

## CHAPTER 8

# PLANNING FOR SOUND MANAGEMENT OF LAKE ENVIRONMENTS

### 8.1 INTRODUCTION

Planning for sound management of lake environments requires integration of scientific knowledges into policies and programmes developed at all levels of decision-making. On one hand scientific information must be collected, collated, evaluated and used for developing practical strategies through on-site study programmes. Many of the basic principles described in earlier chapters will have to be properly integrated into the design of a good study programme. On the other hand, a long-term and comprehensive plan will also have to be developed at the highest level of administration in charge of lake management so that necessary resources could be mobilized to priority activities which collectively contribute to the sound management of lake environments. Since environmental problems are primarily local and regional issues, the environmentally sound management of inland waters, particularly of lakes, requires practical approach in terms of policies, administration and operations in given national, regional and local situations. This chapter deals with these and other aspects of planning for sound management of lake environments.

By way of introduction to the intricacy of planning for sound management of lake environments, a comprehensive international project of inland water management entitled EMINWA, together with institutional mechanisms and procedures required for its successful implementation, will be briefly introduced below.

#### *The Environmental Sound Management of Inland Waters (EMINWA Project)*

The traditional water pollution control approach of engineering orientation at the source of effluent has been challenged by the complex mechanisms of water pollution in the lake environment. The Environmentally Sound Management of Inland Waters Programme (EMINWA) was conceived by UNEP jointly with WHO, UNESCO and WMO in 1985. Within the umbrella of EMINWA, the Environmentally Sound Management of Lake Environments Programme was initiated with approval of the Governing Council of UNEP in 1987.

EMINWA is stated in the programme document by UNEP as follows: The

environmentally sound management of inland(fresh) waters (surface-water and ground water bodies, e.g. rivers, lakes, reservoirs, streams, aquifers, large man-made water projects and their systems) is regarded as **an activity designated to integrate environmental concerns into the management of water resources**. By doing so, it contributes to on-going harmonization among the various interests involved in water-related socio-economic development and the natural environment throughout an entire inland water basin (hereafter referred to as river basin). It thus promotes **sustainable development** in the river basin.

The implementation of environmentally sound management of water resources in a river basin is a long-term activity which should be fit into the integrated river basin development process.

It should be applied to individual projects as well as at the **basin-wide level** and should take into account the co-existing functions (natural resource and ecosystem landscape foundations) of inland waters. It should promote the environmental management of surface water, inland, energy, and biota in terms of quantity and quality.

It would incorporate environmental considerations into a wide variety of water management and development activities connected with water and water-related projects within a water system. Activities would range from **assessment, monitoring, policymaking, planning and analysis of decisions through design and construction, to operation, maintenance and rehabilitation**. It would encourage the practical application of the principles of environmentally sound development of water management.

The **EMINWA programme extends the scope of environmental planning and management** beyond the traditional scope of jurisdiction of environmental administration. No single almighty administrative authority would exist. Planning and management would be carried out by a multi-jurisdictional administration whose goal would be the **integration between environmental conservation and social and economic development related to three terrestrial elements, namely the water body, shorelines and their inner and outer watershed of lake environment**. The effective institutional mechanisms and procedures should be established to comply with the objectives of EMINWA at local, regional and national levels, and even the international level in international river basins. The outline of the EMINWA concept is shown in Fig. 8.1.

### *Institutional Mechanisms and Procedures*

A wide scope and integrated approach of EMINWA programme, together with appropriate **orientation** of an environmental approach within the

SUMMARY

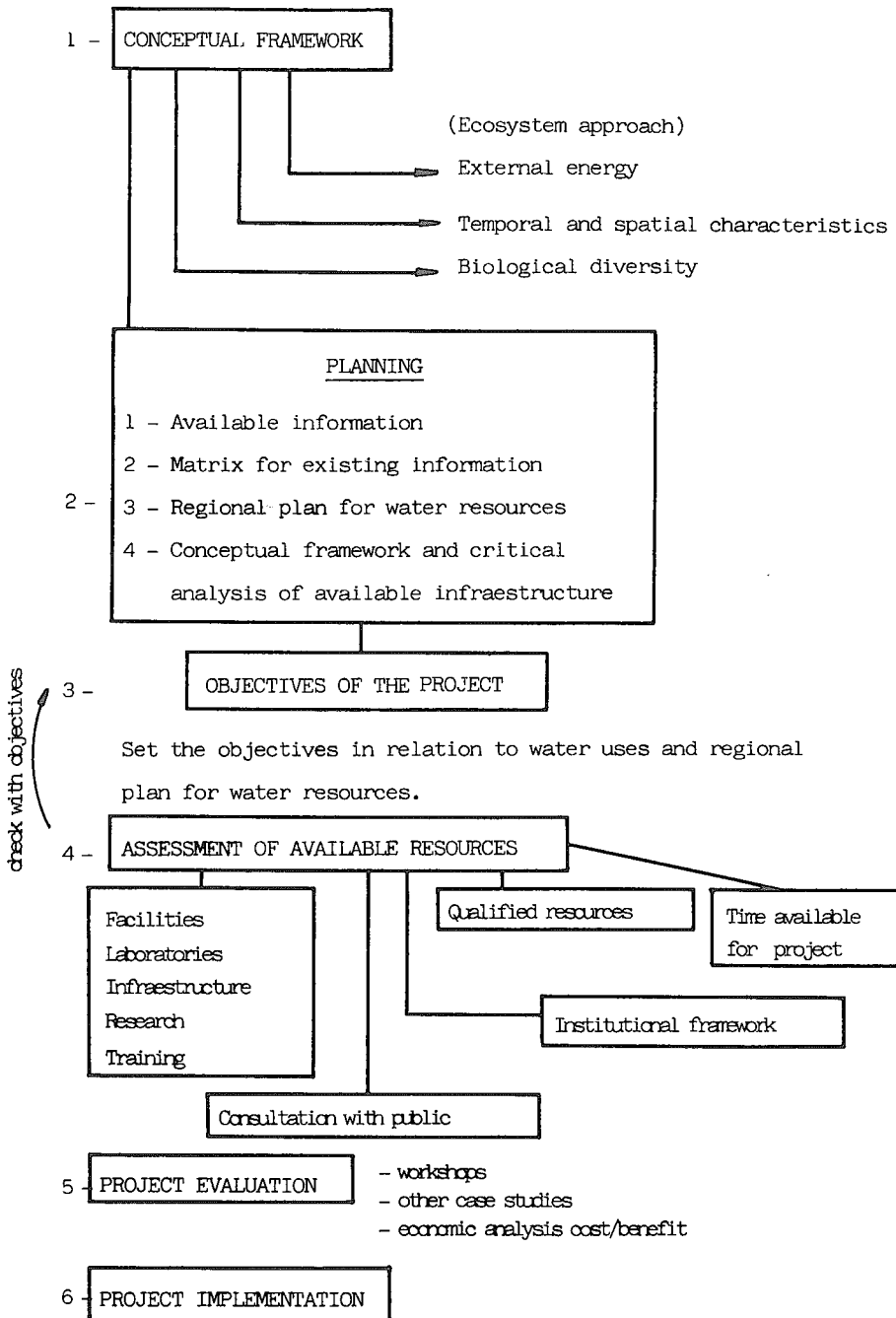


Figure 8.1: The summary of a project flow chart.

institutional mechanisms and procedures are essential for the environmental administrator.

There are three dimensions of interface in planning and management:

I Environmental components/socio-economic activities/government

II Government/public & private organizations

III Environmental authority/others/agencies including planning agencies within a government.

The term "**environmental components**" refers to the water body, soil (shoreline and the inner and outer watershed), flora and fauna in the lake environment.

The term "**social and economic activities**" refers to agriculture, forestry, fisheries, mining, manufacturing, power generation, construction, transportation, tourism and trade, and aspects of the population's behavior which bear significant potential for environmental impact in terms of the quality and quantity of lake water.

The term "**government**", refers to ministries and departments of various jurisdictions, and also stratification of national/local or federal/state governments based on the Constitution. Environmental components and related socioeconomic activities and their relationships with complex jurisdictional structures as well as traditional policy interests reflect the complex patterns and processes in negotiation, coordination and integration within a government.

Inter- and intra-government relations are strongly influenced by public opinions and "**pressure groups**" of private organizations linked with various political interests at national and local levels. In the case of the international Lake environment, diplomatic issues may be involved in planning and management.

Within the government, there is a supreme legal instrument (constitution, laws, statutes, etc.) which provides a universal framework and order for powers, responsibilities, functions and activities of government organizations. Those are the products of legislation by the Congress. Then there is a **superior decision level** that establishes objectives and basic policies and orders, and co-ordinates and integrates among government actions under diversified jurisdictions. This is in the hands of the Cabinet or the Governing Council of the Executive branch of the State.

Under the direction of the superior decision level is a management level which is responsible for planning implementation according to the stated objectives and policies. The management level determines which strategies and supportive instruments will be used. The management level is further stratified into national, regional and local levels and differentiated into divisions of source control, environmental monitoring, infra-structure

development, etc. Developing infra-structure divisions responsible for daily routine administration and technical operation in the field both at regional and local levels is a fundamental challenge of environmental planning and management.

Environmentally sound management of the lake environment involves a complex range of different types of decision-making. Firstly, the legislative policy decision must be made to provide necessary institutional mechanisms for integration between development and environment at the planning stage.

Secondly, the administrative policy decision must be made at superior levels on occasions of national development planning, environmental impact assessment, enforcement programmes, conservation measures and cost bearing for environmental measures. While the implication of the legislative policy decision is essential, the implication of the administrative policy is more substantive. They are more crucial in dealing with the dynamic interfaces among environmental sciences, government administration and national and local politics in the management of lake environments.

## **8.2 GENERAL PRINCIPLES IN PLANNING AND MANAGEMENT OF LAKE ENVIRONMENTS**

Planning is a tool or working methodology to improve the use of available resources to comply with certain objectives. It requires knowledge of the reality on which it operates, capacity to evaluate the expected outcome and the process through which it can be attained.

In defining the planning objectives, it is essential that problems to be solved are clearly identified and appropriately defined. The assessment of available resources is indispensable for examining feasibility of undertaking a project. It also provides the rational criteria for allocation of resources based on a given set of priorities of plans, projects and programmes. Appropriate options, with criteria for selection and the expected outcome and probable consequences, should be presented for a sensible policy planning decision. Since a certain extent of uncertainty is unavoidable in any planning, a reasonable procedure for public involvement should be instituted when appropriate.

Management is a continuous, permanent, everyday work of keeping assigned matters in the best condition based on the mandate within the established jurisdiction. Management is the link between the upper policy-making level and the operational team in the field. Management performs the following functions: provision of directions for implementation of plans, projects and programmes; organization and recruitment of

necessary staff; negotiation and coordination with other relevant organizations; supervision and government of on-going activities; provision of consultation and guidance to staff; formulation of a budget and provision of the necessary materials; development of recording, reporting and data systems for rational management practice; establishment of a man-power development programme through training, education and job placement of staff; undertaking of public information services to promote understanding, support and co-operation, and if possible, appropriate public participation; and evaluation of the achievements of assigned activities.

Planning and management are continuous institutional processes. It is important to recognize that planning and management are real-world undertakings with certain constraints, and must therefore be operational and efficient. Plans must comply with their objectives and be executed within their scheduled time. The effective distribution of information and active efforts of communication between decision-makers, managers and operational staff, and interested organizations and the public are necessary for successful achievement of management objectives.

### **8.3 LAKE ENVIRONMENT DYNAMICS**

#### *Activity Subsystems with a Catchment Area*

Planning and management of a lake environment may be described in terms of three constituent activity subsystems within a catchment area. These are (1) natural environmental systems of the water body and catchment area, (2) quasi-natural environment systems of forestry, agriculture and fishery as primary industrial activities, and (3) the population and its socio-economic activity centres.

The first encompasses a geographic area and constitutes a hydrological unit covered by a variety of ecological systems. These environmental systems support the second and the third. The multipurpose uses of the environment by the second and the third often results in conflict, because complex burdens are laid on the environmental systems. Natural water body and catchment areas cover a unit area irrespective of man-made boundaries between territories and legal jurisdictions of development and growth, which contribute further to environmental burdens. And the institutional gaps attributed to boundaries and jurisdictions often result in barriers to comprehensive environmental planning and management in the real world.

## Lake Environmental Dynamics

The schematic diagram presented in Table 8.1 represents typical component activities and their dynamics with the lake environments.

**Table 8.1**  
**Compositions and dynamics of the lake environment (UNEP, 1987)**

Catchment area and human activities	Probable adverse environmental consequences	Integration of environmental considerations into development
Human settlement Public effluent Source	Environmental Burden of population	Development orders Infrastructure Development Housing sanitation Public & community efforts
Mining & manufacturing industry		
Electric power Station	Point Source of pollution	Industrial pollution control Effluent
Business, Tourism		Wastes Products Processes Discharge
Transportation	Navigation	Accident control
Construction Work	Irreversible Alternation of the state of the Environment	Engineering Design Land use, Site, Route, Design, Technology, Operation
Agriculture Forestry Fishery Wildlife reserve, Natural park	Non-point Source of pollution  Degradation of natural environmental resources	Sustainable agriculture, Forestry, Fishery, Pesticides, Fertilizers Regulation, Management of soil, Irrigation water use, River, Flood Plain & Mountain
Natural Background (Native) transboundary pollution	Disruption of Life support Environmental Systems	Nature conservation Wildlife protection, Historic, cultural heritage protection Flood/drought control

The water body of a lake is the sum total of the water which comes directly from the lake catchment area and indirectly from subcatchment areas of tributary rivers which flow into the lake. All of these are integral parts of the natural water cycle (e.g. precipitation, surface run-off,

infiltration, percolation and groundwater flow). Soil-water interrelations modified by flora and fauna and precipitation influenced by air transport of substances constitute the input and output balance of waters. Environmental burdens are generated through population settlement due to emissions of waters from mining, factories including public sewerage facilities and waste-water treatment plants. The chemicals contained in pesticides and fertilizers used in agriculture and forestry are the burdens of non-point sources. Geochemical elements from mining, and agricultural and animals wastes are other non-point sources. Soil erosion is caused by natural and quasi-natural phenomena of river beds, and dam and lake beds. If the soil erosion is unappropriately controlled, the water pollution in lakes progresses, flood risk increases, dam life is shortened and the future utilization of water is endangered. Underground leakage of toxic chemicals from waste dump sites could have serious environmental impacts. In the 1970's pollution sources of the Great Lakes in North America, toxic chemicals and/or heavy metals deposits attributed to chemical wastes, as well as mining wastes contained in bottom sediments constituted distressing "stock pollution" problems.

The Minamata disease in Japan was caused by biological condensation in fish and shellfish of alkylmercury discharged in industrial effluent of the acetaldehyde manufacturing process which uses an inorganic mercury catalyzer. A heavy oil pollution accident in Lake Maracaibo in Venezuela caused by an oil spill, and the massive loss of human life due to a burst of CO<sub>2</sub> from the bottom of Lake Nias in Cameroon caused by volcanic action are to be remembered as serious experiences of lake disasters.

A river is a flow of water, but a lake is a stock of water. Owing to the long water replenishment time, lakes cannot clean themselves as rapidly as rivers. The stock of nutrients, persistent chemicals and heavy metals deposited in the bottom sediments are difficult to flush out because of the long water replenishment time. Furthermore, the weight of pollution from non-point sources hampers the effectiveness of the traditional water pollution control approach by means of engineering control at the source. Meanwhile the ecosystems of lakes are highly sensitive to changes in their drainage basins. Disruption of the relationship between soil and water at outer and inner watershed of shoreline results in irreversible impairment, sometimes resulting in total destruction of the ecosystems of marshes and wetlands which are indispensable as habitats for wildlife and fisheries. An ecological approach, with due consideration to complex and delicate environmental systems as interactions among soil, water and biosphere, is essential for lake environment conservation.

### *Need for Special Considerations to Water Resource Development Activities*

Fresh water from lakes (natural and man-made) is an essential but scarcely renewable natural resource which supports life and promotes socio-economic development. Surface water is used in extractive and non-extractive ways. Uses such as human consumption, domestic and wild animal consumption, aquaculture, irrigation, operational use at public and private places, electric power generation, mining and industrial uses, artificial aquiferous re-charge, etc. are extractive uses. Uses as a life medium for aquatic ecosystems, fishing and fish culture, hydro-electric production, navigation and transportation, reception of effluent discharge, swimming, recreation and sight-seeing, etc. are non-extractive uses. There is a wide variety of requirements and demand/supply conditions in terms of quantity, quality, location, timing and means among those multiple uses.

Environmental management is important for all modifications made to water basin, but especially important in construction works that directly modify the water flow by retaining or diverting it (frontal dams, lateral dams, water gates, tunnels, aqueducts, channels, etc.). Dams and their impoundments, reservoirs and artificial lakes in particular, produce or lead to drastic modifications of the water regime and aquatic and land ecosystems (which disappear in flood areas) and can produce a substantial modification in the functioning and configuration of the original water system. Careful planning and integrated interdisciplinary analysis of cost and of irreversible environmental impacts is essential. Environmental Impact Analysis (EIA) is institutionally required prior to the approval of a master plan. For major works, the impact must be analyzed in three stages (construction, filling of impounding, reservoir completed), and for different sub-regions of the basin: upstream location area (impounded area), and down stream. After a dam is built and the analysis of the evolution of its multiple impacts carried out, other important aspects of environmental management appear: evolution of reservoir water quality, dam management and spill regime (which will be related to the preparation of the impoundment before fillings as well as the activity developed in the basin upstream).

An increase of endemic diseases often accompanies the creation of large reservoirs. Factors of "vector ecology" related to possible endemic diseases demand special attention from environmental planners and managers. The propagation of schistosomiasis and the northerly migration of malaria mosquito vectors from Sudan are reported as examples of such a case stemming from the Aswan High Dam project. High morbidities of epidemic and endemic diseases related to water are one of the important public health

problems in the Common Zambezi River System.

In de-salinization of brackish lakes for agricultural irrigation, the salt content of lake water dictates the trade-off between agriculture and fisheries. Japanese experience in Kasumigaura Lake and the on-going controversy in Nakanoumi Lake are typical examples of the anticipated impacts. Both cases are connected to sea through tidal estuaries, where a salination barrier is constructed. The simulated operational conditions have proven a decrease in the salinity of the irrigation water which may, however, be adverse to the existing fishery.

Where nature ecosystems for wildlife exist, land reclamation projects along coastal areas of lakes will change the water front environment in an irreversible manner. J.A. Dixon presents the loss of economic development opportunities by multi-purpose dam projects as follows:

- a. Valley dwellers displaced upland or to the flood plain below the dam. Wildlife habitat is destroyed also.
- b. Migrants add to population pressure on marginal and steep sloping lands resulting in increased soil erosion.
- c. Upland activities (farming, forestry, agro-forestry, roads and settlements) causes soil erosion, silt and chemical pollution of streams. Sediment is stored in delivery system awaiting storm events.
- d. Sediment from eroded soil is deposited in reservoir and reduces storage capacity.
- e. Turbidity affects fisheries and recreation.
- f. Nutrient flow causes eutrophication and aquatic weed problems.
- g. Irrigation leads to increased loading of silt into the water requiring dredging canals.
- h. Salinization and water logging of soil may occur from improper irrigation.
- i. Irrigation return flows to river may carry toxic chemicals and salts which affect downstream fisheries and other water uses.

It is important to stress the fact that each water basin and each dam is a unique case. In particular, the differences between characteristics of lake environments in the temperate zone and the tropical zone need to be carefully recognized because of a relative scarcity of data and information of tropical lake environments.