

CHAPTER 10

PLANNING

Milan Straskraba

10.1 INTRODUCTION

The aim of this chapter is to provide guidance in the preparation of management plans, what they should contain and respect. For a more general context, see Anon. (1983) and Jørgensen and Villenwelder (1989).

In the preceding chapters different aspects of lake shore management were treated individually. For planning purposes it is not only necessary to treat the lake-shore problem as a whole but moreover, the lake-shore problem should be considered from the perspective of the whole lake watershed. Therefore, we will begin with a discussion of some of the major problems connected with the lake basin and then consider the combination of the individual aspects. Problems of how to divide the lake shore between the different uses and/or in which way to use the same shore areas for multiple purposes will be considered. The appropriate method for quantitative evaluation of such problems is the cost/benefit-analysis. This will be discussed in the final part of this chapter.

When planning, it is necessary to adopt a holistic system approach. The basic notion is to consider different system elements and their mutual interrelations, and the relation of the system to its surroundings. One major character of natural systems (as opposed to technical ones) is the importance of feedback between system components (Fig. 10.1). A major feedback exists, for instance, between land - lake-shore - water.

The activities on both nearby and more remote land areas determine both the features of lake shores (their vegetation, slopes etc.) and of water (the quantity and quality). Processes on lake shore determine what is going on in the lake. Feedback effects from the lake are represented by micro- to mesoclimatic changes determining vegetation characteristics on land. Feedback from the lake to shores are due to shore erosion, lake eutrophication leading to excessive plant growth, etc. (Fig. 10.2.)

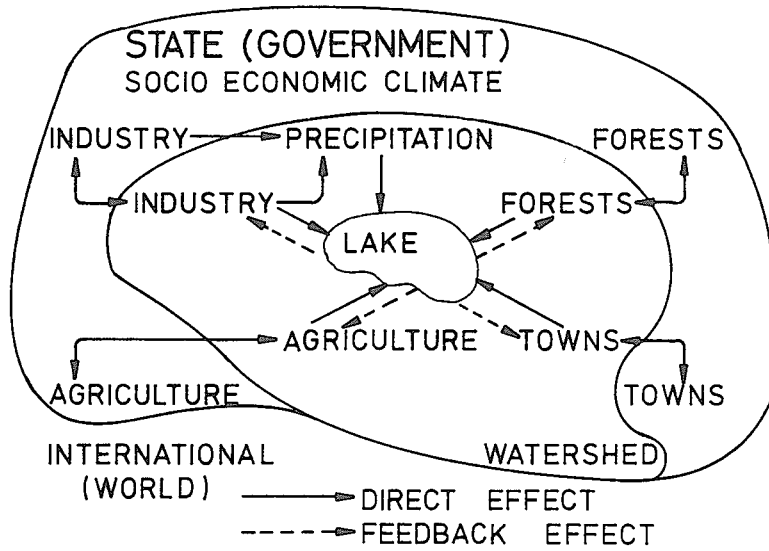


Fig. 10.1. Feedback relations between system components are characteristic for environmental systems.

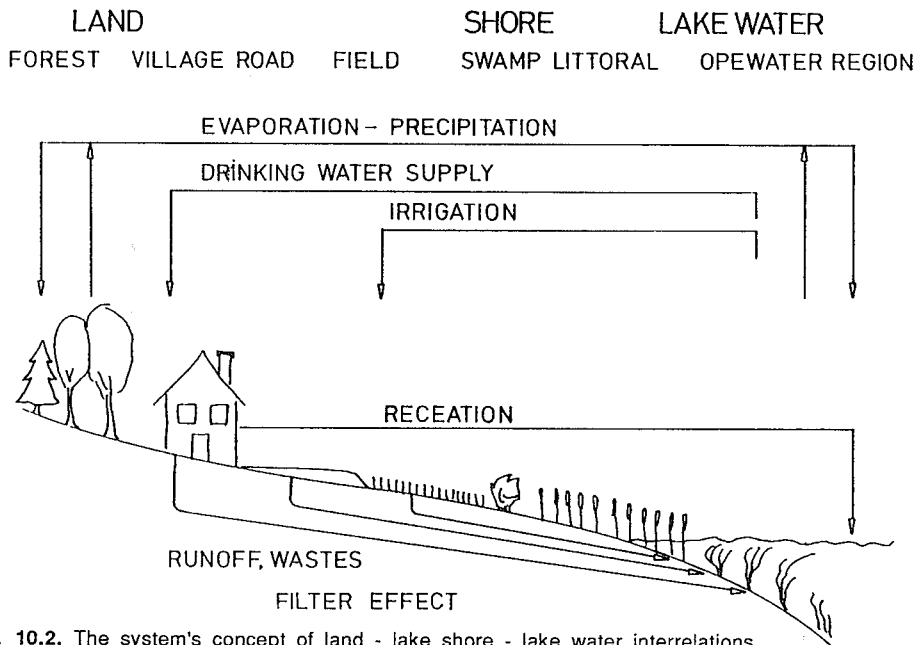


Fig. 10.2. The system's concept of land - lake shore - lake water interrelations.

Therefore, the system's concept dictates that the lake shore system with its natural and human related features is evaluated for management purposes. It cannot be treated as an isolated system because it bears close relations to its surroundings, represented by land areas on one side and the

open lake on the other. Also, consideration of the feedback effects between components is important for management.

From the long-term perspective, focus for planning the environment-human development interface is on the sustainable development of the total environment, ensuring human survival. When planning generates natural resources degradation, future uses will be impoverished. Therefore, it is always necessary to consider carefully and from a broader perspective why and where investments and activities should be located as this may change the whole concept.

The planning process may be considered to consist of the following steps:

- 1) Specification of the objectives.
- 2) Inventory, forecast and analysis of basin, water and shore conditions.
- 3) Formulation of alternative plans.
- 4) Evaluation of the effects of the alternatives.
- 5) Comparison of alternative plans.
- 6) Selection of a recommended plan based on item 3).

10.2 WHOLE LAKE BASIN PROBLEMS

Water has the character of a transport medium, moving substances originating from one place to another, sometimes quite remote, place. From this point of view the watershed of the lake represents an area where different land uses and human activities affect water coming into the lake. This is the reason why it is impossible to separate the planning of activities on the lake itself from those going on elsewhere in the lake basin.

Physical and political boundaries within watersheds

Fig. 10.3 shows different political/physical extreme situations in relation to selected watersheds. On one hand, the watershed of a small lake often belongs to one local political unit, the diversification of activities within the watershed is not great, and these facts make planning much easier. If the lake in question is large, then the lake basin may stretch across many political units of higher order, up to states or provinces.

Industrial, agricultural and other human activities are usually rather diversified. This makes decision-making much more difficult - but not impossible. An example of successful international planning regarding such a situation is the Great Lakes Agreement (Vallentyne & Thomas, 1987). Following some disagreement between specialists, phosphorus was recognized as the source of the Great Lakes deterioration. Agreement was reached concerning permissible phosphorous loads for individual enterprises including farmers (Loehr et al., 1980). An extensive campaign to lower (??) the watershed resulted in the desirable drop in phosphorous concentrations and consequently in water quality improvement.

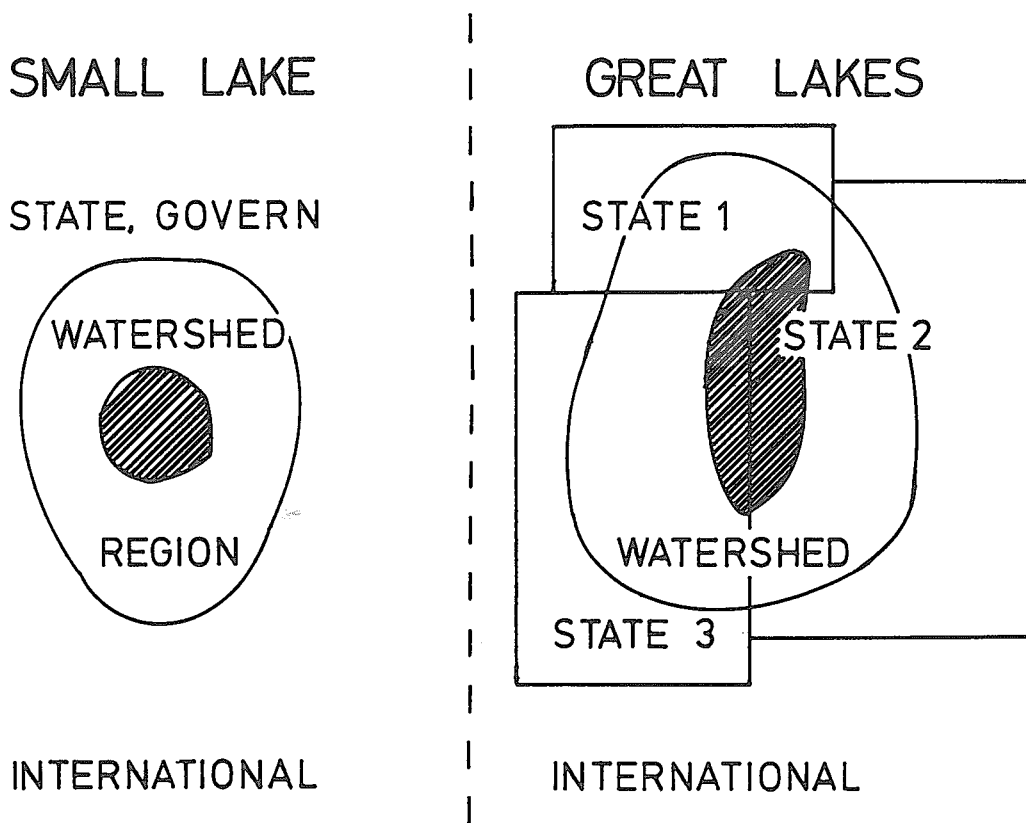


Fig. 10.3. Political and physical boundaries within different watersheds. A - a small lake basin situated in a forest area. The boundaries of the lowest, local political unit exceed those of the watershed. B - a medium size lake, with the watershed belonging to several local political units, physically divided into an urban-industrial area, a settlement and an agricultural area. C - a great lake.

Lake volume/watershed ratio

The ratio of the size of the watershed in respect to the size of the lake has another important aspect - a hydrological one. This ratio is reflected in the retention time of water in the lake, with consequences for water quality. Theoretical retention time is the ratio of the annual discharge of water from the watershed to the lake, to lake volume. In different geographical situations the specific discharge (per unit time per area) varies rather much. In dry regions it is not only much lower, but often also much more irregularly distributed over the year. In extreme situations, like

in Australia, sometimes even between years. In wet regions, the same area will produce much higher discharge to the lake. The ratio affects limnological events in the lake, particularly in man-made lakes and riverine lakes at the lower end of the scale (i.e. with high discharge/low volume conditions). Here a transition from near-river situations to typical lake situations, in respect of lake water stratification, can be observed. Pollutants are spread over the whole water volume in nonstratified water bodies. Whereas in a fully stratified lake, major vertical and horizontal differences exist. Also, natural self-purification processes, including retention of nutrients and other pollutants depend on this ratio. Not only is the load of a particular substance to the lake much higher in the case of high discharges, but also its uptake, mineralization and accumulation in biota is usually much lower. Full development of lake plankton, as well as sedimentation of dead organisms is only possible when certain critical values of this ratio are exceeded.

Activities within the watershed

From a water quality point of view two basic types of sources of pollution can be distinguished: point sources and non-point (diffuse) sources.

Point sources are relatively easy to spot. Also, technical possibilities for their decrease or eradication are well known and the problem is becoming a financial one rather than a technical one. Basic types of point sources are connected with different industries and settlements.

Non-point (diffuse) sources stem from both a number of small point sources (e.g. non-canalized population or farmer units) or they are of areal? character (e.g. ground and surface water pollution from chemicals applied to the fields). It is much more difficult to treat non-point sources (Krenkel & Novotny, 1980; Novotny & Chester, 1981). This is not only because measures have to be extended over large areas, but also because technical means are much less developed. One problem, which is spreading over vast areas in developed countries, is nitrogen entering waters in large quantities (particularly from agricultural activities) and resulting in human health problems. In addition, certain types of pollutants may come to the watershed from outside. This is the case when acid rain causes acidification of water because of the gaseous emissions from the industry which by air are spread over extensive land areas up to entire continents.

The following major activities within the watershed have an impact on water quality:

- a) *Industry*. Its effect on water quality are very diversified, depending on the type of industry products fabricated and chemicals used.

- b) *Agriculture*. Soils have only a limited capacity to take up nutrients, which are used to increase crop production. The nutrients which are not taken up by the soil/plant system leach into the surface and groundwater and are the sources of water quality problems related to eutrophication. In many European countries the application of mineral nitrogen fertilizers in agricultural areas exceeded the value of $100 \text{ kg/ha}^{-1} \cdot \text{yr}^{-1}$ (1981-82) and, in addition, the amount of organic nitrogen from animal wastes also increased due to higher livestock densities. Nitrogen emissions from intensive agriculture also share the responsibility for acid rain and forest die-back. Excess nitrate concentrations in water create health problems, particularly the deadly infant disease methemoglobinemia. Basic measures is the reduction of excess fertilization and modification of fertilizer type and time sequence of dosage in order to make the nutrients fully utilized by the plants. Other health problems are associated with the use of pesticides and other chemicals for crop protection. Transition to sustainable agriculture is one long-term solution.
- c) *Settlements* can basically be classified as urban and agricultural. The dominant type of pollutant is organic matter from domestic wastes. Non-canalized population produces less water pollution per person than the canalized ones, unless proper waste-treatment plants are installed.
- d) *Forestry*. For many geographical locations, forests are the most natural type of vegetation, with optimum effects on the water quality. Therefore, preservation of large forest areas is the optimum state. Deforestation is always connected with water quality deterioration. However, some recent practices of intensive silviculture in developed countries (fertilization, insecticide spraying etc.) also lead to negative water quality effects. Forests dying due to acid rain and air pollution has a negative effect on both water quality and quantity.
- e) *Traffic*. Salt and other chemicals used are transported to water.
- f) *Road building and other construction works* leading to vegetation and soil surface destruction causing an increased erosion and transport of the eroded material to the water.

The principal method of evaluating the importance of different activities for water pollution of the given watershed is by creating budgets of the critical pollutants. To obtain a budget for a substance in the watershed, two principal ways are possible:

- a) Direct measurement or estimates based on simple empirical mathematical models (Chapter 8).
- b) Indirect estimate using simple models based on unit factors for different activities.

TABLE 10.1
An example of the budget of nutrient (phosphorus) load to a waterbody (kg. ha⁻¹)

Activity	Amount	Units	Unit load	Total
Agriculture				
Fields	20.000	ha	1.5	30.000
Pastures	5.000	ha	0.5	2.500
Cattle	7.500	ind.	10	75.000
Atmosphere	40.000	ha	0.2	8.000
Inhabitants				
Canalized	1.500	inh.	0.8	1.200
Non-canalized, distant	800	-	0.01	8
Non-canalized, close to water	200	-	0.1	20
Town	1.200	ha	1.1	1.320
Industry				
Enterprise 1	-	-	-	780
Enterprise 2	-	-	-	6.000
enterprise 3	-	-	-	2.300
Total	-	-	-	127.128

An example of such budget is given in Table 10.1. Here both approaches were used - a) for industry and b) for the rest. It is also indicated which unit factors were used. Such models can be found e.g. in Jørgensen (1981), for 13 nutrients in Straskraba & Gnauck (1985) and Ryding & Rast (1990).

Whereas the first way is much more costly, the second is more uncertain. There are great geographical differences in the pollution per unit activity coming to the water. But these are not well reflected in the existing, mostly local, models. The uncertainty is much higher outside temperate regions from where most models originate

10.3 COMBINATION OF ASPECTS - COMBINED PROBLEMS.

Different aspects of lake shore management were discussed in Chapter 2 - 9. Here the concern is how to determine which remedious actions have to be planned and some kind of optimization of future developments which can be achieved.

One major issue, usually neglected in the evaluations, is the secondary effects. Take, for instance, an example of recreation. An estimate will be made of the number of lake shore visitors, their activities and distribution over the lake shore. Based on per capita/activity estimates, the primary effect will be evaluated with the methods discussed in previous chapters. However, secondary effects will be connected with constructions associated with recreation. Building of houses, hotels, kiosks and other facilities, construction of roads sometimes changes the hydrological conditions of the shore. Erosion associated with constructions increases the load of water. In some instances, these secondary effects can be more significant than the primary ones.

When planning lake shore development, two basic options can be adopted:

- a) to divide the shore areas according to different activities;
- b) to use the same areas simultaneously for several activities.

Option 1 is rather important primarily from a nature conservation point of view. As shown in chapter 5, certain areas of lake shores have to remain as intact as possible to preserve natural habitat and species diversity. The reasons are twofold: to preserve the world's genetic pool for a balanced development of the world and future human generations, and: to preserve for future possible human use the plant and animal species representing potential food, raw materials, natural control of pests, etc.

The first item is particularly urgent in the case of the great, ancient, lakes of the world, where the world's genetic pool heritage is, in part, located.

It should be understood that small nature preservation areas cannot function effectively. This is because animals have some minimum population numbers for survival, also certain minimum feeding areas (home ranges) are necessary. In general, such ranges increase in size proportionally to the animal size. Interrelations between plants and animals are very tight and the area has to be treated as a whole. Eradication of one major component produces complete restructuring of the biological associations. Therefore, it is necessary first of all to take care of the largest organisms in the given area. Moreover, an envelope of transitional areas between the conserved area and cultivated land should be created. Also, each habitat depends on its

surroundings and certain general conditions of its existence. A marsh or swamp area cannot survive in a culturally desertified region.

Reed belts have a particularly advantageous function in respect to water quality (see Chapter 4). They serve both as protection agents against destruction (abrasion, erosion) of the shore and as buffers taking up substances brought to the lake from land. Their preservation should be one of the major goals of lake development planning.

For some other activities, particularly for their intensive versions, the concentration of localized points is preferable to spreading over a broader, less intensive area. This is the case of settlements on smaller lakes - it is preferable to have one shore free for recreation and one more heavily populated, rather than having both sparsely occupied. From a water quality point of view this is also the question of point-sources versus diffuse sources, the latter being much more difficult to handle.

Option 2 - Simultaneous, multiple uses. It is, to a certain degree, possible to use one and the same area simultaneously for several human activities, without much mutual interference. Examples are reed bed development with fishing, and forestry with extensive recreation.

Particular care during planning of lake-shore activities should be taken when the lake is used as the present of potential drinking water supply. The direct and indirect impact of recreation on lake water quality is manifold and in such cases the recreational use should be rather restricted.

10.4 COST/BENEFIT ANALYSIS

This method of evaluation is commonly used for management and planning purposes. The analysis is based on the calculation of possible costs of different alternative activities and the benefits obtained (Cole & McKown, 1986). The measure used is the benefit-cost ratio;

$$BCR = (\text{present value of all benefits} / \text{present value of all costs}).$$

It provides the planner with a much more objective methodology for the comparison of alternatives. It only provides a comparative analysis in respect to the alternatives taken into consideration and says little about the existence of possible other, much more preferable, management options which may exist.

As an example, we consider the planning of a recreation centre for a small city on a lake shore.

Preliminary evaluations have shown two feasible solutions:

- 1) To clean-up a local lake which is now heavily polluted and eutrofied and build a swimming centre of the lake.
- 2) To build a highway to a more remote great lake and construct more diffuse recreation facilities on the lake.

For both alternatives the following costs and benefits are quantified (Table 10.2):

TABLE 10.2.
Costs and benefits to be evaluated in the given example of cost/benefit analysis.

Costs	Benefits
Treatment of the lake water	Improvement of water quality
Construction of the highway	Improvement of transport
Bathing facilities	Increase of land value
Boating facilities	Increase of income from fees
Sanitation facilities	Decreased transport to other regions
Land lost for other uses	Improvement of environmental quality
Decrease of environmental quality	

Considerable drawbacks of the cost/benefit analysis exist. First of all, it is difficult to translate all benefits and costs into a unified currency framework. Monetary units are not an appropriate measure of many benefits, particularly those associated with long-term environmental issues, esthetic values and degree of satisfaction. It is also not easy to estimate the secondary costs of any activity. This is the reason for the recent use of energetic equivalents, of energy used for particular activities (Watt, 1983).

Therefore, the cost/benefit analysis can be considered only a partial solution to the problem and its results have to be evaluated with caution, particularly for purposes of environmental management. In general, environmental problems are of a global character, for which proper evaluation methods are only just being developed.

Pearce (1988) developed a methodology to estimate the true cost of a resource such as water. It is based on confrontation of supply, demands and process. In addition to current price and quantity of the resource used, which are the items considered in the cost/benefit-analysis, the external and user costs (previous and future uses) are considered. Existing market forces do not respond to such questions like aspects of a resource for which markets are not developed or use of resources which do not reduce the amount or quality for other users. External and user costs have to be estimated by interdisciplinary teams of experts. This evaluation will make

it possible to sustain the waste assimilating and environmental amenity values of ecosystems which is normally undervaluated or completely ignored.

REFERENCES

- Anonymous**, 1983: Economic and Environmental Principles for Water and Related Land Resources Implementation Studies. U.S. Office of the Secretary of the Interior. Office of Environmental Project Review: 17 pp.
- Cole, W.G. & McKown, M.P.**, 1986: A cost analysis technique for research management and design. *Environ. Management* 10: pp 89-96.
- Jørgensen, S.E.** (Ed.), 1983: Application of Ecological Modelling in Environmental Management. Elsevier, Amsterdam.
- Jørgensen, S.E. & Vollenweider, R.A.**, 1989: Principles of Lake Management. Guidelines of Lake Management Vol. 1. International Lake Environment Committee, UNEP.
- Krenkel, P.A. & Novotny, V.**, 1980: Water quality Management. Academic Press, New York. xx pp.
- Loehr, R.C., Martin, C.S. & Rast, W.**, 1980: Phosphorus Management Strategies for Lakes. Ann Arbor Sci.Publ., Ann Arbor, Michigan.
- Novotny, V. & Chesters, G.**, 1981: Handbook of Non-point Pollution. Sources and Management. Van Nostrand Reinhold, New York.
- Ryding, S.-O., & Rast, W.**, 1990: The control of Eutrophication of lakes and Reservoirs. Man and the Biosphere Series Vol. I. The Parthenon Publishing Group, Carnforth, 314 pp.
- Straskraba, M. & Gnauck, A.**, 1985: Freshwater Ecosystems. Modelling and Simulation. Developments in Environmental Modelling, Vol. 8. Elsevier, Amsterdam. 300 pp.
- Vallentyne, J.R. & Thomas, N.A.**, 1978: Fifth year review of the Canada-United States Great Lakes Water Quality Agreement. Final Report of Task Group III (Phosphorus loadings) to US and Canadian Governments. International Joint Commission, Great Lakes Regional Office, Windsor, Ontario, Canada.
- Watt, K.E.F.**, 1983: Understanding the Environment. Allyn and Bacon, Boston.