for water resource development projects with the introduction of various financial systems.

For example, in 1965 the Shiga Prefectural Afforestation Public Corporation was founded with the support of the Shiga Prefectural Government and other neighbouring local governments in the lower reaches of the Yodo River, to conserve forests in the mountains around Lake Biwa, upstream of the Yodo River. In 1973, relating to the Lake Biwa Comprehensive Development Plan, the System of Financing of Lower Reaches, and the Shiga Fund of the Management and Adjustment of Lake Biwa were founded. Furthermore, in 1974 the System of Bearing Costs of Lower Reaches was set up. These systems of funds and cooperation pioneered the development of water resource projects in river basins in Japan. Later, another 15 funding systems were founded for other water resource development projects, including the Fund for Yahagi River Water Resources (1978).

4.2.8 OTHER MEASURES AND NECESSITY FOR FURTHER IMPROVEMENT

People who live in the catchment areas affected by water resource development projects tend to experience the negative costs and need the understanding of the people of the lower reaches of the stream. The "upstream and downstream" problem should be resolved through a combination of various measures, including central government aid and financial aid by local governments from the lower reaches. Another important way is to organize communication between the people from upstream and downstream, to promote a sense of solidarity amongst the residents of the river basin.

The following activities are practiced in Japan:

1. People from the lower reaches go to the reservoirs and clean up the water and the shorelines.

2. Marine products and souvenirs from the lower reaches are distributed to the people in the reservoir areas free or at discounted prices.

3. Agricultural products from the reservoir areas are periodically purchased by the people of the lower reaches.

4. Recuperation and recreation facilities in both the reservoir areas and the lower reaches can be opened for both the upstream and downstream residents.

5. In compulsory education, water resources problems are taught with relevant materials and children are encouraged to visit the facilities of the water resources project.

6. People downstream are informed of festivals and events held by the people upstream and are encouraged to actively participate in them.

7. Public education on the importance of water resource development projects is promoted.

Although both the General Compensation Order and the Act for Special Measures for Reservoir Areas Development can cover many necessary measures for re-establishing the life of dislocated people, compensation is usually made in cash. Substitute land for resettlement has been provided with the aid of local governments. However, it has been difficult to provide substitute land for continuing agriculture and afforestation. There are still improvements needed in the operation of the projects.

It has been more and more difficult to find new reservoir areas in Japan due to many natural, economic and social conditions. It is now more important than ever for the responsible project organizers to collaborate with concerned local governments and organizations which represent the people downstream who benefit from the water resource development project.

4.2.9 CONCLUSION

The construction of reservoirs creates many problems, including the resettlement of dislocated people. In developing countries, institutional and organizational systems for the problems of involuntary resettlement have not been well established. The World Bank's experiences in financing water resource development projects for developing countries can give us important insights into resettlement operations. Japanese experiences of institutional and organizational systems to respond to socio-economic problems arising from reservoir construction are also important. Japanese compensatory measures were developed in a context of rapid industrialization and urbanization on the one hand, and rapid depopulation of mountain villages on the other hand. Similarly rapid industrialization and urbanization is taking place in many developing countries today. Japan's experiences may be a good example for those developing countries which are following a similar course of socio-economic development.

REFERENCES

Cernea, M.M. 1990. Population Displacement and Water Resources Development: current practice, issues and policy responses. Third Expert Group Workshop on River/Lake Basin Approaches to Environmentally Sound Management of Water Resources. Otsu.

Cernea, M.M. 1988. Involuntary Resettlement and Development: Finance and Development. The World Bank. September.

Cernea, M.M. 1987. Social Issues in Involuntary Resettlement Process -- policy guidelines and operational procedures in World Bank-financed projects. The World Bank.

Takebayashi, S. 1981. The Present State of Measures for Reservoir Areas and its Problems. Gekkan Yochi (in Japanese). March.

PROFILE F:

AMAZONIAN RESERVOIRS - BRAZIL

J. G. Tundisi

1. INTRODUCTION

The Brazilian Amazonia covers 60.44% of the territory of Brazil and is the largest hydrographic basin in the world. The region is covered largely with tropical rain forest, and about 5% of it is occupied by floodplains along the Amazon River and some of its tributaries. Theoretically, the Amazon region has an enormous economic hydropower potential with unique environmental conditions, and a disperse, very limited economic development with a population of only 3.12 inhabitants/km^2 (Juras, 1990). Recently, the Amazon region has been subjected to intensive exploitation of its forest and mineral resources, with considerable environmental disruption.

The exploitation of the hydroelectric potential of the Amazon region started as far back as 1968. There are now four power plants in operation (Tuevrni, Samuel, Balbina and Coaracy Numes) and nine planned. Fig. F1 shows the existing and planned reservoirs. The four installed reservoirs were located in areas mainly consisting of tropical rain forest (not removed prior to construction).

The reservoirs in the Amazon region present many problems of environmental disruption of the biogeophysical system, but can also produce many changes in the economic and social systems. Therefore, this is an important case study because of the uniqueness of the region, its main mechanisms of ecological functioning, and the need to balance economic and social development with the exploitation of natural resources. On the other hand, the construction of reservoirs in the Amazon region can be an important agent for regional development, removing pressure from areas to be preserved to maintain the traditional low-scale economic activity.

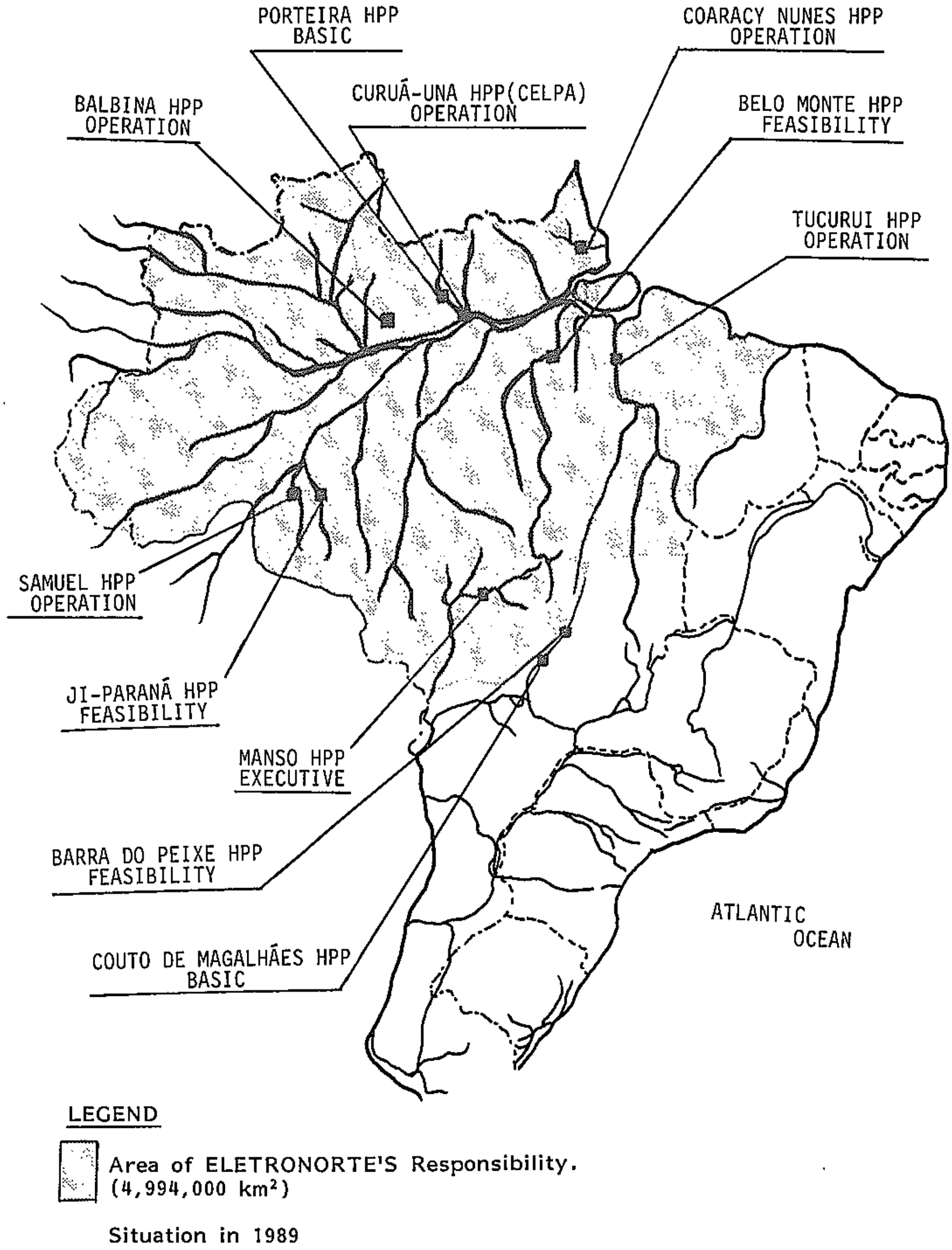

Figure F1. Map of the Amazonian Region with Existing and Projected Reservoirs (from Juras, 1990)

2. THE GENERAL ENVIRONMENTAL EFFECTS OF AMAZONIAN RESERVOIRS

Due to the special characteristics of the Amazonian region, the construction of reservoirs which occupy enormous areas (owing to the low declivity of the rivers) produce several problems in the biogeophysical, economic and social systems. These problems have been addressed by, for instance, Goodland (1977) and Tundisi et al. (1990).:

Chemical effects:
Aerobic decomposition, anaerobic decomposition, oxygen reduction, chemical precipitation, eutrophication, production of hydrogen sulphide, increased acidity.

Physical effects:
Reduction of vertical circulation, mechanical interference with dam, mechanical interference with multiple use.

Biological and human effects:
Loss of environmental "services", loss of valuable timber, loss of wildlife habitats, impaired water quality, proliferation of water needs, increased disease vectors.

Economic and social effects:
Disruption of low-scale economic activities and introduction of new types of economic activities, relocation of populations and increased urbanization of the dam site, relocation of Indian population (Amerindians), increase of tropical waterborne diseases such as malaria, loss of cultural identity of indigenous population and native non-indigenous population, loss of valuable archaeological information.

Generally, after the construction and filling up of the dam, a relatively large migrating human population arrives at the dam site, in the hope of obtaining employment or for the possible further exploitation of the aquatic environment (fisheries, navigation, exploitation of submerged timber). This aggravates the social conflicts and the public health problems. The exploitation of fish biomass is very intensive after filling up (some species of fish, such as the Cicchla ocelaris, grow very quickly after the dam is closed).

Another problem of chemical origin which has a biological and social effect is the discharge of bottom hypolimmetric water which causes extensive fish kills and produces a water of poor quality which cannot be used for any purpose.

Thus the downstream effects can be very severe as regards the river dwelling population.

3. PERSPECTIVES

The exploitation of the Amazonian hydropower is a complex problem. The export of energy outside the Amazonian reservoir is very high, at around 80%, due to the extraregional dependency of the Northeast and Southeast systems. Thus, on top of the above-listed problems, the region exports its hydroelectric potential to the other more developed regions. To solve this problem, recently a system of royalties was devised so that part of the generated hydroelectricity is returned to the original region in the form of investments and correction measures.

Solutions to the problems related to the construction of future Amazonian reservoirs reside in revisions to plans for hydroelectric power and the siting of reservoirs in selected hydrographic basins. On the other hand, the complex social conflicts generated by dam construction have to be solved by extensive negotiations which include upstream/downstream communities, Amerindians, and general users and inhabitants. This is a long process. The revision of the 2020 Brazilian plan for hydroelectric generation has already started. Public pressure, international pressure, and the active participation of the scientific community generated this revision.

As for the existing reservoirs, measures to mitigate the general effects on the ecosystem have been taken. Although not completely satisfactory, these measures show a disposition to work in the direction of large-scale mitigation activities. These include a public health policy to provide health care and preventive measures against endemic diseases, and a relocation policy to provide possible resettlement with extensive social studies of the area before dam construction. Preservation of social interrelationships and the cultural identity of populations is a very important and fundamental problem in this region. Another complex problem is the Indian community which needs special types of compensation which have to be established through negotiations.

The exploitation of the Amazonian hydropower depends on a great deal of skilled capabilities in several sectors involved in the planning, construction and operation of the dam. There also remains a strong need to improve the environmental awareness of the specialists and the general public to solve these conflicts through mutual understanding.

REFERENCES

Balon, E.K. and Coche, A.G., eds. 1974. Lake Kariba, a man-made tropical ecosystem in Central Africa. Junk. The Hague 12: 767.

Barrow, C.J. 1983. The environmental consequences of water resource development in the tropics. In Doi Juni Bee, ed. Natural Resources in Tropical Countries. Singapore University Press. Singapore. pp. 439-476.

Barrow, C.J. 1987. The environmental impacts of the Tucurui Dam of the middle and lower Tocantins River Basin, Brazil. Regulated Rivers. Research and Management 1(1): 49-60.

Baxter, R.M. 1977. Environmental effects of dams and impoundments. Ann. Rev. Ecol. Syst.: 255-283.

Branski, J.M., De Avila, J.P., Lopes, R.L.L., Goncalves, A.J.T. and Tundisi, J.G. 1988. Environmental impact assessment for the Porteira hydroelectric project. Presented at the 2nd Workshop on River/Reservoir Basin Ecosystem Approaches to Environmentally Sound Management of Inland Waters. Bangkok, Thailand.

Garzon, C.E. 1983. Water quality management strategies for the Alto Sinu hydroproject. Preliminary proposal (for) CORELCA, Colombia. Dartmouth College. Hanover, New Hampshire.

Goodland, R.J.A. 1977. Environmental Optimization in Hydrodevelopment of Tropical Foresets. In Panday, R.D., ed. Man-made Lakes and Human Health. University of Suriname. Suriname, Parmmibo.

Goodland, R.J.A. 1980. Environmental ranking of Amazonian Development Projects in Brazil. Environmental Conservation 7(1): 9-26.

Juras, A.A. 1990. Environmental Policies as Applied to Eletrumorte. In The Brazilian Northern Electrical Authority: Enterprises in the Amazon Region. Training Seminar on River/Lake Basin Management. Nagoya, Japan. p. 106.

Junk, W.J. and Nunes de Mello, J.A.S. 1987. Impactos ecologicos das represas hidreletricas na bacia amazonica brasileira. Tubinger Geographische Studien 95: 367-387.

Petr, T. 1978. Tropical Man-made Lakes: their ecological impact. Arch. Hydrobiol. 81(3): 368-385.

Tundisi, J.G. 1986. Ambiente, represas e barragens. Revista Ciencia Hoje 5(27), SBPC: 48-54.

Tundisi, T.G. and Matsumura-Tundisi, T. 1988. Limnology and eutrophication of Barra Bonita Reservoir, S. Paulo State, Southern Brazil. Proceedings of Reservoir Conference. Ceske Budejovice Tchecoslovaquia.

Tundisi, J.G., Matsumura-Tundisi, T., Hino, K., and Calijuri, M.C. 1988. The Lobo (Broa) Ecosystem and Reservoirs in Brazil. Expert Group Workshop on River/Lake Basin Approach to Environmentally Sound Management of Water Resources. UNEP/ILEC/UNCRD. Nagoya, Japan.

Van der Heide, J. 1976. Hydrobiology of the Man-made Brokopondo Lake. In collaboration with Leentvaar, P. and Meyer, J. Brokopondo Research Report 2, Suriname. p. 95.

Van der Heide, J. 1982. Lake Brokopondo - filling phase limnology of a man-made lake in the humid tropics. Amsterdam. p. 428.

SECTION 4.3

SOCIO-ECONOMIC AND CULTURAL APPROACHES TO INVOLUNTARY POPULATION RESETTLEMENT

Michael M. Cernea

4.3.1. INTRODUCTION

Population resettlement is one of the least researched components of the creation of man-made lakes and of lake management in general. This is unfortunate since, in real life, population resettlement occurs frequently and is very important for the successful completion of dam building projects, which create such man-made lakes.

The present paper attempts to place population resettlement in the context of the practical socio-economic and cultural problems that must be addressed by programs that create reservoir lakes. These problems must be dealt with both before the lake is created, as well as after the new body of water is accumulated and requires environmentally-minded management. The paper will briefly describe the size of the resettlement problem, its nature and socio-economic consequences, and will recommend guidelines that can be used by various agencies involved in dam construction and/or lake management. These resettlement guidelines are based on the policy regarding involuntary resettlement in development projects prepared by the World Bank for the programs it finances when such programs cause involuntary relocation. The guidelines suggested in the present paper can be adapted, refined and specified, depending on the local circumstances that vary from one country to another. A more detailed presentation of the World Bank's resettlement policy and of its sociological and technical guidelines can be found in a special publication issued by the World Bank (Cernea, 1988).

4.3.2 THE MAGNITUDE OF DISPLACEMENT

The number of people displaced by dams varies according to population density, ecological conditions and reservoir elevations. In many cases these numbers are quite high, and tens or hundreds of thousands of people are affected. Even when the overall number of people to be relocated is small, the severity of the consequences of displacement inflicted at the level of the individual families affected is essentially the same. Moreover, in the case of smaller countries, where a relatively small number may represent a high proportion of the population, resettlement could strain national resources even more.

The statistics prove convincingly that forced displacement is far from being a minor or secondary problem. Here are some figures: in Indonesia, the large reservoirs recently created by the Saguling, Kedung Ombo, and Cirata multi-purpose dams have dislocated, respectively, some 65,000, 30,000 and 57,000 people (assuming an average family size of 5.5 people). In China, the Gezhouba Dam displaced "only" some 20,000 people but the Dienjangkou reservoir displaced -- 383,000 people. In Brazil, the Sobradinho and the Itaparica dams dislocated 65,000 and respectively, 40,000 people. India is currently the developing country with the largest dam construction program and correspondingly with the most massive involuntary displacement: for instance, the series of dams being built under the Gujarat Medium Irrigation projects I and II are displacing about 150,000 people. The Srisailam dam alone in Andhra Pradesh state dislocated some 100,000 people, while the ongoing Andhra Pradesh Irrigation II project is displacing and must resettle 80,000 people. In Togo, the Nangbeto dam completed in 1988 displaced some 12,000; given the small size of the country, this represents a displacement 20 times bigger than what the displacement of 90,000 people by the famous Narmada Sardar Sarovar dam in India represents vis-a-vis India's total population (Cernea, 1990). The new Nangbeto lake is one of the largest man-made lakes created in the '80s, with an area of over 1,800 km^2.

4.3.3 DISRUPTIVE CONSEQUENCES AND THE NEED FOR RE-DEVELOPMENT

There is no doubt that the submergence of land by a reservoir causes major economic losses and socio-cultural disruption. Farming systems are destroyed, arable lands and forests are lost, land improvements disappear, social support networks are dismantled. As a result, many small and medium-scale farmers, landless laborers, and other people are impoverished. Sociological studies have revealed increased psychological and socio- cultural stress and higher mortality and morbidity rates. Environmental degradation, including loss of forest and grazing lands, is compounded and expanded if the sites to which people are relocated cannot sustain both the population already living there and the newly arriving people.

Although compulsory resettlement is not desirable and is extremely difficult to implement, projects that make relocation inevitable are usually of critical importance for national or regional development. When national long-term interests conflict with the immediate interests of local groups affected by such projects, the former usually prevail. Therefore, preventative and mitigatory steps taken early in the project are essential to minimize the adverse effects of forced resettlement and to reconcile conflicting interests. Because those who bear the consequences of resettlement are rarely those who receive the greatest benefits from the dams constructed by those projects, it is incumbent upon policy makers in each country, and upon project planners, to provide resettled populations with opportunities to re-establish and improve their previous productive potential and living standards.

Despite the great economic and social losses caused by submergence, many of the costs of dam construction have often not been correctly reflected in the pre-project economic analyses and planning. There have been insufficient efforts to minimize the human and economic costs, particularly to avoid or minimize people's displacement, to mitigate the unavoidable short-term impact of the resettlement, and to prevent long-term marginalization and destitution. As recent studies have shown, even now, in many countries, the handling of involuntary resettlement is often flawed by a lack of social planning and insufficient financial and technical resources (Fernandes and Thukral, 1989; Meugeot). Resettlement of people inhabiting the future rim of the reservoir is sometimes omitted from the program's design and consequently from the institutional arrangements and financing. Other times, resettlement implementation is entrusted to second-rank agencies which usually are not adequately staffed, equipped, or funded to carry out the task.

4.3.4 THE ENGINEERING BIAS IN RESERVOIR PLANNING

A phenomenon known as engineering bias can occur when an overwhelming concern to complete the civil construction blinds planners to the social needs of resettled people. For instance, in a number of World Bank-assisted dam projects, particularly during the 1960s and early 1970s, the relocation provisions were limited only to land expropriation and compensation; thus, the Bank's own engineering bias resulted in a lack of adequate social planning for relocation. Many consulting firms that undertake the economic and engineering design or major dams leave out resettlement planning from their design and planning proposals, as if it were not relevant to the design and cost of the dam system itself. At other times, they allow only for compensation for land expropriation, but include no project investment for the agricultural re-establishment of the people whose productive activities were disrupted. Even well intentioned plans can suffer from an engineering bias and sociological naivete. For instance, too many projects have provided for new houses, roads and water without account being taken of how people will earn a living at the new group site, if the resettled village does not have farming land available around the new settlement.

Examples of engineering bias are, unfortunately, easy to find. Technical designs for the Manantali dam in Mali (some 10,000 people displaced), and Nangbeto in Togo (12,000 people) prepared by European consulting companies, underestimated both the needs and the costs for resettlement. An international engineering consortium charged with designing a major dam in Pakistan managed to produce a nine volume study that was exclusively concerned with the technical/economic aspects. It omitted, however, resettlement planning for some 80,000 people that would be displaced by the project, and proposed that somebody else do such planning. The design for the Baardheere dam project on Somalia's Juba river, prepared by technically outstanding Italian consulting companies, was equally neglectful of resettlement. Again there was no mention of what would happen to the significant number of farmers and other inhabitants who would be forced to move by reservoir submergence.

The manner in which reservoir populations are resettled around the rim of the newly created lake also has long-term consequences on the future management of the new lake. One typical planning pitfall is the tendency to ignore the host population at the relocation sites, thus setting the stage for accelerated environmental degradation.

The World Bank has come to the conclusion that leaving resettlement out of a project's design and costing produces defects in the scheme's economic analysis. This is misleading both to policy makers and financing agencies. On the one hand, systematic under-accounting of resettlement requirements leads to a parallel under-accounting of assets lost to the project and an incomplete analysis of benefits foregone from submerged farmland. On the other hand, if project planners do not know the scale of resettlement involved in a project, resettlement programs will be chronically underfinanced. A sound approach dictates that feasibility studies for projects that create man-made lakes should be considered for financing only if they include planning for the socio-economic re-establishment of the people to be relocated.

Improved social, technical and economic procedures can help much in preventing and/or mitigating resettlement difficulties in the early stages of a reservoir development project. Among such procedures are:

- tracing on the ground the reservoir profile at maximum flood level and at the normal operating level, to identify all the impacted settlements and lands;

- a careful calculation of reservoir backwater effects on inhabited areas;

- an analysis of the trade-offs between dam height or location and the scale of resettlement caused by the different options; and

- designing projects so that irrigation, power, and other benefits are channeled to the resettled communities as well.

Project managers and engineers are becoming increasingly aware that improved resettlement planning is in the best interest of the scheme itself. Often when adequate resettlement is not provided, development projects that should have been welcomed by populations as beneficial instead become rallying points for political opposition (Oliver-Smith, 1990). For example, inadequate resettlement proposals for the Chico river projects in the northern Philippines generated such protest among the highland tribes, that all four envisioned dams and reservoirs were eventually abandoned. The recent Subernarekha reservoir area in India has similarly been the site of demonstrations, and the turmoil surrounding resettlement in Guatemala's Chixoy dam project eventually became so severe that the entire area was declared a national emergency zone.

The sobering contrast between the technically elaborate dam design technology and the sociological inadequacies of resettlement components calls for improved policies, a greater allocation of resources for resettlement, and an insistence that resettlement standards meet the same exacting criteria that are required for other aspects of dam construction.

The first requirement to the planners of future reservoir lakes must be to explore all the technical options for avoiding population displacement or reducing its scale. Depending on the topography of the reservoir area, sometimes small increments in dam height and reservoir level can greatly increase the number of people affected by the larger lake area. Conversely, small decreases in height may significantly reduce this number. For instance, the planning for the Saguling lake reservoir in Indonesia has demonstrated that such trade-offs may provide substantial reduction of human dislocation at relative little loss of benefits. The initial feasibility studies proposed a maximum flood level at elevation 650m, but the final decision selected elevation 645m in order to minimize displacement. The higher elevation (650m) would have entailed a displacement almost double compared to 645m (some 12,000 families or over 60,000 people were affected at elevation 645m). It was determined that the objective of generating electricity can be achieved satisfactorily, even though at a slightly reduced level, at the lower elevation. This way, considerable additional social, economic, and environmental disruption was avoided (Soepartomo and Tjiptohandojo, 1988).

4.3.5 THE BASIC GUIDELINES FOR RESETTLEMENT PLANNING

Policies governing involuntary resettlement must embody a number of basic principles about: 1) government responsibility; 2) resettler rights; 3) protection of host population interests; 4) environment protection, together with 5) a clear definition of re-establishment objectives.

Although the presence of national policies and legal frameworks for population displacement and relocation is essential for providing guidance to resettlement activities, many developing countries lack such policy frameworks. Only some governments in the Third World (e.g. Indonesia, Turkey, China, and a few other countries) have issued an explicit national policy, setting the basic norms to be observed in forced population displacement. That the number is so limited represents in itself an indication of underestimation. In India, some of the state governments have adopted policy frameworks, but a national policy for the entire country is long overdue. Recently, a group of Indian voluntary organizations prepared a draft proposal for such a country policy (National Working Group on Displacement, 1989). The absence of policy response by the state allows for unregulated and unsatisfactory practices.

Even in countries where a policy framework exists, national agencies only rarely possess the skilled staff needed for resettlement. Social planning skills must be brought into the early preparation of resettlement projects. Anthropological and sociological resettlement expertise is necessary to design resettlement operations so that they are compatible with the resettlers' and hosts' socio-cultural institutions. For instance, when hydropower dams and reservoir lakes are created in remote areas, the resident population may be ethnically, culturally, and politically distinct from the rest of the country's society. Professional expertise is necessary to deal with such situations. Support for relocating cultural clusters (village units, neighborhoods or extended families, and so on) protects an important social resource (the existing patterns of group organization) and this cushions the disruption caused by resettlement.

The fundamental principle in the World Bank's resettlement policy is that, because involuntary resettlement dismantles existing production systems, all displacement programs must at the same time be development programs. In all cases where a project causes resettlement, the project should ensure that the displaced people improve or at least regain their previous living standards. Circumstances must be created in which the people negatively affected by a project can also share in some of its benefits. Resettlement operations should not only return resettled populations to their former living standards, but also, they should enhance peoples' welfare in environmentally sustainable ways.

The planning framework for displacement and resettlement should include five main components:

- the development "packages" and alternative options;
- compensation;
- new habitat;
- the social organization of resettlers; and
- the host population and the environmental protection of the relocation area.

Whenever the creation of a man-made lake is contemplated, and the settled population must be relocated, the core of the resettlement plan must be a specific "development package". That is the set of provisions aimed at reconstructing the production base of those relocated. Payment of cash compensation alone is usually inadequate to meet the objective of providing the displaced even with the level of livelihood they had before the development intervention, let alone for improving it. Direct financial compensation must be viewed as only part of the packages of options available to displaced families. Lessons derived from dam-related dislocation in Thailand, Indonesia, Kenya, India, Brazil and other countries show that it is necessary to examine the situation of each category of displaced people, landholders, and the landless. The development package must offer sufficient opportunities and resources for their economic and social re-establishment as self-sustaining producers or wage earners.

Two basic strategies may be pursued for the socio-economic and cultural re-establishment of those dislocated from rural settings:

- land-based strategies; and
- non land-based strategies.

In urban and peri-urban settings, those displaced usually depend on non land-based sources of livelihood (e.g. the service sector, industrial employment, self-employment, etc.) but sometimes they may possess also some farming lands. The approach to their situation should take into account, in addition to their need for new house plots, their access to employment opportunities and, when warranted, to some land for farming or gardening.

Depending on local (rural, urban or peri-urban) circumstances, a combination of land-based and non land-based strategies may be adequate.

In *land-based strategies*, adequate financial compensation for lost property is of course important, but providing *economic opportunities* to re-establish the displaced populations as agricultural producers, rural artisans, etc. is the *crux of any viable resettlement*. Technically feasible agricultural production packages are likely to be the main avenue to restoring the production systems of dislocated rural groups. More specifically, it is necessary to initiate and finance land reclamation activities, irrigation schemes, tree crops development, fisheries, commercial or social forestry, vocational training, off-farm employment, and other kinds of lasting income-generating activities. Reforestation schemes are of particular importance not only for their income generating potential, but also for mitigating some of the environmental losses usually caused by submergence.

Land, rather than compensation in cash, is the crucial factor in re-establishment strategies, since the vast majority of those displaced by reservoirs tend to be farmers or agricultural laborers. The reconstruction of their productive potential essentially depends on availability of land. However, the experience in many reservoir projects is not very encouraging, since technical agencies are often reluctant to take all the steps necessary for making land available to those dispossessed of their land. Sometimes, land unavailability is a real and serious constraint, given existing population densities. Usually, however, it is the result of 1) poor project planning, 2) lack of effort to identify land reserves, 3) lack of political will to use government authority for providing land that may legally be made available, or 4) lack of imagination to design proper solutions. The resettlement plan for rural populations should, therefore, start by establishing the basic indicator: *the amount of land necessary* to re-establish those displaced on a productive base. This requires having defined targets, economically and technically viable sites acceptable to relocatees, and timetables for obtaining and preparing new farming land.

Non land-based strategies may also be needed, however, for *some* of those displaced, even when land is available. Moreover, such alternatives become a must in situations of extreme land-scarcity. Opportunities then need to be opened up for those displaced to re-establish themselves in the industrial or service sectors of the local or regional economy. Job creation through new investments may become necessary, because vocational training alone, without actual employment of those displaced in their newly acquired skills, does not restore income.

The use of the newly created lake itself as a productive resource for the displaced/resettled population is also a non-land based strategy, which must be put to work more systematically in all new dam reservoirs. An innovative and successful approach was taken at the Saguling lake in Indonesia through the promotion of *floating net aqua-culture* as a productive activity for displaced families who lost their rice lands to the reservoir. At project appraisal, it was estimated that about 1500 families could benefit from this option within five years after reservoir impounding. Achievements to date indicate that this estimate will be achieved and possibly exceeded. By 1987, two years after impounding, some 550 families, owning more than 1200 floating net units, were producing common carp at a rate of over 6,000 tons per year, a value of US$6,000,000 annually, in the Saguling lake. Significantly, the market value of fish production exceeded by far the value of the rice produced in the area, prior to reservoir filling. The same effort for introducing floating net aqua-culture is going on at the Cirata lake as well (Soemarwoto, 1989; Zainal et al., 1989).

Development-oriented planning for resettlement should also tend to enhance the prior housing standards and the physical infrastructure and services at the new relocation sites, rather than allow only for the same standards. Sociological studies have documented that self-built houses are usually preferred by resettlers over government-built housing. Therefore, planning of the village site with suitable infrastructure, provision of model plans, building materials, and "construction allowances" (for income foregone while building their houses) will afford more freedom of choice to resettlers in building their houses. Planning for site infrastructure and services should take into account population growth over one or two generations.

Most displaced people prefer to move in groups, as part of a pre-existing community, neighborhood, or kinship group. This is to be encouraged, because it reduces social disarticulation. The settlers' social and cultural forms of organization should be supported, protected and maintained whenever possible. Retaining access to cultural property (temples, pilgrimage centers, etc.), often by relocating it, can increase the acceptability of a resettlement plan, and moderate the social disarticulation caused by resettlement.

4.3.6 RESETTLEMENT AND LAKE MANAGEMENT

Adequate socio-economic approaches to resettlement will facilitate the subsequent work for *lake management*, after the reservoir lake has been created.

Many hydropower or irrigation dams create lakes of considerable size, which significantly modify the ecology of the area. The size of the lake varies. For instance, data from 36 dam construction projects financed by the World Bank between 1978-1989 indicate that the average size of the new man-made lakes were, by region, as follows:

Africa	31.573 ha
Asia	15.347 ha
S. Europe, N. Africa, Middle East	12.038 ha
Latin America	36.095 ha

When people are displaced by the reservoir, they often tend to move to higher ground, in the area which will become the catchment zone of the new lake. Therefore, the resettlement plan must foresee possible "second generation" adverse environmental effects in the relocation areas around the future lake. The planning process must rely on well mapped boundaries of the relocation areas, and must calculate likely incremental population density per land unit. This will permit the timely adoption of measures to avoid subsequent soil erosion, further deforestation, and general overload of the carrying capacity of the relocation areas. Similar caution must be exercised in the health-care and sanitation domains by planning facilities and services that will prevent the spread of water-borne disease around the new lakes. Reservoirs in sub-tropical and tropical areas are prone to facilitate an increase in the incidence of such diseases as malaria and schistosomiasis (bilharzia). On the other hand, to take advantage of the new capacities for fishing, tourism, and recreation possibilities created by the new lake, the planning may envisage the establishment of small fishing villages along the lake shore, ferry crossing points with adjacent trading center, etc., which offer some employment potential for those displaced.

The tendency to ignore the host population and allow excessive pressure on the environment is a frequent and serious pitfall that affects adversely the outcome of resettlement. For instance, the feasibility study for a dam in Madhya Pradesh (India) called for three or four displaced villages to be consolidated with one already existing village outside the reservoir area. The combined residents of the relocated villages would have numbered 1,500-2,000 people. Together with their 6,000-8,000 head of livestock, all the people were supposed to fit within the existing perimeter of the receiving village, which was already at capacity with its own 300 people and their cattle. Such propositions spell quick impoverishment and economic, social, and ecological disaster for newcomers and hosts alike around the newly created lakes. These plans were corrected, but the fact that they could come out of a planning office shows how rudimentary relocation planning may still be sometimes.

Confusion sometimes occurs between the socio-economic issues of population relocation and the physical environmental aspects when involuntary resettlement is dealt with under the common heading of environmental problems. Such lumping together happens, perhaps, because environmentalists have traditionally been those who have expressed the strongest criticism about the adverse effects of dams, and thus have helped to increase public awareness about human relocation too. But, by its very nature, resettlement is a socio-cultural/economic process that happens first to people, rather than to their physical environment. Correctly understanding the sociological nature of involuntary resettlement, with its cultural, economic, and psychological ramifications, has strategic consequences, for it leads to a different course of action than if it were regarded only as an environmental problem. When agencies, planners, and project managers fully understand the complex social nature of involuntary resettlement, they are more likely to address it with the tools and resources of social research. Rather than seeking only to mitigate unavoidable damage, they would aim to relaunch the socio-economic development process.

In sum, comprehensive socio-economic plans for resettlement could result only from the harmonious integration of civil engineering and social engineering. Incorporating production-based development packages, adequate compensation, provisions for habitat and new settlement infrastructure, health and environmental protection measures, and so on, will lead to a constructive response to the upheaval inflicted on people by involuntary relocation. Programs that include such plans (and provide financing for them) are thus in a position not only to re-establish people in an environmentally adequate manner, but will also create good socio-economic premises for the future management of the newly created lakes.

The views and interpretations expressed in this section are those of the author and should not be attributed to the institutions with which he is associated.

REFERENCES

Cernea, M.M. 1990. Population Displacement and Water Resources Development: Current Practice, Issues and Policy Responses. Presented at the Third Expert Group Workshop on River/Lake Basin Approaches to Environmentally Sound Management of Water Resources. Otsu, Japan.

Cernea, M.M. 1988. Involuntary Resettlement in Development Projects. Policy Guidelines in World Bank-Financed Projects. World Bank Technical Paper 80. Washington, D.C.

Fernandes, W. and Thukral, E.G. 1989. Development, Displacement and Rehabilitation: Issues for a National Debate. Indian Social Institute. New Delhi.

Meugeot. Future Hydroelectric Development in Brazilian Amazonia I: Towards Comprehensive Population Resettlement. Nucleo de Altos Estudos Amazonicos. Brazil.

National Working Group on Displacement (India). 1989. Draft National Policy on Developmental Re-settlement. New Delhi.

Oliver-Smith, A. 1990. Resistance to Resettlement: the Politics of Protest and Negotiations. Prepared for the American Anthropological Association Task Force on Resettlement. Washington, D.C.

Soemarwoto, O. 1989. Making Dams Work for Rural Development: The Example of Saguling, Indonesia. Prepared for the proceedings volume of the international seminar on Advance Planning for Resettlement. Jakarta.

Soepartomo and Tjiptohandojo, P. 1988. Comparison between Predicted and Observed Environmental Impacts in Saguling Reservoir. In CIGB-ICOLD, Sixteenth International Congress on Large Dams, Vol. 1. San Francisco.

Zainal, Sutaridar, Barry A. Costa-Pierce, Iskandar, R. and Herri Hadikusumah. 1989. Aquaculture Resettlement Option in the Saguling Reservoir, Indonesia. Presented at the Second Asian Fisheries Seminar. Tokyo.

PROFILE G:

SRINAGARIND DAM - THAILAND

Brendan Barrett

1. INTRODUCTION

The Srinagarind Dam and its associated hydro-power plant are located on the Quae Yai River north west of Bangkok in the Ban Chao Nen area (see Fig. G1). This multi-purpose dam, which is 135m in height and 610m in length, was developed by the Electricity Generating Authority of Thailand (EGAT) and supported by funds from Japan's Overseas Development Aid and the World Bank. The project took approximately six years to construct, from 1974 to 1980, with a total cost of $235 million (a 30% increase on the planned construction costs). Some $142 million (roughly 60%) of the project's financing came from overseas sources.

The most serious problems associated with the construction of the Srinagarind Dam were the resettlement and compensation of the inhabitants of the 419 km^2 that now makes up the water surface area of the dam. In total, 65 villages were located in this area prior to the construction of the dam, with 90% of the people living in Srisawat District in close proximity to the Quae Yai River. The remaining 10% lived in the more hilly areas above the 150m elevation. More than 10,000 people (960 families) were affected by the development and thus subject to resettlement and compensation. In addition, four temples, ten schools and a district office had to be relocated.

The families affected were compensated for their land rights, plantations, housing and transportation costs and a total of 52.052 million Baht was paid in compensation. A small town called New Srisawat was developed on the east side of the new reservoir. Each family received 20 Rai of land from which 18 Rai was allocated for agricultural purposes and 2 Rai for the new house. Prior to resettlement, however, the average area of land ownership was around 35 Rai. New public facilities and infrastructure were constructed, including schools, temples, twelve wells and a 75 km main access road, 100 km of agricultural roads and 58 km of 22kV electricity power lines. The total cost of the resettlement and compensation program was approximately 130 million Baht. The resettlement of population was completed by August 1977 with the exception of the Karen Tribe (inhabitants of the more hilly areas) which was completed by 1978.

In 1976, the Ban Chao Nen Cooperative was formed and EGAT gave them 10 million Baht to use as loans to support the farming activities of local villagers. At first some 475 families joined this cooperative (by 1986 this had risen to 628). For 475 families they were able to lend each family 10,000 Baht. EGAT did not ask for interest payments on the loan to the cooperative. The cooperative, however, set a 6% interest rate on its loans to the farmers.

In 1975, EGAT started a pilot farm to experiment with the production of corn, sesame seed and beans. Furthermore, in 1977 the agricultural promotion program was established by the Department of Agricultural Promotion.

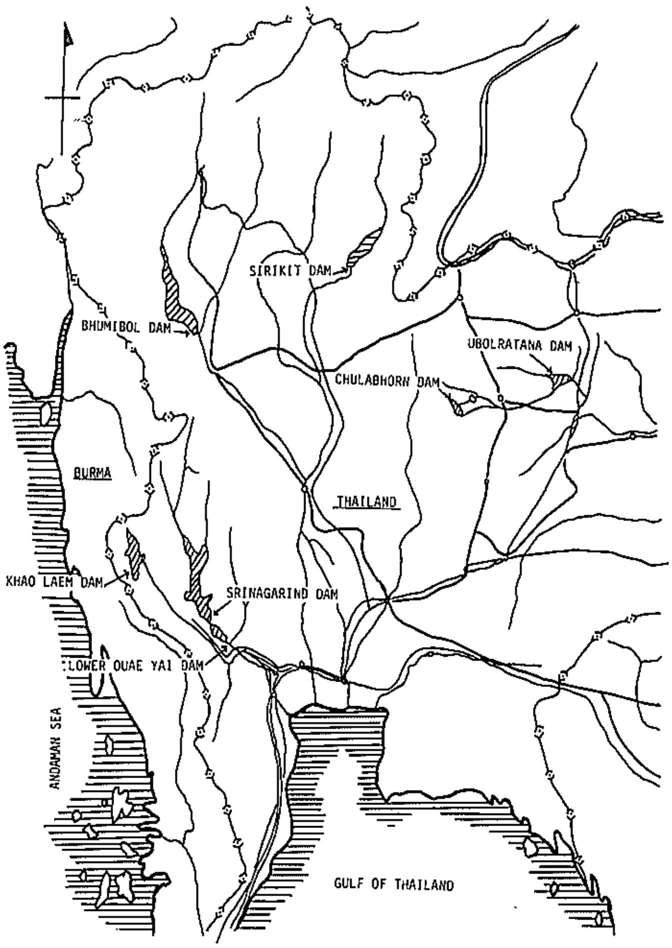

Figure G1 Location of Srinagarind Dam

PROFILE H:

THE SAGULING DAM PROJECT - INDONESIA

Edy Brotoisworo

1. INTRODUCTION

Compensation for lost property has become one of the major social problems associated with dam construction. Assets considered in the calculation of compensation usually include land, houses and crops. Cash compensation is the usual practice. Saguling is not an exception. Interviews with the affected people revealed that most of them indeed expected cash compensation, while only a small section of them expected land. After receiving the compensation, most of them wanted to buy new land outside the inundated area, while also wanting to use some part of the money as capital for businesses in non-agricultural sectors or for other purposes.

2. LAND COMPENSATION

At the early phases of the project development, there were rumors about the project. Since the people did not exactly know about the project planning, what land areas would be affected, and how much they would be compensated for their land and houses, there was some confusion at first. This was followed by a decline in property value, and land speculation became prevalent. The confusion was enhanced by the local government's prohibition of land transactions in the area. These government measures were actually designed to prevent difficulties which might arise during the payment of compensation due to changes of ownership, and also to eliminate the opportunities for land speculators to cheat the local populace.

The land compensation was carried out as the construction phase drew nearer. The key problem faced during the compensation process was that the land ownership system was still traditional, without land certificates. This resulted in conflicts among people and among family members in determining their share of the cash compensation. Even now, five years after the impoundment, there are still people who have not received compensation, and who do not know how to get it. This problem is considered very important, since it will create dissatisfaction, and more importantly reduces the people's capacity to cope with the problems they face during the resettlement process.

The rate of compensation differs for each land use type, and the rates are usually decided by the government considering the local price of the land. Therefore the rate is commonly acceptable, though higher compensation was usually expected. The problem was that during the compensation process there was a significant increase in land prices (25-50% higher) in the surrounding areas. This was particularly due to the high demand for land. As a consequence, there was a decrease of landholdings among the displaced population, since they could not afford the same extent of land as they previously owned, or even could not afford to buy new land at all. An inventory carried out in 1987 in Saguling showed that the percentage of the displaced people who could buy new land was only 41%; the others could not afford new land (33%), and the rest were sharing with their parents or families.

Particular problems arose because at the time the people did not have any clear idea about what the resettlement program entailed. Many people used the money received to purchase consumer goods. This was aggravated by retailers who visited the houses selling goods which for the most part were non-essential. Soon after the payment of the cash compensation, many people bought new radio cassette, TV sets, mini-bicycles, motorcycles, or even cars. Utilization of the cash compensation for such purposes clearly could have adverse effects on their ability to overcome the long term problems during their resettlement process.

3. COMPENSATION FOR OTHER PROPERTIES

Compensation for houses was usually calculated by considering the standard price for various types of houses and rates of depreciation. Therefore, the people received smaller amounts of money than the actual prices of their houses. This caused difficulties for some people since they could not afford the same quality of house using solely the compensation for their former house. A number of them, however, did buy better quality houses, but this was by sacrificing other properties.

Transportation costs were not considered in the compensation, except for the people who joined in the government interisland resettlement program, which is known as the transmigration program. For the transportation costs, the people had to use other means, or try to reduce the costs by selling part of their properties at a cheaper price. The problem was that in the new place they had to buy the same equipment at a higher price. This again reduced their ability to face various problems in the new place.

4. ADMINISTRATIVE COSTS AND TAX

The cash compensation was usually subject to administrative costs and tax. Although in this case the amount was not much, most of the people complained about this. In a normal transaction such costs and tax are applicable, but for involuntary resettlement this should actually not be applied.

5. LOSS OF JOBS

The compensation policy did not consider compensating for the loss of jobs. Therefore, farm workers, share cropping farmers, and other people who do not own land and houses did not receive any compensation, while they are actually the poorest group of the population. Displacement may cause their living standards to drop even further. Compensation for such population groups is still difficult to describe in price terms. However, they are the most aggrieved group in the local population. Therefore, they should have been given priority in access to newly created job opportunities, or new job opportunities should even be created for them.

The State Electric Company reported that 612 people had been trained in various sectors for construction work, but only about 200 people were really absorbed. The low rate of their involvement in the construction work was caused by several factors, which included 1) the tendency of contractors to use their own workers, 2) the tight construction schedule which made contractors hesitate to use local workers who may delay the progress of the work, and 3) delay in the training of local workers which meant that when the construction began, they were not yet ready.

6. CONCLUSION

For those sectors of the population with the lowest level of education and the lowest socio-economic status, displacement may cause serious problems. Cash compensation for the more economically developed sectors will cause fewer problems compared to the low income groups, though generally both groups will be adversely affected. In many cases, if no measures are taken, the living standards of the displaced population will decline.

Therefore, beside payment of cash compensation, the people should receive some guidance on how to use the money to maintain their living standards, and be given options for their resettlement, including provision of new job opportunities within the context of community development.

SECTION 4.4

WATER RESOURCES DEVELOPMENT AND WATER QUALITY MANAGEMENT IN BRACKISH LAKES

H. Harasawa

4.4.1 OUTLINE OF BRACKISH LAKES

A brackish lake is a semi-enclosed water body that forms where fresh water is mixed with and diluted by sea water. In general, the brackish lake is characterized by a high productivity of fishery resources and the development of transportation (Hobo, 1989). Tidal flow into and out of the lake forms a complex hydraulic condition, resulting in a lake ecosystem full of variety. The brackish lake generally forms a fragile environment that can respond dramatically to minor changes in sediment and pollution load, and sea level.

This section deals with five typical brackish lakes; Lake Kasumigaura, Lakes Nakaumi and Shinji, and Lake Kojima in Japan, Lake Songkhla in Thailand, and Laguna de Bay (Lake Laguna) in the Philippines. Lake Kasumigaura, Lake Laguna and Lake Songkhla are typical brackish lakes, which were selected as case studies for the UNEP/ILEC/UNCRD jointly organized research project. Lakes Nakaumi and Shinji are naturally brackish lakes in which a desalinization project has been postponed indefinitely in recent years. Lake Kojima was once part of a coastal bay and was reclaimed and desalinated later. Some characteristics of these typical brackish lakes adopted in this chapter are summarized in Table 4.4.1, the their geographical features are shown in Fig. 4.4.1 at the same scale.

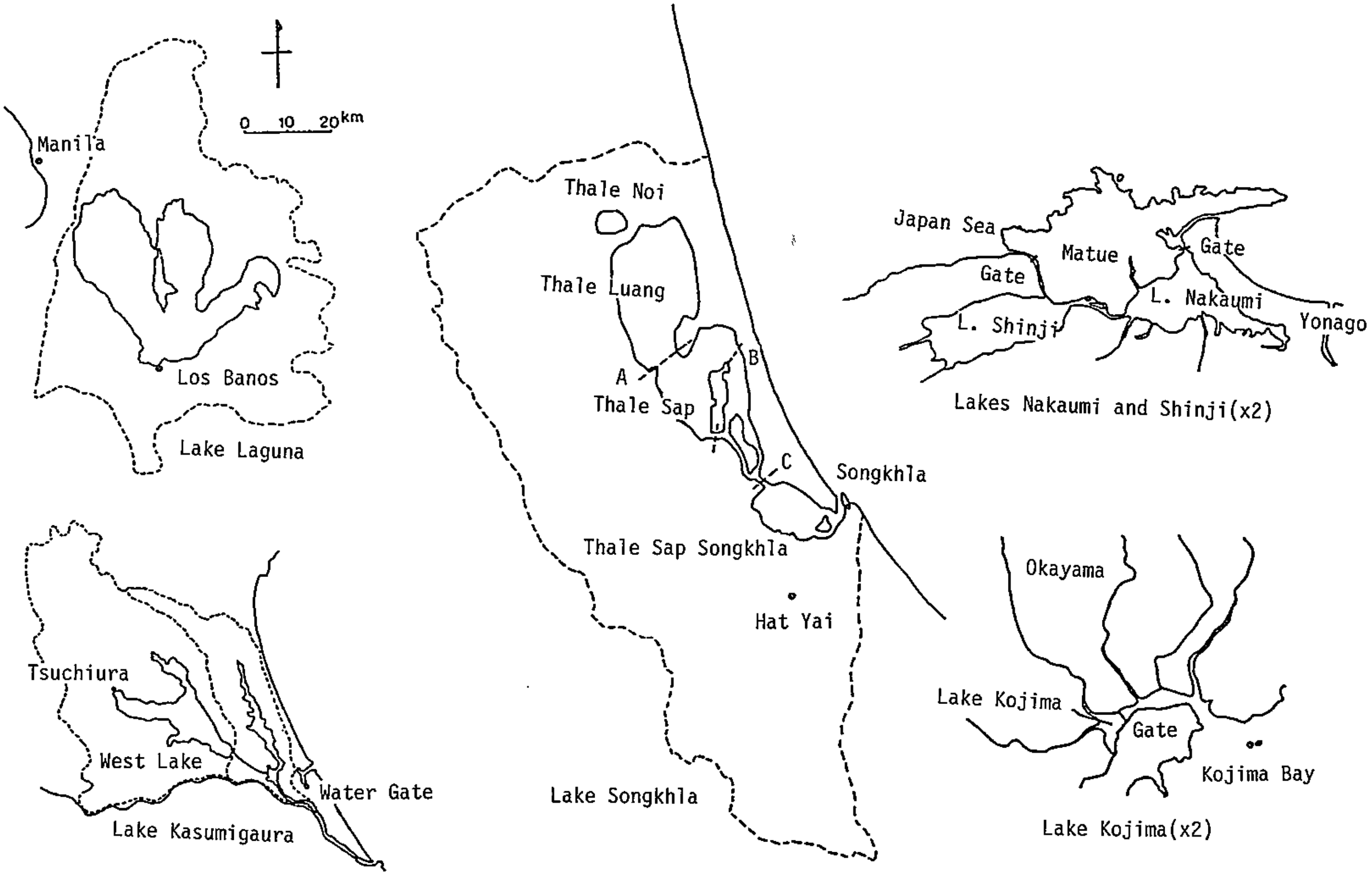

Figure 4.4.1 Maps of the Typical Brackish Lakes

Table 4.4.1
Characteristics of Five Lakes

	Kasumi-gaura	Nakaumi/ Shinji	Kojima	Songkhla	Laguna
Country	Japan	Japan	Japan	Thailand	Philippines
Catchment area (km^2)	2,157	687/1,369	544	8,020	3,811
Surface area (km^2)	220	96.9/80.3	10.9	1,082	891
Mean depth (m)	4	5.4/4.5	1.6	1.5	2.8
Max. depth (m)	7	8.4/6.4	9	>6	7.3
Lake volume (million m^3)	800	521/366	18	1,600	3,200
Salinity (mg/l)	48('87)	3100-15000('88) /400-3700('86)	200-300 ('85)	0 ~ 3000	>100
COD (mg/l)	8.1('87	3.8('86)/ 4.2('86)	10('85)	--	--
T-N (mg/l)	0.96('87)	0.40('86)/ 0.48('86)	2('85)	Luang;0.77	0.89
T-P (mg/l)	0.06('87)	0.052('86)/ 0.048('86)	0.2('85)	IP,Sap 0.1 ~ 0.15	IP 0.068('87)
Population (thousands)	85('85)	16.2('88)/ 27.4('88)	59.8('86)	120('80)	238('80)

Brackish water is defined as natural water which contains more than 0.5 g/l of salt. However, salinity at any one point may vary from that of fresh water (0.2 to 0.5 g/l) to that of sea water (16.5 to 20.0 g/l) during the course of tidal fluctuation. Some characteristics of brackish lakes are summarized as follows (Ohtake, 1982):.

1. Such lakes are generally shallow and connected with the open sea through one or more narrow channels.

2. They are located at river mouths and are rich in nutrients because of the inflow of

the pollutant load of organic materials and nutrient salts.

3. Due to their shallow depth together with their nutrient richness, aquaculture in these lakes can easily utilize solar energy, resulting in high productivity.

4. Lake water tends to be stagnant and can be considered as a natural sedimentation tank. Sedimentation of more pollutants on the lake bottom accelerates water pollution, especially eutrophication.

5. Tidal cycles exert a great influence on these lakes. Alternate tidal flows exchange pollution materials in the lake water with sea water. These phenomena may possibly be considered as one of the major capabilities of purifying lake water naturally.

6. The ecosystem is composed of a variety of aquacultures. Some originate from brackish water and others from inland water and sea water.

7. Hydraulic conditions in these lakes are highly complicated because of the location usually in the transition area from land area to coastal sea, which forms a vulnerable lake ecosystem.

4.4.2 WATER RESOURCES DEVELOPMENT

The five lakes treated in this section are located near large urban areas, so they are generally considered potentially valuable fresh water sources for human activities, if brackish water could be changed to fresh water by salinity barriers or other hydraulic structures. These lakes have large-scale water resources development plans, whose stages differ in response to the national and regional socio-economic situations. These development plans were designed to supply sufficient fresh water to various water uses and users such as municipalities, industries and agricultural lands in the watersheds.

In Lake Kasumigaura, the Hitachigawa Gate salinity barrier was constructed in 1963. Now this gate is the most important facility of the Kasumigaura Comprehensive Development Project, which is one of the largest water resources development projects in Japan. In Lakes Nakaumi and Shinji, a land reclamation and salinity barrier project was initiated in 1963. Though almost all the related facilities were completed the project has been halted (see Lake Profile A). In Thailand, the same sort of desalinization plan for supplying fresh water to farmland was designed in Lake Songkhla. This project has not been realized yet, mainly because of changing national policy, doubtful economic efficiency, and its environmental effects on the lake ecosystem.

The outlines of established or planned water resources plans for the five lakes under study are briefly summarized in Table 4.4.2. The brackish waters of Lake Kasumigaura and Lake Kojima have already been changed to fresh water completely. Water resources developments of these five lakes are briefly explained below together with some specific features of those lakes.

Lake Kasumigaura (Kasumigaura Study Team, 1989)

The Hitachigawa Gate was constructed in 1963. At the time, lakeshore residents and farmers were suffering from frequent flood damage due to heavy rains and typhoons, and crop damage due to salinity penetration during the drought seasons. To prevent these damages, the gate was planned at the mouth of the Hitachigawa, which is the sole effluent river of the lake.

In 1970, the Kasumigaura Comprehensive Development Project was established and implemented. The major works consist of the construction of lake embankments (3.0 m above sea level) and the proper operation of the Hitachigawa Gate so as to prevent flood damage and create new water resources at the rate of 43 m^3/sec. Newly produced water is intended for the Kashima Coastal Industrial Zone, growing urban areas and agricultural lands in the drainage basin of the lake and the Tokyo metropolitan area. This project basically aims to change a natural brackish lake into a fresh water reservoir for various water needs.

Since this project was initiated, various adverse effects have been noted on the existing facilities such as intakes of agricultural water and harbor related facilities. At the same time, the water quality of the lake deteriorated rapidly. To cope with these negative effects and to improve the water quality of the lake, the Water Source Area Consolidation Program was initiated in 1975 based on the national law which was enacted to prevent disruption of water source areas.

Table 4.4.2
Water Resources Developments

	L. Kasumi gaura	L. Nakaumi & L. Shinji	L. Kojima	L. Songkhla	L. Laguna
Purpose	flood control, irrigation, tap& indus trial water	land reclamation, irrigation	land reclamation, irrigation	irrigation	flood control, irrigation, navigation
Period	1971-1991 (gate:1963)	1963-1988	-1956	planned	1982-
Major facility	salinity barrier lake levee	salinity barriers, land reclamation	embankment, water gates	salinity barrier	hydraulic structure, floodway
Water resources	43m^3/sec	1.3m^3/sec (4,700ha)	1.3m^3/sec (5,101ha)		
Organization	Water Resour. Public Corp.	Ministry of Agriculture, Forestry and Fisheries	Ministry of Agriculture, Forestry and Fisheries		Ministry of Public Works
Open fishery (tons/yr)	8,200 ('86)	17,500 ('78-'81) including corbicula	345 ('84) (1,088 ha)	7,000	19,000
Fish culture (tons/yr)	5,100 ('86)	14,400			63,000

A new water supply plan for farmland in the western part was launched in 1979, and two water conveyance works were begun in 1984 to transport relatively clean river water from the nearby rivers to the lake to rehabilitate the polluted lake water. The latter work is intended to produce new water resources simultaneously. The total cost of the Kasumigaura Comprehensive Development Project amounts to over 1 trillion Yen and this project has become one of the largest national water resources developments in Japan.

Lakes Nakaumi and Shinji

The first plan for a land reclamation and salinity barrier project in Lakes Nakaumi and Shinji was announced in 1954 as a comprehensive development plan for these lakes. The initial purposes of the plan were 1) construction of a multi-purpose dam, 2) construction of a floodway to release excess lake water to the sea, 3) reclamation of two lakes with a total area of 5,000 ha, and 4) construction of salinity barriers. In 1963, the national government allotted a budget for this project, which was partially revised, and the Ministry of Agriculture, Forestry and Fisheries started work on it.

In 1970, the basic national policy for agriculture was changed dramatically. The national government adopted a new policy to constrain farmland development and reclamation works, resulting in curtailed rice production. The plan has been revised several times to reflect changes in the socio-economic situation. At present this plan includes 1) land reclamation of 2,542 ha (equivalent to about one-fourth of the lake) in Lake Nakaumi for agriculture, 2) construction of salinity barriers, and 3) works for fresh water supply to the coastal farmland and newly reclaimed farmland. Since the start of this project, 25 years have passed and a total of some 72 billion Yen has been invested in it. However, in May 1988, the trial closure of the salinity barriers as the first step of desalinization was stopped.

Some opposition to this project was raised at its outset. In 1972, one of the interest groups, called the "Lakes Nakaumi and Shinji Nature Conservation Association", which was later renamed the "Shimane Nature Conservation Association", was organized. The members of this group consisted of local residents, fishermen, researchers etc. This group has insisted consistently that the land reclamation and desalinization project has no meaning as a regional economic development plan based on cost-benefit analysis (Hobo, 1989). Moreover, it has potential for providing significant adverse affects on the lake ecosystem. These were their major concerns, and the public movement leading this group to protect the lake ecosystem against the development was the major driving force behind the abandonment of this project.

Lake Kojima

Lake Kojima is the first artificial freshwater lake in Japan (Kawahara et al., 1989). Though this lake was originally a part of the Kojima Bay, land reclamation for farmland had proceeded gradually. Finally, to prevent salinity penetration and to supply fresh water to farmland near the lake, most of the water area was reclaimed and separated from the bay by a water gate and embankment in 1962. The water quality of the lake did not change remarkably for several years after its closure, but later it rapidly deteriorated. The lake was very polluted and eutrophicated at the time when water quality monitoring for public water bodies was started, based on the implementation of environmental standards.

The national and local governments have carried out various measures to purify the lake water, such as conveyance of clean water into the lake and intensive removal of sediments from the lake bottom and river bed as well as construction of a sewerage system. But these efforts have not improved the lake water yet. The causes of eutrophication of the lake are 1) an increase in the pollution load flowing into the lake, mainly caused by the growing population in the drainage basin and changes in life-style, and 2) the closure or desalinization itself. Though the desalinization project of Lake Kojima has served to prevent salinity intrusion and produce fresh water for farmland, it also caused adverse effects on the lake such as poor water quality.

Laguna de Bay

Laguna de Bay, the largest lake in the Philippines, is southwest of Metro Manila, the capital. The lake has a rather complex configuration and is very shallow (mean depth 2.8 m). Since it is categorized as a tropical lake, water temperatures are mostly stable throughout the year, forming a good environment for the growth of aquacultures (see Lake Profile K).

As the lake is situated close to Manila, it is greatly affected by the growing population in the urban areas, and the increasing effluent from factories along the lake. For example, household effluent is directly discharged into streams, rivers and the lake without any treatment. While night soil discharged from households is treated and disposed of properly in developed countries, in developing countries it flows into water bodies directly. The household effluent accelerates pollution and eutrophication of the lake as well as poor sanitary conditions for residents. Lake eutrophication brings about an excess growth of harmful aquaculture such as blue green algae and water hyacinth, which in turn affect fishery and transportation.

To lessen possible flood damage to Manila, the Napindan hydraulic control structure and the Mangahan floodway were constructed in the early 1980s. The former facility functions as a salinity barrier to prevent salt water intrusion through the Pasig River which connects the lake with Manila Bay. These facilities still could not prevent flood damage, mainly due to insufficient design and improper operation, and as a result led to serious conflicts between fishery and agriculture. For instance, fishermen prefer higher salinity because an increase in the brackish fish catch with its higher market value brings them more income. On the other hand, farmers need fresh water to irrigate their farmland.

At present, the lake water is considered a source of valuable tap water for the Manila metropolitan area. However, eutrophication and pollution by heavy metals and chemicals are major obstacles for such a project. Another serious problem is the conflict between big fish culture investors and small fishermen described by Cardenas et al. (1989).

Lake Songkhla

Lake Songkhla is a brackish lake located in the southern part of Thailand. This lake is composed of four shallow lakes with varying water quality, hydraulics and ecosystems. The pollution load from its drainage derives mainly from residential areas and agricultural lands. Thus the growing population has become a serious environmental concern. Like the previously mentioned Laguna de Bay, almost all of the pollution load flows directly into the lake without any treatment.

A desalinization project was designed and two surveys were carried out on this lake. As the result of the first survey, three alternative locations for a salinity barrier were proposed and compared from a cost-benefit standpoint. Two further alternatives were selected and investigated in relation to their significance and effects on the lake environment. On the basis of these survey results, it was said that the final decision would be made by the national government. However, the decision has not been made yet.

The construction of the salinity barrier is controversial because it may cause 1) acceleration of eutrophication, 2) disruption of the valuable lake ecosystem, 3) obstruction of flood control, and 4) problems concerning the questionable economic value of supplying water to farmland in the lakeshore area. Since there are some valuable bird sanctuaries at the lake, these would surely be affected and disrupted by the construction of the barrier if any alternative were adopted. In 1988, a heavy rains caused a serious flood resulting in tremendous damage to the southern area. After this flood, the importance of proper management of forest area was keenly recognized and at the same time this incident also served to heighten the awareness of local residents concerning the salinity barrier project for Lake Songkhla as well as the environmental problems.

Various effects of desalinization projects on brackish lakes

Though a desalinization project can produce new water sources for human uses, it has numerous effects on the lake environment. The advantages and disadvantages of a desalinization project are described below on the basis of the experience mainly obtained in Lake Kasumigaura.

Major benefits are: 1) development of new water resources for municipalities, agriculture, factories and so on encourages various human activities in the drainage basin; 2) promotion of industries increases regional employment, the income of residents and also contributes to national domestic production; and flood control decreases damage to fishery and agriculture. There is little doubt that water resources development and accompanying activities have promoted various industrial activities and raised local income levels.

Unfortunately, water resources development and related human activities have also resulted in unfavorable and unexpected changes and effects on the lake environment, both direct and indirect. These are listed below and depicted in Fig. 4.4.2.

a. direct effects

1. Change of fish species, decline of commercially valuable brackish fish.

2. Wide variations of lake water level decrease and diminish water plant growing areas at lakeshores such as wetlands and marshes where sporing and growing of fish takes place.

3. Disturbance of back flow of sea water into the lake decreases the possibility of lake purification and dilution by sea water and sedimentation of particulate pollutants.

4. Change in residence time increases the possibility of excess growth of phytoplankton, such as the harmful blue-green algae microcystis.

5. Deterioration and disappearance of good lake scenery. Uniform design of lake embankments changes possibly diverse natural scenery into an artificial and monotonous one.

6. Decreases in sandy shoreline, closure of swimming areas, decreases in the

natural purification capacity and adverse effects of the construction of lake embankments on marsh and water reed.

Direct Changes **Indirect changes** **Effects on Water**

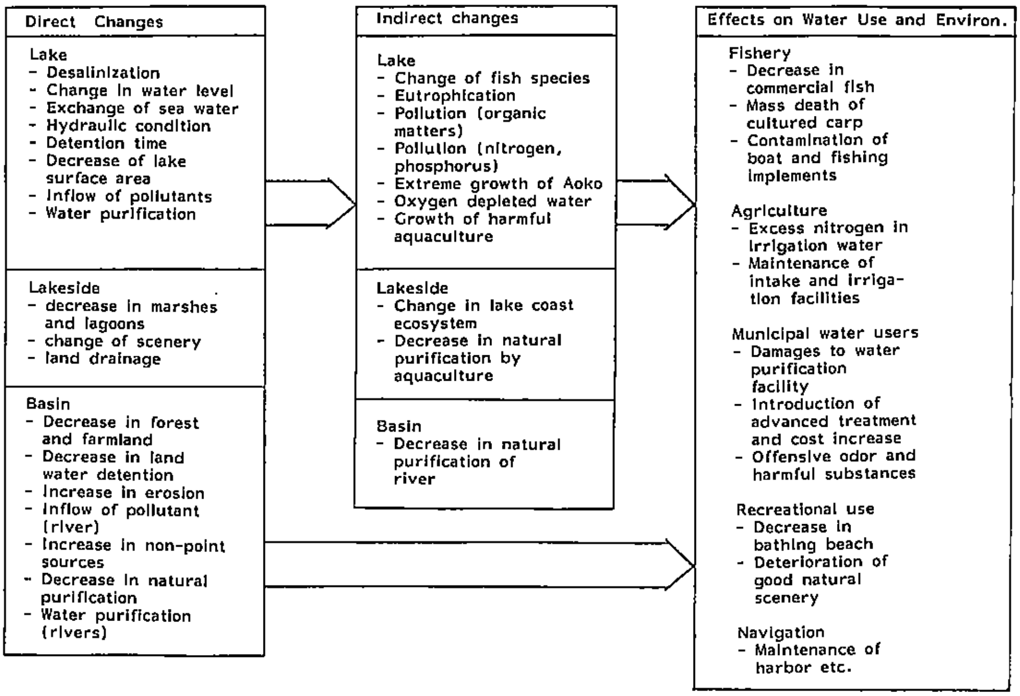

Figure 4.4.2 Relation Between Various Changes in Environmental Factors Caused by Desalinization of Brackish Lakes

b. indirect effects

1. Deterioration of water quality, eutrophication due to primary production of algae.

2. Disturbance of adequate usage of existing intake facilities.

4.4.3 ENVIRONMENTAL EFFECTS OF DESALINIZATION PROJECTS

Various effects of desalinization projects of brackish lakes are summarized here based on the case study works conducted for Lake Kasumigaura and other brackish lakes. A similar desalinization project in Lakes Nakaumi and Shinji was suspended in 1988 as mentioned previously, because the project was considered to have no economic value and to have a potential for disrupting the lake environment. From the experience and findings obtained through an international lake comparative study (Nakagami et al., 1990), the effects of desalinization of brackish lakes are described below from the standpoints of 1) water quality, 2) ecosystem, 3) scenic beauty and amenity, 4) flood control and 5) economic value of projects.

Water quality

Complete closure of a salinity barrier reduced the natural purification capability due to tidal cycles and the lengthened residence time of the lake. The longer residence time heightens the possibility of pollutants such as organic matter, nitrogen and phosphorus settling at the lake bottom, resulting in accelerated organic pollution and eutrophication.

New water resources produced by the salinity barrier have promoted human activities in the drainage basin, which in turn have increased the pollutant load.

Lake ecosystem

The change from brackish water to fresh water has a great impact on brackish fish and shellfish species directly. The death of corbicula in particular, which has a higher market value, is one of the major arguments that the public movement puts forth in its efforts to conserve Lakes Nakaumi and Shinji.

Desalinization does various kinds of damage to any lake ecosystem composed of a variety of aquacultures such as zoo- and phyto-planktons, bacterias and fish species. The direct and indirect effects of desalinization cannot be identified and evaluated scientifically because of the sheer complexity of the problem.

Scenic beauty and amenity

In Lake Kasumigaura, a tall embankment, 3m above sea level, has been constructed along the lakeshore for flood control and water storage. This concrete embankment disturbs human access to the lakeshore and compromises the lake's excellent scenery. Conservation of natural scenic beauty and amenity has been a controversial point in the cases of both Lakes Nakaumi and Shinji.

The embankment also affects the lakeshore ecosystem where aquatic plants such as ditch reed grow. Lakeshore marshes and wetlands provide a good environment for fish as sporing and growing areas. The functions of ditch reed are prevention of lakeshore erosion, provision of sporing area and maintenance of good scenery and natural water purification capability.

Flood control

The Hitachigawa Gate was originally constructed to prevent farmland and residential areas from damage by flooding and salinity intrusion. After its construction, rapid economic growth forced the gate to become one of the major facilities for developing new water resources in Lake Kasumigaura.

Though the gate and many dams and reservoirs constructed in the upper watershed of the Tone River have decreased the fearful damage by floods, the gate together with the Tone River Weir is said to degrade the water quality of the lake, although this remains to be proved. In the case of Lakes Nakaumi and Shinji, flood management in the reclamation and desalinization project did not coincide with the basic flood control policy established by the Ministry of Construction.

Economic value of project

As to the project planned for Lakes Nakaumi and Shinji, Hobo (1989) pointed out that, though a project to reclaim the lakes for farmland and supply fresh water may have been necessary in the 1960s, there was no need to pursue this project any more considering the national agricultural policy and the current regional socio-economic condition.

Since the Kasumigaura Comprehensive Development Project is still ongoing, the related national organizations and the Ibaraki Prefectural Government consider that there is no need to evaluate it at present. The third expansion phase of the Kashima Industrial Water Supply project has almost been completed so as to meet further water demand by factories located in the Kashima Marine Industrial Zone. However, the water supply rate of the existing facility is presently low and a sufficient amount of water is still available. Additional supply capacity is no longer reasonable and is a heavy financial burden on the prefectural government. This failure of the large-scale water resources project was brought about because this project lacks the flexibility to meet changing socio-economic conditions such as a demand-supply relation mainly caused by external forces.

The desalinization project, which is accompanied by the rapid development of industrial and urban areas in the drainage basin, has accelerated the deterioration of the water quality and natural environment of the lake. Recently, a public movement has insisted that opening of the Hitachigawa Gate can rehabilitate the lake environment remarkably. Its opening will certainly be beneficial for fisheries because intrusion of salt water into the lake increases production of brackish fish and shellfish. On the other hand, the possible failure of gate operations will cause a high salinity intrusion of irrigation water and damage to the water supply for urban areas and factories.

In highly developed lakes like Lake Kasumigaura, environmental measures which result in a drastic change to the lake environment such as the opening of the gate, should be discussed from the viewpoint of not only water quality improvement but also water uses. Considering the recent indications of rehabilitation of the water quality during the winter seasons, the complete opening of the gate should be carefully determined after intensive discussion about its impacts on the lake environment and human activities as a practical measure. Close cooperation between the organizations concerned and local residents is necessary to establish such water quality management policies in the future.

4.4.4 LESSONS FOR BETTER MANAGEMENT OF BRACKISH LAKES

Importance of infrastructure development

Natural disasters have caused severe damage to the environment and our daily life and property. Suitable control of floods and forestry conservation is needed to encourage sound development and environmental management. Improvement of sanitary conditions in urban and local residential areas should also be stressed.

Flexibility of large-scale and long-term water resources development

The basic policy of water resources development noted in the national plan has been revised in response to social and economic changes. Though it is difficult to predict future possible changes at the planning stage mainly due to the lack of basic data and scientific knowledge, flexibility should be integrated into an implementation plan to incorporate drastic changes in the socio-economic situation. The water resources development plan is generally established as a far-reaching national plan. Once this kind of plan gains momentum, it is very difficult to change policy directions quickly. On the contrary, if the plan were made in a combination of medium- and small-scale projects, it could be more readily adapted to comply with unexpected changes.

Lake eutrophication

Once lakes are polluted, it is very difficult to recover their water quality, and it costs more to implement various measures than to conduct pollution prevention measures. Environmental impact assessment in both the planning and project stages is necessary to incorporate careful environmental consideration into the project and work in an effective manner.

Cooperation of local governments, local residents and researchers for better lake management

Pollution abatement is not so difficult. People themselves can reduce pollutants from their households with careful attention to the environment. A research report indicates that about 10 to 20% of organic matter can be eliminated by changes in residents' life-style by, for example, proper use of detergents and saving water. Education campaigns are needed to encourage pollution abatement at the grass-roots level. Strengthening these fundamental activities will play an important role in sound lake management. Environmental education for the present and future generations and training of civil engineers must be initiated to promote their understanding of the necessity of environmental management and information exchange with the administration.

Comprehensive management of lakes

From now on, management of non-point or dispersed pollution sources should be given more attention as stated in the Lake Water Conservation Plan formulated based on the Clean Lakes Law. The idea of carrying out the various measures in an integrated and planned manner is widely recognized today, but it is a difficult task due to the lack of knowledge and experience. Recent new technology such as small sewerage systems, combined septic tanks and application of natural purification capability have developed, and may well be crucial measures. However, these applications of new technologies should be considered as supplementary tools, and fundamental and applied research also should be conducted as well as research on systematic application of a variety of measures.

REFERENCES

Cardenas, M.L., Centeno, J.D.Jr., and Viloria, L.A. 1989. Laguna de Bay Region. In Guideline of Lake Management 1: 141-153.

Hobo, T. 1989. Development and management of brackish zones: A review of the land reclamation and salinity barrier project in Lakes Nakaumi and Shinji, Japan. Expert Group Workshop on River/Lake Basin Approach to Environmentally Sound Management of Water Resources. UNEP/ILEC/UNCRD. Bangkok and Hat Yai, Thailand.

Kasumigaura Study Team. 1989. Comprehensive development of Lake Kasumigaura and its environmental management. Expert Group Workshop on River/Lake Basin Approach to Environmentally Sound Management of Water Resources. UNEP/ILEC/UNCRD. Bangkok and Hat Yai, Thailand.

Kawahara, O. and Fuji, M. 1989. Study on planning for water pollution control in closed water bodies - case study of Kojima Lake. Environmental Systems Research 17 (in Japanese): 164-172.

Nakagami, K., Fukushima, T., Harasawa, H., Oya, K., and Espardon, M.V.O. 1989. A strategic concept of basin management - International comparative study of lake basin management. Ritsumeikan Keieigaku 18(4/5): 181-220.

Ohtake, H. 1982. Ecosystem in brackish water zone. In 'Oyo no Umi', Tatara-shobou (in Japanese).

PROFILE I:

LAKE SONGKHLA - THAILAND

Sunthorn Sotthibandhu

1. INTRODUCTION

In 1984, the National Economic and Social Development Board (NESDB) and the Office of National Environment Board (ONEB) jointly initiated the Songkhla Lake Basin Planning Study, aimed at the formulation of a comprehensive and integrated program for socio-economic development of the Basin, while at the same time ensuring pragmatic management of the Basin's natural resources and environment. The study was conducted by a UK/Australia/Thailand consulting team (John Taylor and Sons et al., 1985) and took 14 months to complete. Taking all of the essential factors into account, the consultant recommended that an Induced Development Scenario was preferable to either a Natural Growth or a Rapid Industrialization Scenario. This comprises a Natural Resource Management Plan, a Socio- Economic Development Plan, and an Environmental Management Plan. Nine priority projects under the three plans were chosen for implementation, and these are summarized in Table 1.

2. ENVIRONMENTAL PROBLEMS

The principal environmental degradation in the lake occurs from the urban/industrial zone, consisting of Hat Yai/Sonkhla and the corridor between the two cities. The issues of concern are liquid waste discharge and solid waste disposal into the streams/rivers, and directly into the lake system (Taneerananon et al., 1989). The major sources of air pollution are industry, power generation plants, and vehicles. At present, there is little industry in the coastal zone. There are plans for small industrial areas near the fishing port and the newly established deep sea port. Songkhla port is the largest fishing port in Thailand. It is also used by the Navy, coastal freighters and barges, support vessels for Union Oil's offshore gas fields, and a large number of small craft for lake

Table I1
Songkhla Lake Basin Priority Projects (Songkhla Province Office)

Plan/Project	Aim of Project	Status
SOCIO-ECONOMIC PLAN		
1. Mixed farming system	Improve overall yields of agricultural produce, e.g. rice, fish, vegetables, fruit trees, pigs, fowl.	Demonstration project at Ranot and Sating-Pra. Yield increased threefold.
2. Seawater system for marine prawn culture	Promote cultivation of marine prawn at Sating-Pra peninsula	Government approved of the project. Engineering, economic and environmental studies being undertaken.
3. Bridge over Pak Ro	Facilitates transport and communication between lake-shore dwellers on East and West sides of the lake.	Engineering design completed. Project to be finished by 1991.
NATURAL RESOURCE MANAGEMENT PLAN		
1. Salinity	Store freshwater for agricultural activities in the north-eastern part of the lake.	Not yet approved by government.
2. Khlong Sadao's Water	Secure water supply for economic expansion of Hat Yai/Songkhla. Expected capacity is 30.8 million m^3.	Engineering design near completion. Site not yet fixed.
3. Groundwater development	Supplement freshwater supply for irrigation.	Under investigation.
ENVIRONMENTAL MANAGEMENT PLAN		
1. Improvement of sewage treatment system of Ha Yai municipality	Reduce waste disposal into Lake Songkhla.	Overall plan completed. Await government's approval.
2. Lake-side village sanitation	Solve problem of faecal contamination.	Feasibility study being conducted.
3. Information system for natural resources in Songkhla Lake Basin	Store and retrieve information for future development projects of the basin.	Organizational structure completed. Substantial support in equipment, personnel required. Not yet in operation. transport.

The intense activity around the harbor has led to environmental degradation: fish wastes, sanitary wastes, floatables, bilge-water, and engine oil have been dumped directly into Thale Sap Songkhla. In addition, unsanitary drainage from the Songkhla urban area is directed into the harbor waters (John Taylor and Sons et al., 1985).

There are over 20 main Khlongs (rivers/streams) in the Songkhla Lake Basin, of which Khlong U-Tapao near Hat Yai Municipality is the most important. The Khlong U-Tapao extends at least 200 meters into the lake. It shows a significant level of faecal contamination with some evidence of bacterial die-off in its middle reaches between Wat Chonpratan Prasit (a monastery) and Ban Hua Sapan. There is a marked contrast between stream bacterial levels and the low levels observed in the lake. This has serious implications for lake-shore aquacultural activities as the geometric means of total coliform counts should not exceed 500 MPN/100 ml in aquacultural areas in order to ensure that fish for human consumption are not contaminated.

Three main types of industries are represented in the Basin: fish canning, beverages, and rubber factories. There are 25 rubber processing plants, 7 fish canning and frozen fish factories, 5 fishmeal factories, and a soft drink factory (Taneerananon et al., 1985). As a consequence of these activities, Khlong U-Tapao -- a source for raw water before purification -- is being heavily polluted by floatables and other forms of waste materials originating from urban domestic waste water. Poor solid waste management practices in Hat Yai Municipality seems to be the principal cause of pollution. As a result, the Khlong banks are used as dumping grounds for solid wastes and the floatable materials contained in the solid wastes are washed into the Khlong, and eventually reach the lake (see Fig. I1).

3. SOCIAL PROBLEMS

Lying within two provinces, Pattalung and Songkhla, the Basin is the home of 1.25 million inhabitants. Approximately 740,000 reside in Songkhla and 510,000 in Pattalung. From a study conducted by the Prince of SongkhlaUniversity (PSU) Team in 1987, it was found that the main occupations of the basin's population include rice growing, fishing, mat-making at Thale Noi, etc. (Ratanachai and Suwannatachote, 1989). It was also found that the lake water is an extremely valuable resource socially and economically for the lakeside communities, especially for rice growers and fishermen.

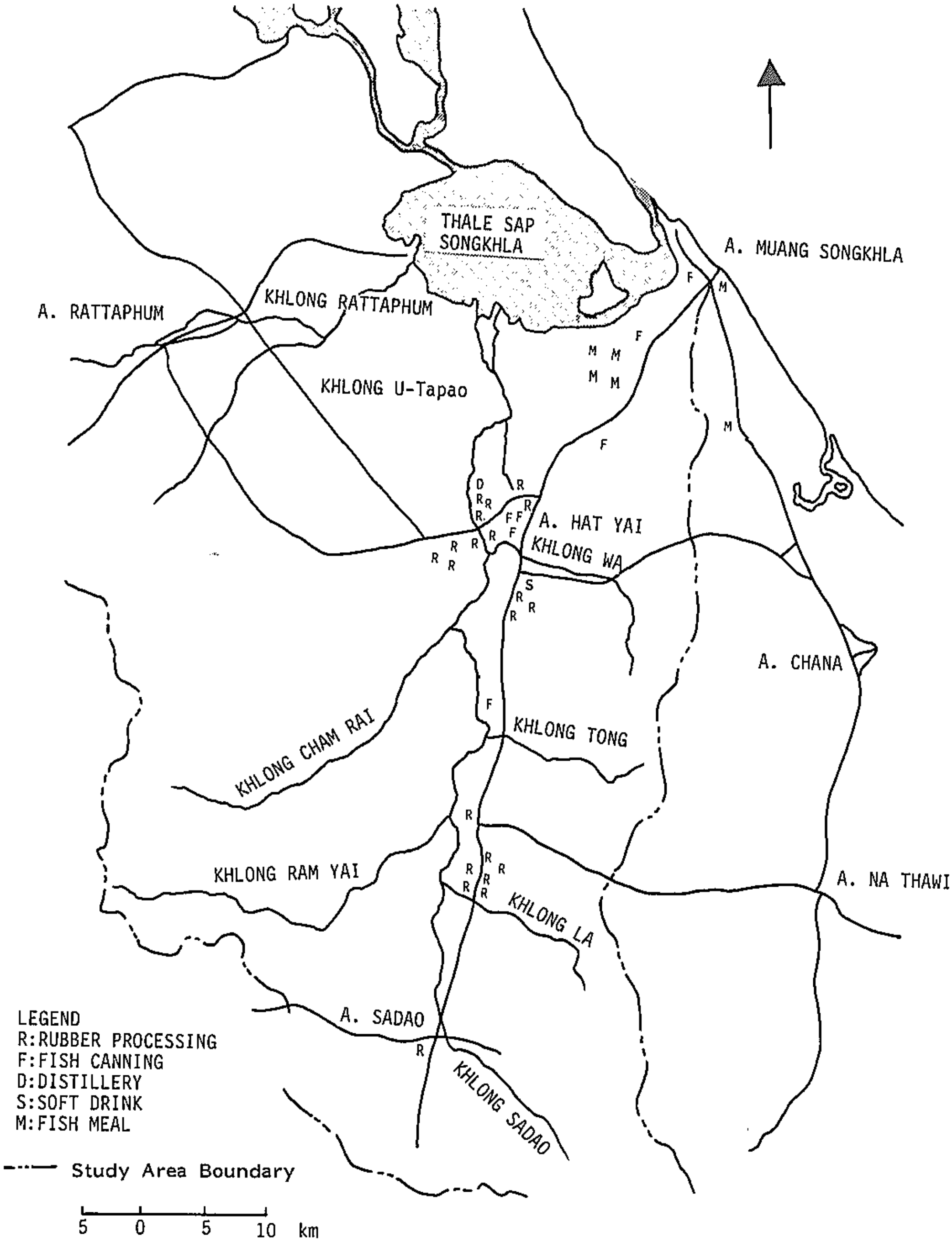

Figure I1 Location of Major Water Consuming Industries and Fish Meal Factories in the Study Area (from Ministry of Industry, Changwat Songkhla Office and Songkhla Lake Basin)

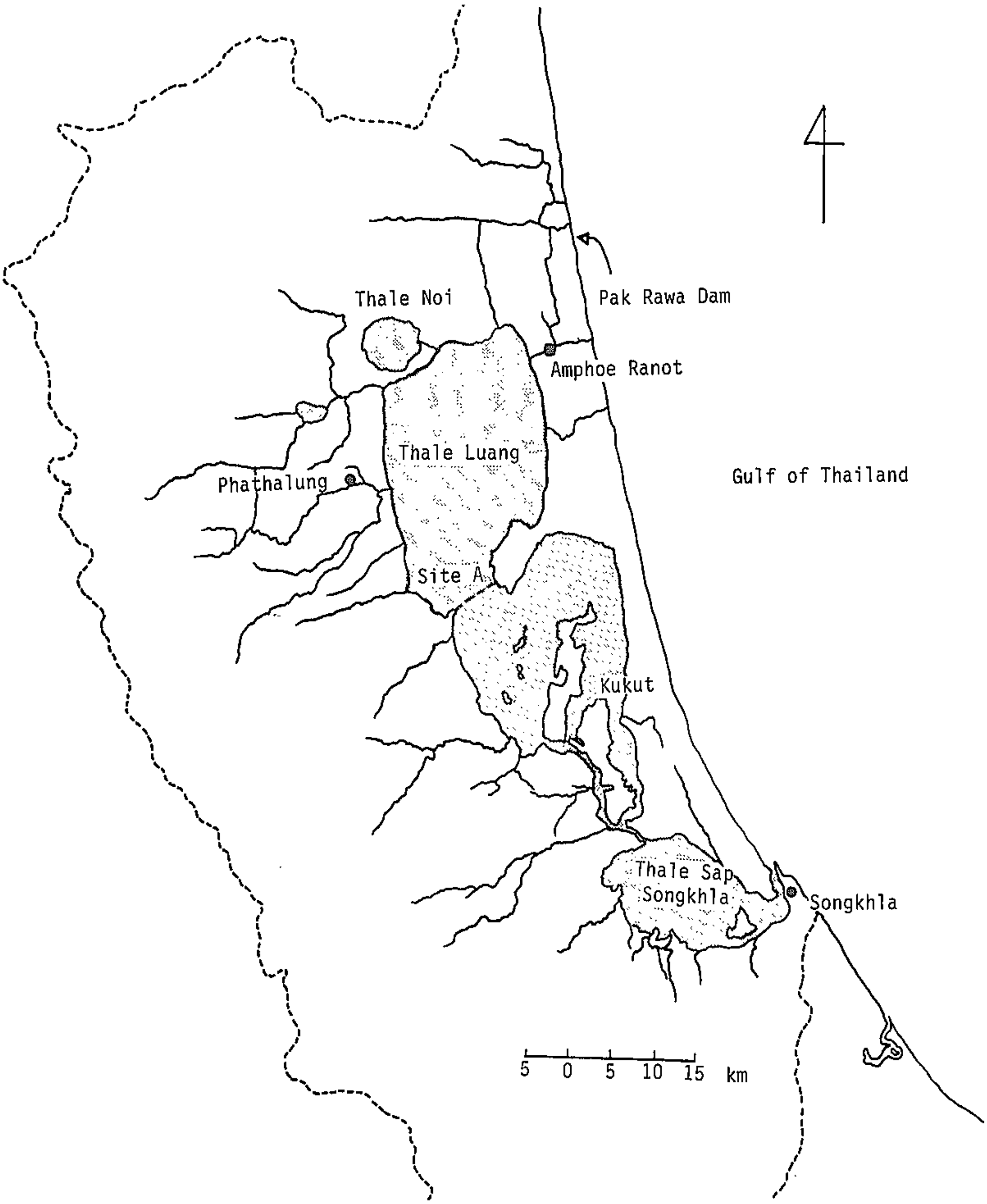

Figure 12 Site of the Proposed Salinity Barrier (site A) and the Pak Rawa Dam near Amphoe Ranot which prevents the intrusion of sea water

Between 1967-1968, rice growers badly needed freshwater due to an extreme dryness of the area. The situation became aggravated because of an occasional intrusion of sea-water from the Gulf of Thailand. A pumping house and canal system were built by the Royal Irrigation Department to alleviate the situation. It was calculated that this scheme had the capacity to irrigate 31,000 ha of paddy fields. However, currently only 9,600 ha can be supplied with freshwater. It is to be noted here that some khlongs around Ranot area used to allow free passage of waters between the upper lake (Thale Luang) and the sea. In order to prevent any intrusion of seawater into the lake system and partly into the paddy fields, these khlongs were closed around 1952.

In response to further demands of rice growers in particular, the Royal Irrigation Department has proposed that a salinity barrier be constructed across Thale Luang at Site A (see Fig.I2) in order to convert a portion of the lake into a permanent freshwater reservoir. The proposal has created environmental concern and become the subject of controversy between economists and conservationists. As mentioned earlier, fisheries and aquaculture are very important activities in the lake as well as rice growing. Recently, the marine prawn industry has entered the scene with the strong support of rice growers from around Ranot, although concern over a possible drop in the market and possible salting of farmland is noted.

Actual conflicts over the use of lake water among interest groups have not yet arisen. However, grievances of rice growers have been echoed by the government from time to time. In late 1989, fishermen living along the north-west coast of the lake Thale Luang appealed to the Ministry of Agriculture and co-operatives asking for the opening of Pak Rawa dam at Rahot which prevents the seasonal influx of seawater from the Gulf of Thailand, making Thale Luang brackish which was suitable for fisheries. Closing the inflow of seawater is believed to cause a decrease in fish production. A recent survey by Sunthorn (1990) showed that there was a shift of interest among interest groups, particularly rice growers and fishermen. When questioned on the salinity barrier issue, 87 percent of the fishermen opposed the proposal, while only 52 percent of the rice growers were in favor of the project. This may be attributable to the introduction of the marine prawn industry which gives more economic return to the farmers as compared to rice growing.

REFERENCES

John Taylor and Sons, REDECON Australia Pty. Ltd., Asian Engineering Consultant Corp. Ltd., and Roger Tym and Partners. 1985. Songkhla Lake Basin Planning Study: Final Report. Bangkok.

Na Chiangmai, N. and Vitsupakorn, K.1982. Pollution Assessment of U- Tapao River. Prince of Songkhla University. Songkhla, Thailand.

Ratanachai, C. and Suwannatachote, R. 1989. Social Impacts of the Proposed Salinity Barrier in Songkhla Lake. Presented at the Second Expert Groups Workshop on River/Lake Basin Approaches to Environmentally Sound Management of Water Resources. Hat Yai, Thailand.

REDECON Australia Pty. Ltd., John Taylor and Sons, and Asian Engineering Consultant Corp. Ltd. 1988. Songkhla Lake Basin Planning Study: Prefeasibility study on the proposed salinity barrier: draft final report. Bangkok.

Setamanit, S. 1988. Environmental and Social Effects of the Proposed Salinity Barrier Project in the Songkhla Lake Basin. Presented at the Expert Group Workshop on River/Lake Basin Approaches to Environmentally Sound Management of Water Resources. UNCRD/ILEC. Otsu and Nagoya, Japan.

Songkhla Province Office. 1990. Priority Projects for SLB Development. Presented at Provincial Meeting. 9 January 1990. Sonkhla, Thailand.

Sunthorn, S. 1990. Community Responses to the Proposed Project on Salinity Barrier Across Songkhla Lake at Thale Luang. Presented at the Third Expert Group Workshop on River/Lake Basin Approaches to Environmentally Sound Management of Water Resources. UNCRD/ILEC/UNEP. Otsu, Japan.

Taneerananon, P. et al. 1989. Water Quality Management for Songkhla Lake Basin. Presented at the Second Expert Group Workshop on River/Lake Basin Approaches to Environmentally Sound Management of Water Resources. Hat Yai, Thailand.

PROFILE J:

LAKE KASUMIGAURA - JAPAN

H. Harasawa

Lake Kasumigaura, the second largest lake in Japan, is located in the Kanto plain near the Pacific Ocean. The surface and drainage basin areas of the lake are 200 km^2 and 2,157 km^2 respectively. The lake consists of three parts; Nishiura (West lake), Kitaura (North lake), and Sotonasakaura (Outer lake). It is a shallow lake with 4m mean depth and 7m maximum depth (see Table J1 and Figs. J1 and J2). Though the lake water was originally brackish, the Hitachigawa Gate, which works as a salinity barrier, was built in 1963 at a site 23.5 km south-east of the end of the lake (Nishiura basin) and 18.5 km upstream from the river mouth (see Fig. J1).

Table J1
General Hydrological Data of Lake Kasumigaura

Water catchment area	2,157 km^2
Lake surface area	220 km^2
- Nishiura Basin	171 km^2
- Kitaura Basin	34 km^2
Mean depth	4 m
Maximum depth	7 m
Lake volume	800 million m^3
Annual rainfall	1,370 mm
Inflow water volume	1,400 million m^3
Mean lake water leve	Y.P. + 1.00 m (= T.P. + 0.16 m)

Note: Y.P. +/- 0m is equivalent to T.P. - 0.8402 m, where T.P. +/- 0 m means the mean seawater level at Tokyo Bay

The initial purposes of the gate were flood control and mitigation of salinity intrusion. With ongoing industrialization and urbanization in the drainage basin, the lake became an important freshwater source for irrigation, fishery, domestic and industrial uses. To respond to the growing water demand, one of the largest national water resource developments projects, called the "Kasumigaura Comprehensive Development Project", was launched in 1970 and is still on-going. The primary purpose of this project is to supply lake water to the Kashima Coastal Industrial Zone, the Tokyo metropolitan area, and other nearby regional developments in Ibaraki and Chiba prefectures. Consequently, the earlier gate has been almost completely closed since 1974, except during heavy floods. The chlorine concentration of the lake has decreased since then and is now at the same level as that of other freshwater lakes.

On the other hand, eutrophication has grown severe due to nutrient loading from settlement areas and many factories in the drainage basin, and has given rise to blooms of blue-green algae. Every summer, the lake has extensive blooms of the blue-green algae microcystis, which does serious damage to cultured carp, gives tap water a bad odor, and undermines the value of the lake.

To rehabilitate the deteriorated lake water, the Ibaraki Prefectural Government enacted the Kasumigaura Eutrophication Prevention Ordinance in 1981, and has since promoted various measures to reduce nitrogen and phosphorus loads from the drainage basin. In addition, after the Clean Lakes Law was enacted in 1984, the lake was designated as a lake for implementation of various measures in a comprehensive and planned manner. To respond to this requirement, the prefectural government established a lake management plan, and has made concentrated efforts to clean up the lake. The construction of sewerage systems and the strict regulation of factory effluents are stressed in the plan. Over the past several years, high transparency has been observed at the central part of the lake in winter. Though the water quality of the lake has seemingly gradually improved owing to various measures, there is no scientific evidence to explain this new symptom at present. However, some interest groups strongly insist on opening the gate to purify the lake water further.

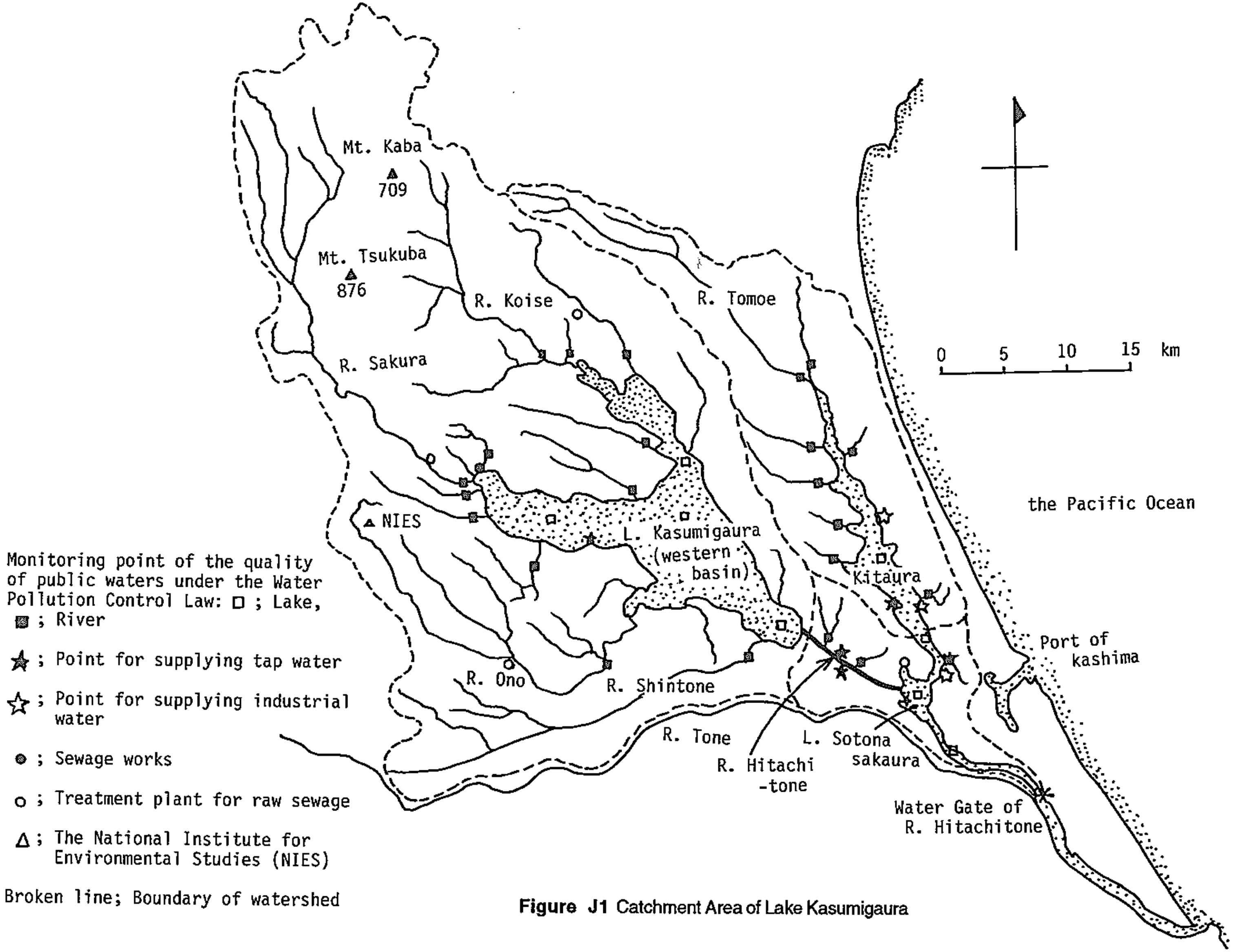

Figure J1 Catchment Area of Lake Kasumigaura

Figure J2 Scenic Beauty of Lake Kasumigaura

PROFILE K:

SOCIO-ECONOMIC PROFILE OF THE LAGUNA LAKE BASIN - PHILIPPINES

Enrique P. Pacardo

The Laguna Lake basin includes the provinces of Rizal and Laguna, two towns in Batangas province and part of Metro Manila. With a land area of 290,000 ha and 90,000 ha water surface, the basin holds a population of 2.6 million (Table K1).

Between 1960 and 1980, the annual growth rate in the basin was 5.22%. This was due mainly to the natural birth rate and in-migration from other provinces. Assuming a continued annual birth rate of 5.22%, the basin's estimated population now is around 4.3 million, and the population density is 14,995/km^2. Females outnumbered the males by 9,941 (1,312,203 v. 1,302,262), registering a sex ratio of 99.24.

Table K1
Population in Various Census, 1960-1980 (in thousands)
(National Census of Statistics Office, 1980)

Area	1960	1970	1975	1980	Annual Growth 1960-1980	Doubling time, years
Philippines	27,850	36,684	42,071	48,098	2.91	24.0
Laguna Lake Basin	945	1,645	1,955	2,614	5.22	13.4
Batangas	78	108	120	135	2.78	25.2
Cavite	44	70	109	134	5.71	3.3
Laguna	472	700	804	973	3.68	19.0
Quezon	17	23	23	26	1.98	35.4
Rizal	174	307	414	556	5.58	11.7
Metro Manila	160	437	485	791	8.34	8.4

The total number of households was 472,684, 63.4% of which are in the urban sector and 36.6% in the rural sector. The close proximity of the basin to Metro Manila accounts for this. Table K2 shows the age composition of the population. About 58% are within the working age group (14-64).

Table K2
Age Composition, Rural-Urban, 1980 (in thousands)
(National Census of Statistics Office, 1980)

Age group	Total	Urban	Rural
all ages	2,615	1,916	699
0-14	1,017	724	293
15-64	1,519	1,137	382
65 and above	79	55	24

Based on 1975 data, the majority of households (60.1%) depended primarily on wages and salaries for their livelihood. Of those households engaged in private ventures, 24.9% were engaged in agriculture; 2.6% of the total households were dependent on fisheries as their main livelihood. However, this number declined from 13,000 in 1964 down to 8,620 in 1983 (Table K3). This may be attributed to the increase in fishpens which

Table K3
Estimated Number of Fishermen in Laguna Lake

	1962-64	1968	1983
full time	6,511	7,674	3,184
part time	6,489	2,139	5,436
total	13,000	9,813	8,620

proliferated so fast that in 1983 an area one-third of the lake was covered with fishpens. At present the fishpen area has decreased to less than 10,000ha. It could also be presumed that the number of open-fishing fishermen has also declined due to lake pollution.

With regard to the income profile of the families, the only available data are from 1975; the are as follows:

Income group	percent
below 2,000	17.6
2,000 - 10,000	62.1
above 10,000	20.3

About 66% of the total income is earned by only 20% of the population. In other words, there are a higher number of poor families than there are of the middle income group.

SECTION 5

CONCLUSIONS AND RECOMMENDATIONS

by Michio Hashimoto

5.1 Conclusions

The management of integrated land/water ecosystems of the lake environment requires a comprehensive identification and appreciation of the social, cultural and economic issues involved (Kada, section 2.1). An understanding of the interdependency of various elements based on the natural and social history of the environment of lakes and reservoirs is a prerequisite for good management.

The planning and implementation of water resource developments and management policies is, however, influenced by the wide range of perceptions and interpretations of particular issues by the interest groups involved (Nakagami, section 2.2). Moreover, competition and even conflict between communities, social groups and sectoral human activities over the use of water resources further complicates the management process. Such conflicts include those between agriculture and fisheries, up-stream and down-stream areas, local versus regional versus national interests and so on.

The local population and NGOs have an important role to play in water resource planning and management. Environmental and other pressure groups from outside the lake/reservoir or water development area can also play a key role by requesting further consideration of environmental matters and modification or suspension of development projects where unacceptable environmental effects can be anticipated. The case of Lake Shinji in Japan provides an example of how environmental groups can effectively participate in the decision-making process to prevent environmentally harmful projects from taking place. NGOs can also make a major contribution by functioning as a mediator to correct the sometimes biased power balance between pro- and anti-development interests groups. International NGOs are becoming increasingly involved in lake/reservoir environmental management issues (Jackson and Eder, section 2.3, Sendama, section 4.1).

A conceptual framework for the composition and dynamics of water resource management (Hufschmidt and McCauley, section 3.1) is an important part of the water resource planning process and provides a useful background when overviewing the problems posed by lake/reservoir management. Another prerequisite for effective planning, design and management of sustainable water resources is the availability of adequate and reliable data (Biswas, section 3.2). Unfortunately, at present, managers of lakes and reservoirs around the world have in many cases limited data on which to base their decisions. The mass media can play an important role here by providing a timely and useful analysis of the content of the information produced and its relevance to the decision-making process. In addition, education and information programs can work to raise the awareness of local citizens in relation to the quality of the lake environment and its importance.

When planning, managing and monitoring water resource developments it is very important to use the most up-to-date technology and scientific knowledge. However, it is also necessary to refer to traditional practices related to integrated land-water systems and their potential modern applications (Loffler, section 3.3). Public policy decisions for investment should be analyzed in a social benefit and cost analysis framework (see 3.4, Dixon). Alternative projects, design formulations and management strategies can be developed through the consideration of various options for cost allocation and sharing related to water resource development planning and implementation (Easter and Waelti, section 3.5). Furthermore, economic principles concerning the efficiency of resource allocation and social principles of equity, in the context of the distribution of benefits and costs related to water resource development and management, play an important role in determining the issue of cost sharing.

In the past significant economic and social losses have been incurred by communities in close proximity of major water resource developments. Large dam construction projects have failed, in some cases, to bring about anticipated major improvements in the socio-economic conditions of the local population. This has been clearly shown with the papers on African dams (Sendama, section 4.1), on compensation in Japan (Matsui, section 4.2) and on the problems of involuntary resettlement (Cernea, section 4.3). Many of the costs of dam construction and water resource developments, in general, have often not been correctly reflected in the project economic analysis and planning process. There is a lack of basic research on these problems and no clear social policy framework for water resource development projects.

Manpower development, recruitment policies and programs are vitally important at the project implementation and operation stages. Infrastructural development, project construction and operation can be achieved smoothly if capable manpower can be recruited. In the case of projects where bilateral assistance is involved a major weakness has been the failure to adequately provide funds for the operation and maintenance of the project once construction and installation is completed.

The issues related to brackish lakes were presented in four of the eleven lake profiles (Lakes Shinji/Nakaumi, Songkhla, Laguna and Kasumigaura) and in one of the main papers (see Harasawa, section 4.4). These lakes have very particular characteristics and the problems and experiences of brackish water lakes and desalinization projects are well documented in the papers presented in this volume. In addition, the other seven profiles show the range of socio-economic factors affecting lakes and reservoirs throughout the world and some of the associated lake/reservoir environmental management issues. Although each case is unique some interesting similarities can be observed for different stages of development and with a variety of different political, economic, cultural and and social backgrounds.

5.2 Recommendations

The range of possible recommendations based on the papers included in this volume is very wide. Consequently, this section seeks merely to highlight some of the most important points raised. These are as follows;

[1] Alternative options for planning and management strategies for the lake environment should be derived through the identification of the different perceptions, conflicting interests and policies among the individuals and organizations involved.

[2] Policy decisions in relation to water resource developments and investment should be analyzed in a benefit/cost analysis framework.

The policies for cost allocation and cost sharing should be critically examined based on the criteria of economic efficiency, social equity and political feasibility. Guidelines should be developed to cover these matters with consideration of the tradeoffs which may be necessary.

[3] A more long-term view, one that includes the socio-economic costs, needs to be applied when determining the financial needs of the project plan. In addition, local agencies (with sufficient funding) need to be set up to manage the development project from the initial design stage, through implementation to operation and maintenance. If possible, administrative, management and technical functions should be delegated to these agencies.

[4] Public participation procedures are an essential part of the development process and of the integration of social, cultural and economic factors into policy-making. Farmers, fishermen, villagers, lake-shore residents and other water resource users, and those people affected by development projects should be encouraged to participate in the planning and design of local projects and in policy development.

[5] Institutional channels should be set up to handle local complaints and for the arbitration of pollution disputes within a lake/reservoir environment as a transboundary zone.

[6] Effective monitoring systems (hard and software) need to be developed to cover not only the physical quality and quantity of the water but also socio-economic and cultural parameters. The monitoring programs themselves should also be subject to periodic evaluation in terms of cost-effectiveness, data priorities, feasibility and sustainability.

[7] Environmental education programs should be targeted at schools, community groups and other pressures groups so as to increase the local citizens' ability to participate in the water resource development process.

[8] A legal framework for the rights of land ownership/tenure, water use, timber and fishing rights etc., needs to be developed by the national administrations involved. This should include detailed consideration of the method of compensation for any perceived losses. Relatively smooth implementation of the project can be achieved if the project planner, from the start of the initial design stage, aims to ensure that the affected population improve, or at least regain, their previous living standards and set up mechanisms to achieve this goal and to include socio-economic and cultural factors in their preliminary planning. These include adequate consideration of the following;

* method of compensation,
* quality of the new habitat,
* social organizations of the resettlers,
* interaction with the host population and environmental protection of the relocation area, and
* creation of new employment and training opportunities.

All displacement and resettlement programs and costs must be integrated into the development program for the initial stage.

[9] Manpower development and recruitment policies and programs are an extremely important part of the successful implementation of a development project. Training programs need to be organized to overcome recruitment problems.